Cochlear Implantation for Single-Sided Deafness in Children and Adolescents

Douglas Sladen, PhD
Dept of Communication Sciences and Disorders
Western Washington University

Daniel M. Zeitler MD, Virginia Mason, Seattle, WA
Matthew L. Carlson, MD, Mayo Clinic, Rochester, MN
DISCLOSURES

I have no proprietary interest in any product, instrument, device, service or material related to this presentation.

I will be discussing off label use of a cochlear implant.
Current Indications for Use

Adult cochlear implant candidacy

2005

bilateral moderate to profound sensorineural hearing loss ≤ 50%
sentence recognition in the ear to be implanted and
≤ 60% in the best aided condition

*Medicare guidelines stipulate ≤ 40% sentence recognition

Pediatric cochlear implant candidacy

2009

children 12 – 23 months of age, ≥ 90 dB HL and lack of auditory progress

children ≥ 24 months of age, ≥ 70 dB HL and score ≤ 30%
on LNT or MLNT
Background

- Mayo Clinic – Post-lingually deafened adult data
- 310 implanted patients between Jan 2010 and Jan 2012
- 89 cases were included in analysis after removing:
  - Children
  - Adults getting second sided implant
  - Pre-lingually deafened
  - Incomplete data points
  - Patients in FDA clinical trials
• Speech presented at 60 dB SPL in a sound field
  • Preoperatively with hearing aid on the ear to be implanted
  • Postoperatively with sound processor and user settings
Phonak - Unilateral Hearing Loss in Children

Percent % correct

CNC words
- 24 to 60 years (n=27): 9.5%
- 60-69 years (n=23): 9.7%
- 70-79 years (n=23): 6.6%
- 80+ years (n=16): 14.3%

CNC phonemes
- 24 to 60 years (n=27): 25.4%
- 60-69 years (n=23): 23.7%
- 70-79 years (n=23): 16.5%
- 80+ years (n=16): 27.3%

AzBio sentences
- 24 to 60 years (n=27): 19.3%
- 60-69 years (n=23): 14.8%
- 70-79 years (n=23): 10.5%
- 80+ years (n=16): 15.2%

- 188 children from 6 centers who had CI prior to 5 years of age and 97 same-age children with normal hearing
- Performance of spoken language comprehension and expression using the Reynell Developmental Language Scales
- All children scored within two standard deviations of the norm on the Bayley Scale of Infant Development or Leiter Performance Scale-Revised
Niparko et al., 2010
Comprehension Scores

Figure 1. Developmental Trajectories of RDLS Raw Scores of Comprehension and Expression Grouped by Age at Baseline
Niparko et al., 2010
Expressive Scores
Background

- Cochlear implants improve localization and speech understanding in noise among adults and children with single-sided deafness (Firszt et al., 2012; Arndt et al., 2011; Friedman et al., 2016; Mertens et al., 2015; Beurnstein et al., 2017; Zeitler et al., 2015)
Specific aims

- **Aim 1.** Does cochlear implantation restore speech understanding abilities to the ear implanted among adults and children with unilateral hearing loss (UHL)

- **Aim 2.** Does cochlear implantation result in a binaural advantage among adults and children with UHL: improved speech understanding in diffuse noise, improved self perceived spatial hearing, decreased listening effort
• **Binaural advantage**
  • Overall speech understanding in noise is enhanced when using two ears compared to one (Bronkorst & Plomp, 1988; Licklider, 1948)

• **Binaural disadvantage, interference**
  • Overall speech understanding in noise is worse when listening with interaural asymmetries compared to listening with the better hearing ear (Shinn-Cunningham et al., 2001; Rothpletz et al., 2004)
Participants

• Inclusion
  • Moderate to severe sensorineural hearing loss on the affected side, with contralateral hearing thresholds $\leq$ 30 dB HL through 2K Hz
  • Aided monosyllabic word score less $\leq$ 50%, ear to be implanted
  • Adults and children
    • Started with children 7 to 18 years of age and older, then removed the lower age limit
    • Started with hearing loss that was greater than 6 months and less than two years

• Exclusion
  • Known cognitive deficits
  • Retrocochlear hearing loss
Test Measures

- Speech understanding in quiet
  - Speech presented at 60 dB SPL in a sound field (contra ear masked)
    - CNC words (Peterson & Lehiste, 1962)
    - AzBio sentences (Spahr & Dorman, 2012)
- Speech understanding in noise
  - HINT sentences adaptively (Nilsson et al., 1998) in an R-SPACE 8-speaker array
- Questionnaires
  - Speech Spatial Hearing Questionnaire-Comparative (SSQ-C; Noble & Gatehouse, 1990)
  - SF-36 (Ware & Sherbourne, 1991)
  - Nijmegen Cochlear Implant Questionnaire (Hinderink et al., 2009)
- Listening effort
  - Dual task paradigm
Speech, Spatial and Qualities of Hearing Questionnaire – Comparative (SSQ-C)

4. You are in a group of about five people in a busy restaurant. You can see everyone else in the group. Can you follow the conversation?

Comparing your ability now with your ability wearing the previous hearing aid/s

- Much worse
- Unchanged
- Much better

-5 -4 -3 -2 -1 0 +1 +2 +3 +4 +5

8. In the street, can you tell how far away someone is, from the sound of their voice or footsteps?

Comparing your ability now with your ability wearing the previous hearing aid/s

- Much worse
- Unchanged
- Much better

-5 -4 -3 -2 -1 0 +1 +2 +3 +4 +5

14. Do you have to concentrate very much when listening to someone or something?

Comparing your experience now with your experience wearing the previous hearing aid/s

- More need to concentrate
- Unchanged
- Less need to concentrate

-5 -4 -3 -2 -1 0 +1 +2 +3 +4 +5
## Test Intervals

<table>
<thead>
<tr>
<th></th>
<th>Pre-operative (37)</th>
<th>3-months post activation (32)</th>
<th>6-months post activation (28)</th>
<th>12-months post activation (20)</th>
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<tbody>
<tr>
<td>CNC words</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>AzBio Sentences</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Speech in noise (R-SPACE)</td>
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<tr>
<td>Questionnaires</td>
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<tr>
<td>Listening effort</td>
<td></td>
<td></td>
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<td>X</td>
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</table>
Participants

• 42 implanted (33 adults, 9 children)
  • 5 withdrew
    • 2 lost to follow up (moved)
    • 2 progressed to bilateral
    • 1 became a non-user
    • 1 failed device

• Comprised of 18 Cochlear, 14 MED EL, 1 AB
Results: Speech Understanding

- CNC words
- AzBio sentences

Pre-operative 3-months 6-months 12 Mos

Percent (%) Correct

Test Interval

Phonak - Unilateral Hearing Loss in Children
R-SPACE HINT

* p = .03

Phonak - Unilateral Hearing Loss in Children
Results – SF-36

Domains of SF-36

- Physical Functioning
- Role Functioning/Physical
- Role Functioning/Emotional
- Energy/Fatigue
- Emotional Well-Being
- Social Functioning
- Pain
- General Health

Preoperative vs 6 Months Post

Phonak - Unilateral Hearing Loss in Children
Results - NCIQ

![Bar chart showing the average total score for different domains of the Nijmegen PreOperative and 6 Months Post.

- Basic Sound Perception
- Advanced Sound Perception
- Speech Production
- Self Esteem
- Activity Limitations
- Social Interactions

Domain of the Nijmegen

Phonak - Unilateral Hearing Loss in Children
Results: Self perceived benefit; SSQ-C

Phonak - Unilateral Hearing Loss in Children
## Implantated Children

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age (yrs)</th>
<th>Sex</th>
<th>Side</th>
<th>Etiology</th>
<th>Notable</th>
<th>DOD (yrs)</th>
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<td>M</td>
<td>L</td>
<td>Idiopathic Sudden</td>
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<td>1.1</td>
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<td>2</td>
<td>11.0</td>
<td>M</td>
<td>R</td>
<td>Cholesteatoma</td>
<td>BAHA removal</td>
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<tr>
<td>3</td>
<td>15.2</td>
<td>F</td>
<td>R</td>
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<td>1.5</td>
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<tr>
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<td>F</td>
<td>R</td>
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<td>5</td>
<td>1.5</td>
<td>F</td>
<td>L</td>
<td>Idiopathic Congenital</td>
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<td>1.5</td>
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<tr>
<td>6</td>
<td>5.8</td>
<td>M</td>
<td>L</td>
<td>Idiopathic Congenital</td>
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<td>5.8</td>
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<tr>
<td>7</td>
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<td>M</td>
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<tr>
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<td>F</td>
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<tr>
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<td>F</td>
<td>R</td>
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</table>
# Implanted Children

<table>
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<th>Subject</th>
<th>Insertion</th>
<th>Device</th>
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<tr>
<td>2</td>
<td>Cochleostomy SV</td>
<td>Cochlear 24 RE</td>
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<tr>
<td>3</td>
<td>RW</td>
<td>Med El Flex 28</td>
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<tr>
<td>4</td>
<td>RW</td>
<td>Cochlear 522</td>
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<tr>
<td>6</td>
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<tr>
<td>7</td>
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<td>Med El Flex 28</td>
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<tr>
<td>8</td>
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<td>Med El Flex 38</td>
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<tr>
<td>9</td>
<td>RW</td>
<td>Med El Standard</td>
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</table>
• Frequency of device use
  • 8 of 9 implanted children are full time CI users

• Tinnitus
  • Four had tinnitus preoperatively
  • All 4 experienced improvement with device "on"
    • 2 complete resolution
    • 2 partial resolution
CNC word scores

Phonak - Unilateral Hearing Loss in Children
Monosyllabic Word Score – ear implanted, 6 mos

P = .21
Phonak - Unilateral Hearing Loss in Children

[dB SNR]

CI On CI Off

Phonak - Unilateral Hearing Loss in Children
SNR Advantage from adding CI

Phonak - Unilateral Hearing Loss in Children
Listening effort

• Dual task
  • Primary task, speech recognition
  • CNC words at 65 dB SPL
  • Restaurant noise at 65 dB SPL
  • Baseline, quiet, noise (device on, device off)

• Secondary task, button push to perfect square among tall and long rectangles

Latency of the button response is the dependent variable

Phonak - Unilateral Hearing Loss in Children
Listening Effort – dual task
Results: Listening effort (n=10)

CNC Words

Percent (%) correct

0 dB SNR

Device On

Device Off

Quiet

Phonak - Unilateral Hearing Loss in Children
Results: Listening effort, 12 mos (n=10)

Reaction Times

- Baseline
- Device On
- Device Off

Quiet

0 dB SNR

Phonak - Unilateral Hearing Loss in Children
Clinical implications

- CI can improve speech understanding for those with UHL
- CI can improve HRQoL using a measure that is disease specific
- CI may have a negligible impact on listening effort
- Insurance remains an obstacle
- Despite our best efforts, one became a non-user
Questions & Discussion