Hybrid Cochlear Implants: Long-Term Results

Bruce J Gantz, Camille Dunn, Marlan Hansen

The Iowa Cochlear Implant Clinical Research Center
Department of Otolaryngology—Head and Neck Surgery
The University of Iowa, Iowa City, Iowa

Supported by grants from the NIH-NIDCD, Iowa Lions Hearing Foundation

Consultant for: Cochlear Corporation
Advantages of Acoustic Hearing + Electric Hearing

- Preservation of Low Frequency
  Acoustic Hearing Enhances
  - Word Understanding in Quiet
    - Average: 20% >CI only
  - Word Understanding in Noise
  - Spatial Hearing
    - Ability to Localize Sound
  - Music and Melody Recognition
  - Quality of Sound

- Provides Temporal Fine Structure not available in current CI speech coding algorithms
Hearing Preservation: Important Concepts

• **Useful Hearing:** “Functional Acoustic Hearing”
  – Must maintain better than 85-90dB in low frequencies*
  – If cannot amplify with hearing aid: not useful
  – Not worthwhile to discuss the change or delta pre to post op if do not maintain function hearing

---

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Hearing Threshold (dB HL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>-10</td>
</tr>
<tr>
<td>250</td>
<td>0</td>
</tr>
<tr>
<td>500</td>
<td>10</td>
</tr>
<tr>
<td>750</td>
<td>20</td>
</tr>
<tr>
<td>1000</td>
<td>30</td>
</tr>
<tr>
<td>1500</td>
<td>40</td>
</tr>
<tr>
<td>2000</td>
<td>50</td>
</tr>
<tr>
<td>3000</td>
<td>60</td>
</tr>
<tr>
<td>4000</td>
<td>70</td>
</tr>
<tr>
<td>6000</td>
<td>80</td>
</tr>
<tr>
<td>8000</td>
<td>90</td>
</tr>
</tbody>
</table>

*Hornsby BWY, Ricketts TA.

The effects of hearing loss on the contribution of high- and low frequency speech information to speech understanding. II. Sloping hearing loss.

Hybrid Clinical Trial

Inclusion Criteria

>18 y/o

Implant Ear
10-60% CNC
Contra Lateral Ear
Up to 80% CNC

US Hybrid FDA Clinical Trials:

- 164 Hybrid devices
- 17 Centers in US (2000-14)
  - 87 Hybrid S8
  - 27 Hybrid S12
  - 50 Hybrid L24

Average at 2, 3 and 4k Hz
Hybrid Clinical Trial Studies
CNC Words

Preoperative 12 months Preoperative 12 months
Combined

Percent Correct

S8 (6-12 mos; N=82)
Multi-Center Hybrid S12 (N=25)
Iowa Hybrid S12 (N=13)
Hybrid L24 (12 mos; N=50)

N=157
Hybrid Electrodes versus Standard Electrode
CNC Words (Iowa Subjects)

Listening Conditions:
- Combined
- Hybrid
- CI-Alone

CNC Percent Correct

<table>
<thead>
<tr>
<th>Conditions</th>
<th>CNC Percent Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>S8</td>
<td></td>
</tr>
<tr>
<td>S12</td>
<td></td>
</tr>
<tr>
<td>L24</td>
<td></td>
</tr>
<tr>
<td>Unilateral</td>
<td></td>
</tr>
<tr>
<td>Bilateral</td>
<td></td>
</tr>
</tbody>
</table>

Hybrid Implant
Standard Implant
CI-Only CNC Words Different Devices

- Hybrid S12 CI-Only
- Hybrid L24 CI-Only
- Standard CI-Only

CNC Percent Correct

Subject
Hybrid L24 & S12: 6 Month Outcomes
Groups 1 (Functional) & 2 (Non Functional)

Within Group subsets reveal similar results

Functional Hearing

L24 CNC Word Recognition
Hybrid 6 Months Postactivation N=48

S12 CNC Word Recognition
Hybrid 6 months Post Op N=25

Severe or Better
Group 1 (n=33)

Profound/Total
Group 2 (n=15)
Benefits of Preserving Residual Hearing Speech Recognition in Multiple Talker Babble

* 5dB SNR improvement corresponds to increasing HINT scores from 43% to 76% (Eddington et al., 1997)
Important Issues

• Acoustic Hearing Preservation
Profound Acoustic Hearing Loss Over Time

(% Non Functional Acoustic Hearing) N=213

<table>
<thead>
<tr>
<th>Component</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>S8</td>
<td>83</td>
</tr>
<tr>
<td>S12</td>
<td>27</td>
</tr>
<tr>
<td>L24</td>
<td>50</td>
</tr>
<tr>
<td>422-20</td>
<td>27</td>
</tr>
<tr>
<td>422-24</td>
<td>26</td>
</tr>
</tbody>
</table>

3% 17% 16% 10% 6mo 33% 20% 44% 46% 45% 56%
89% Functional Hearing Preservation N=57
93% Functional Hearing Preservation N=53 (excluding over stim group)

*Red shapes indicate non-functional hearing with no AC use
Important Issues

• Long Term Results
Iowa Hybrid Acoustic PTA (.125-1k) Over Time

S8

Unaided PTA (dB HL)

N=24

S12

N=13

Years Post Op
Averaged PTA Over Time - Hybrid S8 and S12

Years Post Implantation

Pre 0.5 1 2 3 4-6 7-8 9-10 11-12 13-16

dB HL

S12 N= 14 14 14 12 6 9
S8 N= 23 22 23 20 16 16 18 16 14 6
Averaged CNC Words Over Time - Hybrid S8 and S12 Combined and Hybrid Conditions (Iowa)
1. Long Term Stability of Results – over 16+ years
   • 90% using A+E
   • 86% > 60% CNC word understanding (combined condition)
“Functional” acoustic hearing can be maintained in most subjects with hearing preservation electrodes at initial activation (93%).

13-51% lose “Functional” hearing over time, majority lose hearing after activation.
- Shorter electrodes have better preservation rates.
- Mechanisms: Trauma, Excitotoxicity, Other.
- In fibrosis case: apical hair cells and neurons preserved!

Central auditory plasticity can accommodate to place-pitch shift.

“Functional” acoustic hearing and improved speech perception scores can be preserved for over 16 years using A + E.

Performance with CI quite variable for all lengths of electrodes.
Hybrid FDA Multicenter Trial Centers

- **FDA Clinical Trial: Hybrid S8**
  - University of Iowa*
  - New York University*
  - University of Miami*
  - Indiana University*
  - House Ear Institute*
  - University of Texas Southwestern*
  - Kansas City Ear Institute*
  - California Ear Institute*
  - Dallas Otolaryngology Associates*
  - Mayo Clinic Rochester*
  - University of Washington*
  - UCSF*
  - Denver Ear Associates*
  - Center Hearing & Balance St Louis*
  - Arizona Ear Center*
  - University of Florida*

- **FDA Trial: Hybrid S12**
  - University of Iowa
  - University of Washington
  - UCSF
  - University of Miami
  - Dallas Otolaryngology Assoc
  - Cleveland Clinic

- **FDA Trial: Hybrid L24**
  - New Your University
  - Mayo Clinic
  - University of Iowa
  - House Ear Institute
  - Northwestern University
  - Kansas City Ear
  - University of Cincinnati
  - Center Hearing and Balance St Louis
  - Washington University