Physiologic Consequences of Intracochlear Electrode Placement

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Disclosures

• Advisory Board
  » MED-EL North America
  » Advanced Bionics Corporation

• Research Support
  » MED-EL North America
  » Cochlear Americas
  » Advanced Bionics Corporation
Background

- Why CIs destroy hearing?
- Intracochlear electrode insertion
  ...trauma to delicate membranes
Recent Efforts

- Surgical access
- Non-traumatic electrodes
- Insertion methods
  limited insertion depths
Role of Insertion Depth

• The **deeper** the insertion
  » ...the greater the **trauma**
  » ...thus, the **less likely to preserve hearing**
  » ...the **better** the CI
    *at least coverage of one turn*
Current Clinical Practice

- **Full** insertions w/o attempted HP
- **Limited** insertions w/ HP
  - 6 mm
  - 10 mm
  - 16 mm
  - 20 mm
  - > 20 mm

- Does **not account for**
  - Functional parameters
  - Cochlear **size variations**
Our Philosophy

• **Customized** electrode insertions

• **Fit** the insertion **to the patient**
  account for size, hearing, trauma, etc…
  
  » Long-enough electrode
  
  » **Record functional** parameters **DURING** insertion

• **Customize insertions** based on physiology

• Several **scenarios**
  
  » **Irreversible** trauma – full insertion
  
  » **Imminent** trauma – retract, modify parameters
  
  » Presence of **hair cells** – overlap? Stop insertion?
Why Not?

- Devices have **ability to record**
  NRT, NRI, ART (**electrical** stimulus)

- Can be **active during insertion process**
  Hook-up receiver/stimulator intraoperatively

- **Acoustically evoked** parameters
  might demonstrate
  - Intracochlear (imminent) **damage**
  - Relation of **electrode** tip to functional or dead
    **regions** in the cochlea
Setup via EP Device & Implant

Data Analysis
- Raw
- CM
- CAP

Processor

Acoustic Stimulator

Implant electrode

Coupled via RF link

Trigger
Setup via EP Device & Implant

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Project Plan

- **Feasibility** of recordings
  Acoustically evoked potentials recorded via intracochlear electrode
  - **Animals**
    normal hearing and w/ NIHL efficiency (real time)
  - **Humans**
    various levels of HL

- **Interpretation** of parameters
  various levels of HL, rigid and flexible electrodes
different stages, different recording set-ups

- Feasibility of **using the implant**
Early Auditory Potentials

• **Stimulus**
  Clicks or tone bursts @ 1, 2, 4, 8, etc…

• **Measuring gross cochlear response**
  Filtering CAP & CM

  • CM: Cochlear Microphonic
    *outer* hair cells, follows stimulus polarity

  • SP: Summating Potential
    inner hair cells, follows envelope of tone burst stimulus

  • ANN: Auditory Nerve Neurophonic
    nerve fibers, fine structure *phase-locked* AP from nerve to LF

  • CAP: Compound Action Potential
    nerve fibers, onset activation of spiral ganglion cells
Endoscope & Electrode
Recording Abbreviation
Longitudinal Penetrations
Summary – Animal Studies

- **Feasibility**
  using acoustically evoked CM, CAP, ANN, SP

- **Abbreviate** protocol
  accomplish real-time feedback

- **Detect subtle** changes
  imminent trauma

- **Estimate proximity** to basilar membrane
  absent in areas w/o hair cells

- **Feasible in hearing loss** setting
  even in severe-to-profound scenario

- **Detect tonotopicity**
Human Studies
Recording Setup

[Image: Diagram showing recording setup with labels for Pinna, Sound Tube, Recording Electrode, Round Window Niche, and Facial Recess.]
RW ECoG

A

500 Hz
90 dB nHL
107 dB SPL

Response (µV)

Time (ms)

B

250 Hz
102 dB SPL

Response (µV)

Frequency (Hz)

C

1000 Hz
97 dB SPL

Response (µV)

Time (ms)

Frequency (Hz)
RW Response Distribution

Children
N=52

Adults
N=32
Intracochlear Recordings
Insertion Tracks

Response (dB re 1 μV) vs. Depth Inserted (mm)

- Extracochlear (RW)
- Intracochlear
- Return
Insertion Tracks

![Graph showing depth inserted vs response in dB re 1 μV]
Summary

• Feasibility
  …using acoustically evoked potentials in the OR

• Potentials remain strong
  even in the setting of flat ABR/profound SNHL

• Intracochal ear recording location possible
  even larger potentials!

• Good correlation w/ adult performance
  …so far even w/o further signal analysis
  • More adult data
  • Pediatric data

• Weak correlation w/ audiogram
  hearing testing does not predict implant performance
To Do

• Data on **intrascalar** recording locations
• More data on **longitudinal** penetrations mainly in human setting
  • Detect **active regions** in NIHL
    *customize insertion depths*
  • **Trauma patterns** w/ flexible electrode
    *elevation of basilar membrane*
• Adapt implant **software and setup** using acoustically evoked CM & CAP
• Learn more about **CI performance**
• Learn more about **phase**
  location within scala tympani, etc…
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