The relationship between electric charge requirements and speech recognition of adult cochlear implant recipients

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Speaker Disclosure

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Introduction

- Little data exists regarding the average psychophysical responses of cochlear implant recipients, particularly as they relate to speech recognition.
- Such information can be used to guide clinicians in their programming sessions and may shed light on some of the variability seen with adult outcomes.
Excluded the mapping requirements of 184 children (188 ears) enrolled in the CDACI study, evaluated at 6 different CI centers

Examined T and C levels at activation, 6, 12, and 24 months post-activation

All 3 types of implant devices were included

Children with normal and abnormal cochlea were included
CDACI study key findings

- Children demonstrated significant increases in C/M levels between device activation and the 24 month mark.
- Significant differences were noted in mean C/M levels between devices.
- Children with cochlear anomalies demonstrate significantly greater C/M levels than children with normal cochleae.
- Although mean C/M levels varied across the 6 centers, differences were not significant once the results were adjusted for device type.
- The results provide average T, C/M data that clinicians may use as a guide when setting levels for pediatric recipients.
Primary Objectives

- To provide mean threshold (T), comfort level (C), and dynamic range (DR) data for adult patients implanted with Nucleus CI24RE devices.
- To evaluate the relationship between post-operative electric charge requirements and speech recognition.
Methods

- Retrospective review of electric charge requirements (T,C, DR) and speech recognition obtained 24 months post-activation (+or- 6 mos)

- Subjects = 97 postlingually deafened adults with normal cochleae, no clinical concerns about cognition, all implanted with Nucleus CI24 devices at a single CI clinic
Pulse widths were not consistent across all subjects so Cochlear units could not be used.

Threshold, comfort level, and Dynamic Range (C-T) measurements (+or- six months) were converted to units of charge per phase (nC) using a formula provided by Cochlear Americas:

\[
\text{Current (\mu A) \times \text{pulse width} / 1,000}
\]
In order to evaluate various areas of the electrode arrays, measurements were additionally grouped as follows:

- 1-5 = basal
- 6-10 basal-mid
- 11-15 apical-mid
- 16-22 apical
Speech Recognition

- Speech recognition was based upon the score obtained at the 24 month test interval (+or- six months) on the CNC Monosyllabic Words Test (Peterson & Lehiste, 1962).
- Recorded CNCs were administered at a level of 60 dB A as part of the subjects’ annual evaluation.
Data Analysis

- Pearson correlation was performed to evaluate the relationship between T, C, DR, and speech recognition.
- Paired samples t-tests were used to compare dynamic ranges at various areas of the electrode array.
Demographics

- Total # of subjects = 98
  - 47 left, 51 right
- Mean # of disabled electrodes = 1.8 (tend to be E1 and E2)
- Mean number of active electrodes = 20.19
Demographics

- **Strategy**
  - $98/98 = \text{ACE}$

- **Rate:**
  - $2 = 250 \text{ Hz}$   $8 = 500 \text{ Hz}$   $3 = 720 \text{ Hz}$   $69 = 900 \text{ Hz}$   $14 = 1200 \text{ Hz}$   $2 = 1800 \text{ Hz}$

- **Pulse width**
  - $93/98 = 25 \mu A$   $5 = 37 \mu A$

- **Maxima**
  - $1 = 6$, $70 = 8$   $5 = 10$, $1 = 12$
Results

- **Adults**
  - Threshold Mean = 5.10 nC (136 CU)
  - Range = 2.4-12.49 nC (94-185 CU)
  - C level Mean = 11.25 nC (180 CU)
  - Range = 4.37-26.45 nC (127-227 CU)
  - DR Mean = 8.6 nC
  - 43 CU

- **CDACI**
  - Mean C at 24 mos (n=102) = 213 CU
  - Mosca et al. (2014)
  - Mean C at 12 mos = 199 CU
Mean Map
(Average T, C for each electrode averaged across the group)

T (136 CU)
C (180 CU)
DR (43 CU)
Patient ranges

Patient with Lowest average thresholds (CNC=80%)

Patient with Highest average C levels (CNC=88%)
## Differences between mean Dynamic Ranges based on place

<table>
<thead>
<tr>
<th>Electrodes</th>
<th>Mean</th>
<th>Sig. diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal 1-5:</td>
<td>4.92</td>
<td>6-10, 11-15, 16-22</td>
</tr>
<tr>
<td>Mid Basal 6-10:</td>
<td>5.76</td>
<td>1-5, 11-15, 16-22</td>
</tr>
<tr>
<td>Mid Apical 11-15:</td>
<td>6.62</td>
<td>1-5, 6-10</td>
</tr>
<tr>
<td>Apical 16-22</td>
<td>6.69</td>
<td>1-5, 6-10</td>
</tr>
</tbody>
</table>

Dynamic ranges are greatest at the apical end, significantly smaller at the basal end.
**CNC score mean = 59%**

<table>
<thead>
<tr>
<th>Description</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNC</td>
<td>75</td>
<td>.00</td>
<td>96.00</td>
<td>59.3467</td>
<td>26.10296</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CNC score was significantly correlated with Dynamic range

<table>
<thead>
<tr>
<th></th>
<th>CNC</th>
<th>DRAVG</th>
<th>DRAVG1_5</th>
<th>DRAVG6_10</th>
<th>DRAVG11_15</th>
<th>DRAVG16_22</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNC</td>
<td>1</td>
<td>.253*</td>
<td>.263*</td>
<td>.299**</td>
<td>.331**</td>
<td>.342**</td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.029</td>
<td>.029</td>
<td>.009</td>
<td>.004</td>
<td>.003</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>75</td>
<td>75</td>
<td>69</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
</tbody>
</table>

Greater dynamic range at each area of the array positively correlates with a greater CNC score
**Correlations**

<table>
<thead>
<tr>
<th></th>
<th>CNC</th>
<th>Disabled</th>
<th>Max_C</th>
<th>Min_T</th>
<th>Range</th>
<th>Avg_C</th>
<th>Avg_T</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNC</td>
<td>1</td>
<td>-.464*</td>
<td>.211</td>
<td>-.322*</td>
<td>.310*</td>
<td>.189</td>
<td>-.190</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.070</td>
<td>.005</td>
<td>.007</td>
<td>.103</td>
<td>.102</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
</tbody>
</table>

CNC also correlates negatively with number of disabled electrodes.

Average C and average T did not correlate with CNC score.
Summary/Conclusions

- Mean programming data can serve as a helpful guide for clinicians.
- In patients with normal cochlea, levels exceeding those of average users should be questioned and investigated.
- C levels for these adults (obtained at a single site) tend to be lower than C levels obtained for children in the CDACI study and by others—this needs further investigation as several sites are involved in the CDACI study.
Conclusions

- CNC score was **not** correlated with average T or C but **was** positively correlated with DR
  (greater DR = greater CNC score)
- CNC score was negatively correlated with number of disabled electrodes
  (greater # inactive electrodes = poorer CNC)
- Additional studies are needed to further understand the relationship between mapping characteristics and outcomes and to further understand difference between adults and children