Cochlear Implants

CDS 484/529 AURAL REHABILITATION
What is a Cochlear Implant?

- An electronic device designed to restore hearing and communication to severely and profoundly HI individuals by bypassing the defective sensory mechanism and directly stimulating auditory nerve fibers.

http://ais.southampton.ac.uk/cochlear-implant/
Cochlear implants offer an alternative for sound stimulation to individuals who receive limited benefits from traditional amplification.
Differences Between Cochlear Implants and HAs

○ Cochlear implant:
  ◦ An electrical amplifier of sounds
  ◦ Bypassing hair cells, electrically stimulating the cochlear nerve
  ◦Benefiting patients with severe cochlear damage

○ Hearing aid:
  ◦ An acoustic amplifier of sounds
  ◦ Mechanically stimulating hair cells
  ◦ Requiring some extent of hair cell functions
Benefits of a Cochlear Implant

- Improving hearing sensitivity:
  - Detection of environmental sounds
  - Enhancement of lip-reading skills
  - Enhancement of speech perception skills (detection, discrimination, identification, recognition, comprehension)

- Cochlear implants typically provide more benefit than hearing aids for patients with severe to profound hearing loss.
How the CI Works

- Sounds are picked up by the small microphone located in the behind the ear device.

- The speech processor, a powerful miniaturized computer, filters, analyzes, and digitizes the sound into coded signals.

- The coded signals are sent from the speech processor to the headpiece or transmitting coil.
o The transmitting coil, or headset, sends the coded signals via RF to the cochlear implant under the skin.

o The cochlear implant delivers the appropriate electrical energy to the array of electrodes which has been inserted into the cochlea.

o The resulting electrical sound information is sent through the auditory system to the brain for interpretation.
Risks

- General surgical complications
- Effects of CI on the cochlear integrity
  - Insertion trauma
  - Damage due to electrical stimulation
- For infants and young children
  - Effect of head growth on the implanted device.
- Explanation and re-implantation
Cost of Cochlear Implantation

- $40,000 to $60,000 in US
- Cost including evaluation, the surgery itself, hardware (device), and rehabilitation.
- Typically covered by health insurance if meets FDA criteria.
- Costs are involved for external equipment maintenance and upgrades.
Components of the Device

- External part:
  - Headset (external processor)
  - Microphone
  - Speech processor
  - Transmitter coil
  - Battery
Components of the Device

- Internal part (implanted part):
  - Receiver/stimulator:
    - Receiving signals through the skin and converting to electrical impulses
  - Electrode array:
    - Delivering electrical signals to the cochlear nerve
1. Sounds are picked up by the microphone.

2. The signal is then “coded” (turned into a special pattern of electrical pulses).

3. These pulses are sent to the coil and are then transmitted across the skin to the implant.

4. The implant sends a pattern of electrical pulses to the electrodes in the cochlea.

5. The auditory nerve picks up these electrical pulses and sends them to the brain. The brain recognizes these signals as sound.
Electrode Array

- Insert to the scala tympani of the cochlea
- Consist of multiple channels: each channel delivers currents to a confined group of auditory nerve fibers
- Electrical stimulation must be balanced to minimize DC current
  - DC leads to electrode corrosion, production of toxic products and neural and tissue damage.
Frequency Representation
The Channels of the Cochlear Implant

- Channel refers to the number of stimulation sites within the cochlea
- A single channel (old technology) vs. a multi-channel cochlear implant
Three Companies in US

- Cochlear Corporation
  - In Australia
  - Nucleus Nu8 cochlear implant system

- Advanced Bionics
  - In US
  - Advanced Bionics 90K cochlear implant system

- MED-EL
  - In Austria
  - Pulsar cochlear implant system
Best Implant System?

- No clear cut winner
  - The same CI in two different people will have different outcomes
  - All multiple channel systems have ranges of success
  - Selection of a device: individual (patient’s) choice
The Cochlear Implant Team:

- **Audiologists (the team leaders):**
  - Determine audiological candidacy
  - Program the speech processor
  - Develop an AR plan

- **Otolaryngologists:**
  - Make the medical decision and perform the surgery

- **Speech-language pathologists**
  - Responsible for training speech and language skills
  - Parents, Psychologists, Teachers, Social workers
Candidacy Selection

- The criteria are constantly changing
- Factors that affect the decision:
  - Auditory functions
  - Suitability of surgery
  - Response to hearing aids and rehab service
  - Motivation and realistic expectations
  - Commitment to follow-up appointments
Audiometric Evaluations

- Audiometric (aided and unaided)
- Standard audiometric test batteries
- Speech perception testing
  - Aided speech reading
  - ABR test
  - Otoacoustic emissions
General Adult Candidacy Criteria

- Hearing abilities:
  - Severe to Profound hearing loss in both ears
  - Less than 50% auditory only speech recognition performance with open-set sentences in the ear to be implanted (HINT sentences)
Pediatric FDA Criteria

- Infants 12-24 months:
  - Profound bilateral SNHL
  - No progress in auditory skill development with HA and EI
  - High motivation and appropriate expectations

- Children 25 mon-17 yrs:
  - Severe to profound bilat. SNHL
  - Up to 30% on MLNT/LNT
  - No progress in auditory skill development
  - High motivation and appropriate expectations
Preoperative Selection Criteria

1. Severe or profound bilateral sensorineural hearing loss
2. One year of age or older (unless ossification is present)
3. Intact auditory nerve
4. Little or no benefit from hearing aids
5. No medical contraindications to undergoing surgery
6. No active middle ear disease
7. An educational setting that emphasizes auditory therapy and communication
8. The family and candidate should be highly motivated and have realistic expectations
General Candidacy Criteria

- No medical contraindications to surgery
  - CT
    - cochlear condition (the sign of ossification of cochlea)
    - internal auditory canal (the auditory nerve)
  - facial nerve
  - mastoid cavity
  - Ear infection
  - Malformation
  - No other medical contraindications, such as tolerance to anesthesia- MRI is contraindication once implanted
General Candidacy Criteria

- Receive little or no benefit from hearing aids
  - 3-6 month trial period with appropriate amplification and AR service

- Motivation
  - Be motivated to undergo extensive AR
  - Want to be part of the hearing world
General Candidacy Criteria

- Access to education and rehabilitation follow-up
- Realistic expectation
- Age:
  - no upper age limit
  - >12 months (FDA approved)
Steps to the Candidacy Decision

- Contact implant center
- Medical/ENT
- Audiological and speech language
- Educational/Psychological
- Team meeting
- Recommendation: yes, wait, no.
Surgery to Implant a CI Device

- Opening mastoid for the placement of the receiver stimulator
- Inserting the electrode array: through the mastoid and middle ear cavity and then inserted in the scala tympani of the cochlea through RW (or through the lateral wall of the cochlea, need drill a hole)
- 3-4 hours to complete the operation
Surgical Complications

- Severe bleeding
- Facial nerve damage
- Perilymph gusher
- Mal-positioning
- Damage to the electrode array
Post-Surgery “Fitting”

- Initial Hook-up (fitting or activating)
  - 3-6 week after the surgery
  - Testing the integrity of the internal device:
    - Testing electrode voltages and impedances
    - If any of the electrodes are out of compliance with standard values they will not be programmed for use
    - Can also be done in the operation room
Patients may experience post operative complications such as nausea, vomiting, pain, tinnitus, or dizziness following surgery.

Surgery is performed under general anesthesia and usually takes around 3 hours.

There are risks from anesthesia.

Precautions are taken to minimize the chance of infection post operatively.

Can be done on an outpatient basis.
Mapping of the Implant

- Programming the implant (mapping):
  - Loudness mapping: determining the electrical dynamic range for each electrode used.
  - T-level: the electrical threshold:
  - C-level: comfort level:
- Frequency mapping
  - Based on channels
  - Applying one of the several encoding strategies provided by manufacturers
“Turning on Implant”

- Initial reactions- adults- speech high pitched, mechanical, cartoon like
- Children- no reaction, minimal sound awareness, quieting, frightened, crying
- Program multiple memories with increasing levels of stimulation
- Discussion of care and maintenance
- Patient is then seen on a regular basis for mappings and fine-tuning of the device
Variation in the Outcome

- Variable outcomes
  - Providing auditory awareness:
    - Hearing environmental sound better
  - Improving speech reading ability:
    - giving cues to speech
    - Enhancing speech perception
  - Enabling verbal conversation, telephone usage

- Normal speech acquisition may not occur in all implanted patients

Poor

Good
Variables Affecting Progress:

- Age at diagnosis/Age at CI implant
- Cause and degree of hearing impairment
- Etiology/ Cochlear nerve survival
- Effectiveness of audiological management
- Effectiveness of cochlear implant
- Length of consistent implant use
Variables Affecting Progress- Child

- Health of the child
- Emotional state of the family
- Active participation of the family
- Skills of the professionals
- Child’s learning style
- Child’s intelligence
- Child’s motivation
Factors that Affect the Results (2)

○ Status of the cochlea
  ◦ Ossification of the cochlea, how many electrodes can be fitted into the cochlea

○ Surgical issues and implanted device
  ◦ The number of electrodes used
  ◦ Speech coding strategy
  ◦ Accuracy of the mapping, should be adjusted as necessary
Factors that Affect the Results (3)

○ Other Factors
  ◦ Motivation
  ◦ Education environment, parental involvement
  ◦ The quality of the therapy team
  ◦ The mode of communication strategy used
The Signs of Internal Device Malfunction

- Inconsistent auditory responses
- Changing parameters but the patient has no response
- Frequently returns for adjustment
- Sudden irregular response
- Sub-standard performance
Causes of the Equipment Failure

- Normal wear and tear - equipment must be maintained
- Static charges
- Manufacturer faults
- Excessive Water/Moisture - water resistant, not water-proof!
Time for Remapping

- Decline in Ling 6-sound performance
  - /U/, /a/, /i/, /sh/, /s/ and /m/
- Does not respond to name
- Decline in speech perception and production
- Change in behavior
Other Types of Implantation

- Bilateral cochlear implants- both ears should be considered for implantation- if not, consider fit with HA
  - Aiding in sound localization and speech understanding

- Auditory brainstem implant
  - Indication: a patient with a missing or damaged auditory nerve
The Issues that Should be Considered in Young Patients

- **(12-18 month)**
  - Child should be in an enriched sound environment
  - Speech production takes more time to improve than speech perception does

- **(5-8 years)**
  - Post-lingual deaf – rapid development of speech production
  - Pre-lingual deaf – improving but slow
Contraindications of Cochlear Implant

- Hearing loss
  - Hearing is “too good”
  - Profound hearing loss for a very long time
  - Deafness is caused by a lesion to the central auditory nervous system.

- Motivation
  - No motivation to get an implant
  - No support systems:
    - Lack of an auditory environment such as in deaf culture
    - Lack of access to AR
  - Unrealistic expectations
Contraindications of Cochlear Implant

- Medical problems
  - Active middle or external ear infection
  - Cochlear malformation that may prevent insertion of the electrode array of the implant
  - Other medical conditions
Future Trends In CI

- Use of objective measures in programming - NRT, EARB, Acoustic Reflexes
- Bilateral Implants
- Remote programming
- Virtual Channels
- Fully Implantable
Devices

HiRes 90K-Advanced Bionics-1-800-678-2575
www.cochlearimplant.com

Freedom Contour-Cochlear Corp.-1-800-523-5798
www.cochlear.com

Pulsar-Med-El-1-800-633-3524
www.medel.com
Cochlear – Nucleus 6

- Nucleus 6 Sound Processor
  - Two Models:
    - CP910
      - Slightly larger and compatible with plug in accessories
    - CP920
      - Smaller but won’t work with plug in devices
Advance Bionics - Naída CI Q70

- Volume Control
- Phonak Dual-Microphone Technology (front and back microphones)
- Program Button
- AB’s Patented T-Mic 2
- Sound Processor
- Universal Headpiece (UHP)
- Battery Cartridge
- Headpiece Cable
- Microphone
Med-El

Opus 2

Rondo

Battery Pack
Red Indicator Light
Control Unit
Microphone with Cover
Red Indicator Light

On/Off Switch
The Heather World

https://www.youtube.com/watch?v=jhm5OaXJVMQ