Hybrid Cochlear Implants

The University of Iowa
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Early Hearing Detection & Intervention
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Outline of Talk

- Basics of a cochlear implant
- History of cochlear implants
- Cochlear implant hearing users
- Bimodal
  - Single sided deafness
- Hybrid
  - Traditional
  - New profiles
    - For preservation of hearing
    - For preservation of anatomy
Who is a “traditional” candidate?

- The FDA currently provides the following guidelines for pediatric cochlear implantation:
  - at least 12 months of age
  - profound, bilateral hearing loss
  - Lack of auditory progress with bilateral hearing
  - receive minimal “benefit” from hearing aids

- Guidelines for adult implantation:
  - profound, bilateral hearing loss
  - receive minimal “benefit” from hearing aids
  - speech recognition scores ≤ 50% (private insurance) and ≤ 40% (Medicare)
Types of Devices

• **Standard-length**
  - 19-31.5 mm, depending upon device
    - 22 electrode contacts (Cochlear)
    - 16 electrode contacts (Advanced Bionics)
    - 12 electrode contacts (Med-EL)

• **Short Electrode**
  - Nucleus S12 – 10 mm
  - Nucleus L24 – 16 mm
  - Med-EL Flex – 24 mm
Types of Users

- Unilateral CI
  - Bilateral profound
- Bilateral CI
  - Simultaneous
  - Sequential
- Unilateral CI with residual hearing
  - Bimodal
    - CI + HA opposite ears (CI+HA)
  - Single-sided deafness
    - CI + Normal acoustic opposite ears (SSD)
  - Hybrid
    - Acoustic + Electrical same ear (A+E)

Standard Device

Short Electrode
Nucleus® Hybrid™
Cochlear Implant System
What is a Hybrid Cochlear Implant?

- Shorter electrode array than traditional cochlear implant
  - Only stimulates the basal end (10-16 mm, 195-270 degrees) of the cochlea
- Hybrid allows individuals with steeply sloping HF hearing losses an alternative to traditional cochlear implantation
Purpose of Hybrid CI

- Preserve low-frequency residual hearing
- Allow for combined acoustic and electrical stimulation in the same ear
Benefits of A+E Hearing

• Improved speech perception abilities (Gantz & Turner, 2004, 2003; Gantz, Hanson, Turner, Oleson, Reiss, & Parkinson, 2009).

• Better frequency selectivity, which helps with understanding speech in environments with background noise (Turner, et al., 2007).

Hybrid Indications

- Low-frequency residual hearing ≤60 dB HL at 500 Hz.
- Profound HL >1500 Hz
- Aided CNC scores 10% - 60% in ear to be implanted.
- Aided CNC word scores ≥ than ear to be implanted, but no more than 80%.
Nucleus Hybrid Electrode Arrays

- **L24**:  
  - 16mm in length  
  - 22 electrodes  
  - 4 electrodes disabled  
  - Used to preserve low-frequency hearing

- **S12**:  
  - 10mm in length  
  - 10 electrodes  
  - Used to preserve low-frequency hearing

- **Standard device**:  
  - 19 mm in length  
  - 22 electrodes
Hybrid Cochlear Insertion

Hybrid L24

Hybrid S12

S-8 & S12 “200 degrees”

Standard “320 degrees”

L-24 “250 degrees”
How is sound delivered?

• Hybrid (or electro-acoustic) = electric hearing via a cochlear implant with acoustic hearing via amplification in the same ear.

• The Cochlear Hybrid System combines electric and acoustic stimulation for hearing in the one integrated system

Freedom™ Hybrid™ sound processor
Initial Concerns

- Short electrode and hearing loss over time
  - First used a standard device; partially implanted
- Yao et al. 2006 study: Long-term rate of decline in hearing in patients that fit candidacy for hybrid
  - Adults: average of 1.05 dB hearing deterioration per year in the low frequencies
    - presbycusis accounted for approximately one third to one half of this decline.
  - Pediatric: average of 1.2 dB hearing deterioration per year in the low frequencies;
    - considerably more variable (across individuals and across frequencies) than in adults.
Pre- to Initial Activation change in LF (125-1k Hz) Thresholds

Initial Activation N=161 Total Hearing Loss= 3 (1.8%) Profound Loss = 8 (5%) <30dB Loss = 149 (93%)
Pre- to Most Recent change in LF (125-1k Hz) Thresholds

- **S8**: 20%
  - Preoperative Hearing Threshold (dB HL)
  - Postoperative Hearing Threshold (dB HL)
  - 12 month N=80
  - No Response at any Frequency
  - 11/80 Profound (14%)
  - 5/80 Total loss (6%)

- **S12**: 25%
  - Preoperative Hearing Threshold (dB HL)
  - Latest Evaluation N=24
  - No Response at any Frequency
  - < 10 dB 7/24 (29%)
  - < 20 dB 12/24 (50%)
  - < 30 dB 16/24 (67%)
  - > 30 dB 8/24 (33%)
  - 3/24 Profound (13%)
  - 3/24 Total loss (13%)

- **L24**: 34%
  - Preoperative Hearing Threshold (dB HL)
  - Latest Evaluation N=50
  - No Response at any Frequency
  - < 10 dB 11/50 (22%)
  - < 20 dB 21/50 (42%)
  - < 30 dB 25/50 (50%)
  - > 30 dB 25/50 (50%)
  - 13/50 Profound (26%)
  - 4/50 Total loss (8%)
Test Conditions

1. **Combined**: bilateral HA in addition to the CI

2. **Hybrid**: CI and the HA ipsilaterally, but no HA on the contralateral ear

3. **Bimodal**: CI plus the contralateral HA, but no ipsilateral HA

4. **CI Only**: CI only, no HA

5. **Bilateral HA**
Hybrid S12 - Combined 
CNC Word Recognition 

Pre- to Postoperative Interval 
3 Months 6 Months 12 Months 

0 10 20 30 40 50 60 70 80 90 100 

Pre HA Combined 
N = 24 N = 18 N = 20 

All pre-to-post comparisons significant, p < 0.001.

Hybrid L24 - Combined 
CNC Word Recognition 

Pre- to Postoperative Interval 
3 Months 6 Months 12 Months 

0 10 20 30 40 50 60 70 80 90 100 

Pre HA Combined 
N = 50 N = 28 N = 45 

All pre-to-post comparisons significant, p < 0.001.
Purpose: To evaluate the effectiveness of hybrid cochlear implantation in improving word recognition ability.

Methods: A group of 50 patients underwent hybrid implantation and were compared to a control group.

Results:
- Pre to postoperative improvement was significant at 3 months, 6 months, and 12 months.
- All pre-to-post comparisons were significant, with p < 0.001 at 12 months.
- The average improvement in word recognition was 30% at 12 months.

Conclusions: Hybrid cochlear implantation significantly improves word recognition ability compared to preoperative levels.

Keywords: Hybrid cochlear implantation, word recognition, preoperative/postoperative comparison.
CNC Words – CI Only

Hybrid S12 - CI Only
CNC Word Recognition

- Pre HA
- CI Only

N = 18
N = 16
N = 13

3 Months
6 Months
12 Months

Hybrid L24 - CI Only
CNC Word Recognition

- Pre HA
- CI Only

N = 25
N = 22
N = 13

3 Months
6 Months
12 Months

Pre- to Postoperative Interval

Percent Correct
L24 or S12?

- All subjects, regardless of device type show improvement in speech perception
  - Combined condition is only 10% different from
  - Seems that recognition overall is better with L24

- Hearing loss is better preserved with a shorter electrode (S12)
NEW USES FOR THE HYBRID
New Studies

• Hearing preservation
  – Severe HL in the low-frequencies
    • Adults and children

• Anatomy preservation
  – Profoundly deaf
    • Pediatric population
Hybrids with Severe LF HL

- FDA IDE to see if acoustic hearing in the severe range is beneficial
  - 15 Adults
    - L24
  - 30 Children
    - L24 or S12
Hybrids with Severe LF HL

- Gap in candidacy for implantation
  - Mild to Moderate HL in the LF
  - Severe to profound HL in all frequencies
- Purpose: Determine the benefit of residual hearing in severe LF range
Candidacy in Adults

- PTA between 60-90 dB HL between 125-1500 Hz in the ear to be implanted
  - Profound loss at higher frequencies
- CNC word recognition score between 0% and 35% in the ear to be implanted
  - Contra CNC word recognition score equal to, or better than, the ear to be implanted but not more than 60%
Adult Hybrid L24
Unaided PTA (125-1500 Hz)
Adult Hybrid Condition

Adult CNC Words
Ipsi HA vs Hybrid

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<th>Pre-implant ipsi HA</th>
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<th>6 months</th>
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Percent Correct
Adult Combined

Adult CNC Words
Bilateral HA vs Combined

- Percent Correct
- Pre-implant HA+HA
- 3 months
- 6 months

Newly enrolled
Candidacy in Children

- Five to fifteen years of age
- PTA between 70-90 dB HL between 125-1500 Hz in the ear to be implanted
  - Profound loss at higher frequencies
- PBK word recognition score between 0% and 50% in the ear to be implanted
  - Contra PBK word recognition score equal to, or better than, the ear to be implanted but not more than 60%
L24 or S12 in Children

- S12 vs L24
  - Hearing threshold $\leq 90 \text{ dB HL}$ at 1500 Hz will be implanted with the Hybrid S12
  - Hearing threshold $> 90 \text{ dB HL}$ at 1500 Hz will be implanted with the Hybrid L24
  - N=3
Child Hybrid L24
Unaided PTA (125-1500 Hz)

Post-steroid treatment

Pre 1w 2w 3w 1m 4m 6m 6m 6m Pre 1w 2w 3w 1m 4m Pre 1w 2w

P01 P02 P03

dB HL
Adolescent CNC Words
Ipsi HA vs Hybrid

Percent Correct

Adolescent CNC Words
Ipsi HA vs Hybrid

Pre-implant Ipsi HA
CI Only
Newly enrolled

P-01
P-02
P-03

Pre-implant Ipsi HA
4 months
8 months
Adolescent CNC Words
Bilateral HA vs Combined

Percent Correct

P-01  P-02  P-03

Pre-implant HA+HA  4 months  8 months

Newly enrolled

Bimodal
3 mos interim
Challenges

• Programming the acoustical portion to provide enough amplification
• Stability of acoustic portion
Short Electrode in Profoundly Deaf Infants

• Two separate FDA IDEs
  – S12 + Standard
    • N=9
  – L24 + Standard
    • N=1

• Purpose: 1. Evaluate equality in performance between ears; 2. Evaluate bilateral benefits

• Goal: Preservation of anatomy for future medical interventions
Candidacy

- 12-24 months at time of implantation
- Severe-to–profound hearing loss bilaterally
  - Determined by combination of:
    - electrophysiological
    - auditory brainstem response
    - otoacoustic emission
    - steady state evoked potential
    - behavioral observation audiometry
- 3-month HA trial
Programming of Devices

• Hybrid programmed with full frequency allocation
ESP/CID Word Test

Percent Correct

S1  S2  S3  S5  S6  S7  S8  S9  Bilateral Unilateral Standard Standard (N=8) (N=19)

S12  Standard  Bilateral

The University of Iowa
GASP Word Perception

Percent Correct

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- S12
- Standard
- Bilateral
New Uses for Hybrid Cochlear Implants Conclusion

• Adult and adolescents with severe hearing loss in the LF are benefitting from the use of a hybrid.

• Too early to determine if a Short electrode will provide similar performance to a standard.
  – Need more data as children get older
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