Effects of Setting Thresholds for the MED-EL Cochlear Implant System in Children

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Background

- Movement in CI programming is to shorten appointment times and streamline fittings
  - Reduction in reimbursement
  - RVU demand at clinics causing shortening of appointment times
  - Expansion of CI services to new clinics

- Most adults are physically and mentally capable of setting thresholds

- Children, however, may not have the readiness skills for or have learned the “conditioned play” task

- With children, additional concerns include attention, fatigue and the global assumption that they are not able to accurately set thresholds
Background

- Manufacturers are suggesting to focus on upper stimulation levels
- Significant research has been done on the setting of upper stimulation levels
  - Behavioral settings and balancing
  - Objective measures like eSRTs and ECAPs
- For at least 2 devices, it has been suggested by manufacturer representatives to set thresholds to 0 or to 10% of the MCL
- This would alleviate the need to set thresholds and allow for shorter programming session appointments while increasing profitability
Previous research

- Skinner et al (1999) evaluated 2 methods for setting thresholds with Cochlear’s N22 device
  - Counted thresholds were found to be most effective
  - Uses different processing, bipolar stimulation and smaller input DR
- Spahr and Dorman (2005) evaluated thresholds set to 0 or 10% in adults with the MED-EL device (C40+ implant with TEMPO+ processor)
  - No significant differences found for sentences at low levels in quiet or noise or for consonants and vowels for either condition
  - Significant difference on consonant test noted for voicing but not for place or manner of articulation
  - Authors noted that the “importance of low level inputs should not be overlooked for sound awareness or incidental learning in pediatric populations”
Previous Research

- Boyd (2006) evaluated how thresholds and maplaw effect acoustic thresholds and speech discrimination in adults
  - MED-EL C40+ implant with the clinic’s CIS PRO+ body worn processor
  - Set behavioral thresholds and MCL then made 3 maps
    - Behavioral threshold, BT X 2, and minimum
  - Evaluated the effects on acoustic thresholds for how thresholds were set, maplaw, background threshold stimulation (“hum”) and speech discrimination
  - Setting thresholds did not effect the CI audiogram or speech discrimination significantly but did produce audible “hum”
  - Steeper maplaws produced lower acoustic thresholds
Considerations for Children

- Young implanted children typically:
  - Have little to no language at time of implantation
  - Acoustic demands range from quiet to excessive noise
  - Much of their listening in early years is through overhearing and incidental learning
    - Children need to hear soft sounds
  - Access to sound/speech is critical for a child to learn to listen and speak
  - Children learn to speak how they hear!
Flexer and Madell’s “speech string bean”

- Flexer and Madell
  - Children need to hear in “The Speech String Bean”
    - The “softest” part of the speech banana = 15-20dBHL

MED-EL’s Recommendations

- Chris Durst at MED-EL UK Ltd (handout provided by ME rep)
- “For the overwhelming majority of pt.s, MCL is the only critical parameter to ensure good performance. (All others can be left at default).
- For a small subset of patients other parameters such as THR etc. may be important in securing good performance.
- Clinicians' priority (in general) should be to focus on measuring accurate MCLs…”
- “THR levels must be Inaudible
- Use a PTA type technique to determine threshold
- Then adjust downward 1/2/3 steps”
Current Study

- Evaluate the use of thresholds following MED-EL’s recommended fitting technique versus 10% of MCL on behavioral acoustic thresholds and speech perception in children
- 13 children aged 5 years to 18 years (mean = 12 years, 6 months)
- Etiology:
  - CI use ranged from 1y, 8m to 15y, 4m in at least one ear
    - Mean = 9 years, 11 months

- Etiology:
  - Genetic: n = 7
  - Unknown: n = 4
  - Meningitis: n = 1
  - EVA: n = 1
Current Study

- 7 subjects were bilateral users and 6 were unilateral
  - 20 total implants

- Implant

![Bar chart showing implant usage:]

- C40+: 8
- Pulsar: 5
- Sonata: 9
- Concert: 1
Current Study

- All subjects used the OPUS 2 processor
  - Verified good working condition prior to testing
  - No issues or problems with device or hearing prior to testing

- All subjects used:
  - Maplaw = 1000
  - FSP (n=12) or FS4 (n=1)
  - Default frequency range for internal
Methods

- Behavioral thresholds were set using a conditioned play technique (n = 2) or behavioral indication “I hear it” or “Yes” (n = 11)

- Once subject heard the stimuli, levels were decreased in 1 down arrow steps until no response was obtained

- Threshold level where response was obtained was then reduced by 3 down arrow clicks to ensure inaudibility (verified by presenting stimuli for response)
Methods

- MCLs were rechecked using loudness judgments and all were not significantly different than previous MAPs
- A new map was created with thresholds set at 10%
- MAPs were downloaded to the recipient’s processor and synced to clinic remote
  - Subject had no access to change volume or sensitivity
  - MAPs changed by tester
- Randomized use of MAPs were used for testing
Testing

- Testing was completed in a calibrated Acoustic Systems soundbooth using a GSI 61 audiometer
- Subjects were seated 1 meter from speaker at 0 degree azimuth
- Warble tone stimuli was used for behavioral acoustic threshold measurements at 250, 500, 1000, 2000 and 4000 Hz
- Speech perception testing was completed using MLV presented at 50dBHL
  - Small subset of subjects tested in noise at +5SNR
- Tests included CNC words and HINT sentences (2 lists)
## Results

- **Audiogram results using measured thresholds**

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<thead>
<tr>
<th>Hz</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
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</table>

| 17.31 | 17.31 | 16.54 | 16.92 | 18.46 |
## Results

- **Audiogram results using 10% of MCL**

<table>
<thead>
<tr>
<th>Hz</th>
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<th>2000</th>
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</table>

**Means:**
- 23.46
- 25.00
- 26.54
- 30.77
- 35.00
Results

Average acoustic thresholds

- Measured
- 10%

p < 0.05 for all frequencies
Results

- Speech Perception in Quiet

<table>
<thead>
<tr>
<th></th>
<th>Word</th>
<th>Sentence</th>
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<tbody>
<tr>
<td>% Correct</td>
<td>91.4</td>
<td>97.8</td>
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</tbody>
</table>

p = 0.00000008

Measured

10%
Results

- Speech Perception in Noise (+5 SNR)
  - n = 5

<table>
<thead>
<tr>
<th></th>
<th>Word</th>
<th>Sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Correct</td>
<td>89.6</td>
<td>97.8</td>
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</tbody>
</table>

Measured

10%

p = .00016

p = .0074
Results – Testing in Noise Data

% Correct

S1  S2  S3  S4  S5

Word-measured  Word-10%  Sent-measured  Sent-10%

92   92   80   88   96
72   76   60   64   72
76   71   78   91   74
100  100  95   97   97
Conclusions

- Behavioral thresholds of good reporters and using MED-EL’s recommended procedures yielded results at lower audiometric levels
  - Within normal limits (average of 16-18dB)
  - Within the speech string bean range
- 10% of MCL thresholds in this study yielded poorer behavioral audiograms
  - BWNL to mild hearing loss range (average of 23-35dB)
- Decreased speech perception scores were noted for both word and sentence tests in quiet with 10% THR
- In a subset of subjects, word and sentence scores decreased significantly in noise when using 10% THR program
Conclusions

- If children have poorer access in quiet and even worse access in noise, their speech and language development can be severely restricted over time.

- Generalizations of adult data to children should be considered carefully before implementation so as to not inhibit hearing and speech and language progress in developing children.
  - Continued research is needed.