Developments

• New electrodes
• New speech processing strategies
• Bilateral implants
• Hybrid implants
• ABI in Kids
• MRI vs CT
• Meningitis
• Totally implantable devices.
Advantages of bilateral CIs

- Improved speech perception in noise
- Sound localization
- Assurance that better hearing ear is implanted
- Preserve neural elements
- Less fatigue

Disadvantages of Bilateral CIs

- Compromise second ear
- Cost
- Increased surgical risk

Data from the Würzburg Team, Individual Subjects

![Graphs showing data from individual subjects for different conditions and implant configurations.](image-url)
What is a Hybrid device?

- Uses residual, natural hearing together with a CI to replace missing high tones. I.E., both electrical and acoustical stimulation.
- A hearing aid is often used in the same ear as the cochlear implant.
- Residual hearing must be preserved.
Potential advantages of hybrid device

- More natural sound
- Much improved speech understanding, especially in noise
- Much improved tone discrimination and music appreciation

Indications

- Convention implant criteria
- EAS implant criteria
Hearing preservation

Pre-op

Post-op

COCHLEOSTOMY

- Minimal trauma associated with cochleostomy placement
- Visibility and landmarks that guarantee that the cochleostomy enters the middle of ST below the BM/SL
- Ability to use an angle of insertion that minimizes intra-cochlear trauma
- An approach that all surgeons can learn and be comfortable with
With respect to path thru FR array must be inserted from superior to inferior: Ave. $16.0^\circ \pm 5.3^\circ$ (10.7-23.9)

For completely straight insertion into most basal scala tym, some bone (ave 0.7mm) of ant-inf rim of RW would need to be removed

Takahashi & Sando Laryngoscope 1990

Audiometric Results Initial Activation

**Median Unaided Audiometric Data**

10 mm Subjects ($N=31$)

**Preoperative**

**Initial Activation**

**Median Pre- to Post Differences**

Overall Median LF (.125-1k Hz) Shift = 10 dB
### Preoperatively vs. 12 Months

#### Implanted Ear

- **HA Ipsilateral Pre**
- **Hybrid Post**
- **Bilateral HA Pre**
- **Combined Post**

#### Matched Pre and Post

**Unilateral**
- N = 77
- 22% improvement
- *p<0.001*

**Bilateral**
- N = 77
- 26% improvement
- *p<0.001*

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5 subjects withdrew prior to 12 months, not included
2 subjects missed 12 months
3 subjects not yet tested at 12 months

- 4 subjects CI only unilaterally
- 21 subjects used 9 month data for bilateral (Combined not assessed Phase I)
BKB-SIN Preoperatively vs. 12 Months
Implanted Ear Bilateral Condition

Matched Pre and Post

3.5 dB $p<0.001$

Unilateral
$N = 72$

Bilateral
$N = 70$

4 feasibility subjects not included (BKB-SIN not in protocol)
5 subjects withdrew prior to 12 months, not included
3 subjects missed 12 months unilateral
5 subjects missed 12 months bilateral
3 subjects not yet tested at 12 months

4 subjects CI only unilaterally, bimodal bilaterally
4 subjects with hearing loss prior to 12 months carried forward
5 subjects used 9 month data for unilateral
21 subjects used 9 month data for bilateral (Combined not assessed Phase I)
1 subject used 3m HA alone score for preoperative, unilateral and bilateral

Improvement in Word Recognition and Speech Reception Threshold at 9-12 Months Bilateral ($N=71$)

Significant Decrement
in Word Score

Significant Improvement
in Word Score

-15
-12
-9
-6
-3
0
3
6
9
12
-40 -30 -20 -10 0 10 20 30 40 50 60 70

* Bimodal
^ 3 or 6 Months

Severe
Profound
Total

4 feasibility subjects not included
8 subjects missed testing or withdrew
1 profound subject not included, lost to follow up
3 profound/total losses carried forward from 3 or 6 month evaluations
1 subject used 6 months

Significant Improvement in SRT

Improved Both = 34
Decreased Both = 1
No Change Both = 11
Improved Word Score Only = 16
Improved SRT Only = 5
Improved on at least 1 measure = 53 (75%)
Improved on at least 1 measure or showed no change = 64 (90%)
**Pre- to Postoperative Change in LF (125-1k Hz) Thresholds**

| Preoperative Hearing Threshold (dB HL) | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 |
|---------------------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Latest Audiogram N=78                |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 1 to 5 yrs postactivation             |    |    |    |    |    |    |    |    |    |    |    |    |    |
| No Response at any Frequency         |    |    |    |    |    |    |    |    |    |    |    |    |    |

Preoperative Hearing Threshold (dB HL)

1 subject used 18 months (missed 12 months)
1 subject with profound loss, withdrew < 3 months but carried forward
1 subject with total loss, withdrew < 6 months carried forward
3 subjects with profound loss, withdrew < 12 months but carried forward

2 subjects withdrew < 3 months not included
1 subject withdrew < 6 months not included
3 subjects withdrew < 12 months not included
3 subjects not tested yet at 12 months yet

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**Speech Recognition in Multiple Talker Babble**

<table>
<thead>
<tr>
<th>SRT-in Babble (dB)</th>
<th>-25</th>
<th>-20</th>
<th>-15</th>
<th>-10</th>
<th>-5</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
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<tbody>
<tr>
<td>Long-Electrode</td>
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<td>Short-Electrode</td>
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<tr>
<td>Normal Group</td>
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</tbody>
</table>

-7 dB
N=13

Courtesy Chris Turner, PhD Univ. of Iowa
Melody Recognition

Three approaches

- Med-El
- 20 mm electrode
  - 360 insertion
  - More trauma?

- Cochlear
- 10 mm electrode
  - Basil end of basil turn
  - Less trauma?

- 15 mm electrode

Courtesy Kate Gfeller, PhD, University of Iowa
What is seen on CT

- Middle ear structures are well seen.
- Oval/round windows.
- Tympanic segment facial nerve.
- Bony labyrinth.
What CT can not see

• Endolymphatic sac.
• Membranous labyrinth (fluid within).
• Subtle cochlear abnormalities.
• Cochlear nerve !!!!
• Brain - including brainstem and temporal lobes.

Glastonbury CM et al AJNR 2002 23(4):635-43

Ossifying cochleitis

• CT will only demonstrate ossification of the labyrinth.
• MR demonstrates fibrous obliteration - earlier in course.
• Potentially making implantation easier.
Central abnormalities

- Tumors - acoustic neuromas (VHL), brainstem lesions (astrocytomas).
- Gliosis/demyelination - ? Relate to intrauterine infection.
- Metabolic/toxic insults - mitochondrial disorders, kernicterus.
1 year old with left SNHL.
**MR of the membranous labyrinth**

- **Advantages.**
  - Better visualization of anomalies of the cochlea.
    - Modiolus, scalar asymmetry, intra-scalar defects.
  - Direct visualization of endolymphatic duct and sac.
  - Ability to visualize the nerves.
  - No radiation.

- **Disadvantages.**
  - Facial nerve not visualized distal to IAC.
  - Oval window atresia and otosclerosis missed (both are rare).
  - Sedation for some adults and deep sedation for small children
  - Cost

**Summary**

- If single study is to be performed, MR is more useful the in the pre-operative evaluation of CI patients.

- CT is useful:
  - mixed hearing loss,
  - strong clinical suspicion of potential anomalous course of facial nerve (EAC abnormalities)
Meningitis after CI

• Reefhuis et al  NEJM  2003
  – Incidence:  0.006 in children implanted < 6 yo
  – 23% had meningitis pre-op
  – 11.5% had labyrinthine dysplasia

• Suzuki et al  Arch Oto 1998
  – T-bone: Mondini
  – meningitis from non-implant ear
Recommendaions

- Prompt treatment of children with cochlear implants remains important beyond 2 years after implantation, especially in children with positioners.

- Vaccination recommendations for all implant recipients and for potential implant patients continue to apply.

OUTCOME Reopens discussion:
- explantation of the positioner (with or without replacement of the electrode)

Recommendaions

- Complete all three Prevnar hepatvalent conjugate vaccines before age 1.
- Pneumovax between ages 1-2
- Pneumovax 23 valent polysaccharide vaccine for all over 2 yrs
- Debated: single Prevnar for over 2 yrs; “boosters”
Reviewing a position statement prepared by devices subcommittee

If accepted, may lead to a promotional campaign

Should children undergo surgery to remove positioner?

Removal of positioner → Positive outcome

• Decrease risk of meningitis
• Maintain function

**HOWEVER:**

Removal of positioner → Negative outcome

• Increase risk of meningitis
• Decrease function
COCHLEAR IMPLANTS & MENINGITIS

- Risk is highest immediately after implantation
- Risk increases with cochlear trauma
- Following re-implantation decrease in implant performance does occur
- Incidence of meningitis decreases over time following implantation (no reported incidence of meningitis in patients ≥ 48 months post implantation)

Soft Failures

Medical/audiological assessment in verbal patients

Symptoms (with/without device present)
- Auditory: atypical tinnitus, perceived decrement in performance (noise, jangle, loudness scaling)
- Non-auditory: headache, shock, pain, facial stim

Medical Eval
- H&P and imaging

Audiological Eval
- Speech performance, mapping

Drop in best performance: sudden or gradual drop in performance over time

Failure to achieve expected benefit

Change in sensitivity: reduced sensitivity or tolerance to stimulation

Device Assessment
- Internal: reduced number of active channels, map deterioration, telemetry changes, surface potentials?
- Faulty external hardware
- Device integrity testing
Management

• Replace device after full testing and medical evaluation
• Follow-up data to assess for improvement after new device stimulated
  – Majority of patients improve or attain level of performance experienced prior to explant
• Data to manufacturer to assist in failure analysis
• CSR determination

ABI in Children
ABI in Children

• 30 month old profound HL (Kabuki syndrome)

• Axial HRCT
Vittorio Colletti, MD (Verona, IT)
- 16 non-tumor children
  - 10 auditory nerve aplasia
  - 2 complete ossification
  - 2 incomplete partition
  - 1 common cavity
  - 1 labyrinthe fracture

- No complications
- “Good results” but little published speech data
Problems to be worked out

1) Microphone Technology
   1) Sensitivity and freq response
   2) Head conducted sound
   3) directionality
Problems to be worked out

1) Battery performance
   1) Time/charge
   2) Time to charge
   3) Life in years
   4) Number of charges

Problems to be worked out

1) Hazards
   1) Catastrophic battery failure
   2) Electronic failure
Problems to be worked out

1) Other
   1) Compatibility
      1) Future upgrade
   2) MRI compatibility
   3) Price

Botton line:

Maybe in about 5 years!