Comparison of Speech Perception & Functional Listening Performance according to Inter-implant Intervals in Sequential Bilateral Cochlear Implantations

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Part I.
Comparison of **Speech Perception**
according to Inter-implant Intervals in
Sequential bilateral CI
INTERIM

**Inter-implant intervals in Sequential Bilateral CI**

- **Shorter inter-implant intervals** in sequential bilateral CI result in better auditory outcomes.  
  
  *(Litovsky et al. 2004, Dorman et al. 2005)*

- **Negative influences** of **long inter-stage interval** along with older age at implantation showing significant differences in **directional test performances** and **speech perception scores**.  
  
  *(Litovsky et al. 2007)*

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 retaliation

**Bilateral CI**

- **Simultaneous**
- **Sequential**

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![Diagram](image)
• If children (long inter-stage interval of >5 years) are excellent performers with the first implant, they are likely to be capable of developing better perceptual abilities and functional benefits using the second implant within a short time after the second implantation.

(Boons et al., 2012; Kim et al., 2013)
Comparison of Test Scores of the 1st implant only & 2nd implant only 3, 6, and 12 months after 2nd CI

Comparison of Mean Ratios of postop 12 months after bilateral CI
1. To measure and compare the speech perception scores of the 1\textsuperscript{st} and 2\textsuperscript{nd} CIs according to time period.

2. To analyze differences in speech perceptions by different inter-implant intervals in sequential bilateral CIs.
1) Subjects

Ajou University School of Medicine, Department of Otolaryngology

- **Period:** March, 2004 – June, 2017
- **Patients:** who received both CIs in our hospital (n=69 patients)
- **Inclusion criteria** (n=29 patients)
  - underwent sequential CIs
  - use of both CIs ≥ 12 months
  - 65% ≥ speech perception after 1st CI and before 2nd CI

**Performance of bilateral CI** (Simultaneous vs. Sequential)

- Simultaneous: 10 pts (14.5%)
- Sequential: 59 pts (85.5%)

**Age of sequential bilateral CI** (Children vs. Adult)

- Adults: 3 pts (4.3%)
- Children: 66 pts (95.7%)
### Table 1. Demographics

<table>
<thead>
<tr>
<th></th>
<th>Current Age</th>
<th>Age at 1st CI</th>
<th>Age at 2nd CI</th>
<th>Interval of 1st &amp; 2nd CI</th>
<th>Use of 1st CI</th>
<th>Use of 2nd CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (±SD)</td>
<td>14yr 2mon (±3yr)</td>
<td>3yr 6m (±3yr 4m)</td>
<td>9yr 4mon (±3yr 7mon)</td>
<td>5yr 10mon (±2yr 9mon)</td>
<td>10yr 8mon (±2yr 10mon)</td>
<td>4yr 8mon (±1yr 9mon)</td>
</tr>
<tr>
<td>Minimum</td>
<td>8yr 9mon</td>
<td>12mon</td>
<td>3yr 10mon</td>
<td>11mon</td>
<td>2yr 2mon</td>
<td>1yr 6mon</td>
</tr>
<tr>
<td>Maximum</td>
<td>20yr 4mon</td>
<td>13yr 6mon</td>
<td>18yr 10mon</td>
<td>12y 2mon</td>
<td>14yr 6mon</td>
<td>7yr 1mon</td>
</tr>
</tbody>
</table>

### Table 2. Classification according to time of Interval between 1st & 2nd CI

<table>
<thead>
<tr>
<th>Interval period between 1st &amp; 2nd CI</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interval &lt; 4yrs</td>
<td>7</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>4yrs ≤ interval &lt; 7yrs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interval ≥ 7yrs</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1) Materials & Analysis

(1) Comparison of speech perception between 1\textsuperscript{st} & 2\textsuperscript{nd} CI:
- monosyllabic word, bisyllabic word, and sentence scores were evaluated from pre-operation to 1yr post-operation
  
  \textit{(paired t-test)}

(2) Evaluation of speech perception scores according to time intervals between 1\textsuperscript{st} & 2\textsuperscript{nd} CI:
- monosyllabic word, bisyllabic word, and sentence scores were measured from pre-operation to 1yr post-operation
  
  \textit{(one way ANOVA and Mann-Whitney U test)}
RESULTS

1) Speech Reception of 1\textsuperscript{st} & 2\textsuperscript{nd} CI

Scores of Monosyllabic Word Test

\[ \begin{align*}
\text{Preop} & : p^* = .000 \\
\text{Postop 3mon} & : p = .234 \\
\text{6 mon} & : p = .848 \\
\text{1 yr} & : p = .182
\end{align*} \]
1) Speech Reception of 1\textsuperscript{st} & 2\textsuperscript{nd} CI

Scores of \textit{Bisyllabic Word} Test

\begin{itemize}
  \item Preop \hspace{1cm} Postop 3mon \hspace{1cm} 6 mon \hspace{1cm} 1 yr
  \item $p^*=.000$ \hspace{1cm} $p=.170$ \hspace{1cm} $p=.521$ \hspace{1cm} $p=.539$
\end{itemize}

\begin{itemize}
  \item 1\textsuperscript{st} CI only
  \item 2\textsuperscript{nd} CI only
\end{itemize}
1) Speech Reception of 1st & 2nd CI

Scores of **Sentence** Test

- **Preop**: $p^* = .000$
- **Postop 3mon**: $p^* = .014$
- **6 mon**: $p = .796$
- **1 yr**: $p = .288$

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*1st CI only*  
*2nd CI only*
2) Speech Perception according to Time Interval of Bilateral CIs

**Postoperative 3 months**

<table>
<thead>
<tr>
<th>Group</th>
<th>Time Interval (yrs)</th>
<th>2nd CI Score / 1st CI Score</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>&lt; 4 yrs</td>
<td>1</td>
<td>0.513</td>
</tr>
<tr>
<td>Group 2</td>
<td>4 yrs ≤ interval &lt; 7 yrs</td>
<td>1.5</td>
<td>0.007</td>
</tr>
<tr>
<td>Group 3</td>
<td>≥ 7 yrs</td>
<td>1</td>
<td>0.256</td>
</tr>
</tbody>
</table>
2) Speech Perception according to Time Interval of Bilateral CIs

Postoperative 6 months

RESULTS

2) Speech Perception according to Time Interval of Bilateral CIs

Postoperative 6 months

Results show the ratio of the 2nd CI score to the 1st CI score for three groups based on the time interval between the two implantations:

- **Group 1**: interval < 4 years
- **Group 2**: 4 years ≤ interval < 7 years
- **Group 3**: 7 years ≤ interval < 10 years

The statistical significance for each category is as follows:

- **Monosyllabic word**: $p = 0.453$
- **Bisyllabic word**: $p = 0.305$
- **Sentences**: $p = 0.139$

The graph illustrates the ratio of scores for each group, with error bars indicating variability.
2) Speech Perception according to Time Interval of Bilateral CIs

Postoperative 12 months

- **Group 1 (interval < 4 yrs)**
- **Group 2 (4 yrs ≤ interval < 7 yrs)**
- **Group 3 (7 yrs ≤ interval < 10 yrs)**

- **Ratio of 2nd CI score / 1st CI score**
  - *p* = .222
  - *p* = .254
  - *p* = .205

- **Monosyllabic word**
- **Bisyllabic word**
- **Sentences**
1) The comparison of speech perception between the 1\textsuperscript{st} and 2\textsuperscript{nd} CI showed similar results in monosyllabic, bisyllabic word and sentence scores.

2) According to time interval of the two sequential surgeries, speech perception scores were significantly higher in group 1 with short intervals compared to group 3 with long intervals in post-operative 3 months. However, no significant differences were observed by the time of post-operative 6 months.
Part II.

Functional Listening performance of Children with Sequential Bilateral CI in Daily Life
**INTRODUCTION**

- The benefits of **binaural hearing** include **better understanding of speech in noise** and **localization of sound sources.**
  
  *(Tyler, 2002)*

- Benefits of **bilateral CI** in the short term are clearest in children with limited delays *(< 12mons)* between implantations.

  *(Gordon, 2009)*

- Children who receive their **2nd CI at 8 - 12 years** of age do **not acquire the same speech perception ability** achieved by younger children.

  *(Peters, 2007)*
Children who had been unilaterally stimulated with a CI from an early in life (mean: 2.3 yrs) could achieve improved speech performance of the 2^{nd} implanted ear within 1 or 2 years after the 2^{nd} CI with a long inter-stage delay of 5 years. 

(Manrique, 2007)

Speech-recognition scores obtained with CI-2, and the extent to which it differs from CI-1, are most closely related with inconsistent use of CI-2 in pediatric sequential implantees.

(Fitzgerald, 2013)

Subjective assessment of hearing ability in everyday life complements more objective forms of evaluation.

(Galvin, 2013)
PURPOSE

1. To evaluate **device usage habits** among the patients with sequential bilateral CI, and identify the **factors that affect their adaptation** of listening ability & device use.

2. To analyze the **difference in improvement of listening skills** by different inter-implant intervals in sequential bilateral CI using daily life listening evaluation.
1) Subjects

Ajou University School of Medicine, Department of Otolaryngology

- **Period:** March, 2004 – June, 2017
- **Patients:** who received both CIs in our hospital (n=69 patients)
- **Inclusion criteria (n=38 patients)**
  - underwent sequential CIs
  - use of both CIs ≥ 12months
  - use of 2\textsuperscript{nd} CIs ≥ 3months
  - communication mode : Verbal

Table 1. Demographics

<table>
<thead>
<tr>
<th></th>
<th>Current Age</th>
<th>Age at 1\textsuperscript{st} CI</th>
<th>Age at 2\textsuperscript{nd} CI</th>
<th>Interval of 1\textsuperscript{st} &amp; 2\textsuperscript{nd} CI</th>
<th>Use of 1\textsuperscript{st} CI</th>
<th>Use of 2\textsuperscript{nd} CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean (±SD)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current Age</td>
<td>11yr 4mon</td>
<td>3yr 4mon (± 2yr 7mon)</td>
<td>8yrs 9mon (± 4yr 8mon)</td>
<td>5yr 5mon (± 3yr 9mon)</td>
<td>8yr (± 3yr 3mon)</td>
<td>2yr 6mon (± 1yr 5mon)</td>
</tr>
<tr>
<td>Minimum</td>
<td>3yr 1mon</td>
<td>12mon</td>
<td>1yr 3mon</td>
<td>1mon</td>
<td>1yr 4mon</td>
<td>4mon</td>
</tr>
<tr>
<td>Maximum</td>
<td>23yr 8mon</td>
<td>11yr 7mon</td>
<td>21yr 8mon</td>
<td>13yr 8mon</td>
<td>15yr 8mon</td>
<td>7yr 3mon</td>
</tr>
</tbody>
</table>
Table 2. Classification according to time interval between 1st & 2nd CI

<table>
<thead>
<tr>
<th>Interval period between 1st &amp; 2nd CI</th>
<th>Group 1 Interval &lt; 4yrs</th>
<th>Group 2 4yrs ≤ interval&lt; 7yrs</th>
<th>Group 3 Interval ≥ 7yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>13</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>Current age</td>
<td>8yr 9mon (±4y 3mon)</td>
<td>9yr 10mon (±10mon)</td>
<td>15yr 4mon (±11mon)</td>
</tr>
<tr>
<td>Age at 1st CI</td>
<td>3yr 9mon (±3yr 6mon)</td>
<td>2yr 1mon (±10mon)</td>
<td>3yr 11mon (±2yr 4mon)</td>
</tr>
<tr>
<td>Age at 2nd CI</td>
<td>5yr 2mon (±3yr 10mon)</td>
<td>7y 6mon (±1y 1mon)</td>
<td>13yr 7mon (±3yr 5mon)</td>
</tr>
<tr>
<td>Interval between 1st &amp; 2nd CI</td>
<td>1yr 5mon (±1yr 2mon)</td>
<td>5yr 4mon (±1yr 1mon)</td>
<td>9yr 7mon (±2yr 3mon)</td>
</tr>
</tbody>
</table>
2) Materials & Analysis

The **Speech, Spatial, and Qualities of hearing scale** for parents of children with impaired hearing (SSQ)

3 sections, 22 questions, 0 ~10 scales, 1 : 1 interview

- **Speech perception**
  - in quiet, on the telephone, in groups and/or in noisy and reverberant environment

- **Spatial hearing**
  - the location and direction of sounds

- **Other qualities of hearing**
  - segregating and identifying sounds and listening effort

(Galvin, 2007)
1) **SSQ score** - percentage by Section

**RESULTS**

- **Speech Perception**: 67.5%
- **Spatial Hearing**: 63.2%
- **Other Qualities of hearing**: 74.2%
- **Total**: 69.0%
2) SSQ scores of **Speech Perception** by Questions

**Best!** You are talking with your child in a quiet, carpeted lounge room. Can your child follow what you’re saying?

**Worst!** Your child is in a group of about five people, sitting round a table. It is a noisy room, such as a busy restaurant or large family gathering at home. Your child cannot see everyone else in the group. Can your child follow the conversation?
3) SSQ scores of **Spatial Hearing** by Questions

**Best!** You and your child are in different rooms at home. It is quiet. If your child hears you call out their name, will he/she know where in the house you are?

**Worst!** Your child is sitting around a table with several people. Your child cannot see everyone. Can your child tell where any person is as soon as they start speaking?
4) SSQ scores of Other Qualities of hearing by Questions

Best! Can your child recognize family members or other very familiar people by the sound of each one’s voice without seeing them?

Worst! Can your child tell the difference between sounds that are somewhat similar, for example, a car versus a bus, or water boiling in a pot versus food cooking in a frying pan?
Correlations between Preoperative Hearing Status & SSQ scores in Sequential Bilateral CI

**RESULTS**

Correlations between Preoperative Hearing Status & SSQ scores in Sequential Bilateral CI

**Before 1st CI**

- 1st CI-preop ABR
  - SSQ (%)
  - 100
  - 80
  - 60
  - 40
  - 20
  - 0
  - 60
  - 70
  - 80
  - 90
  - 100
  - 110 (dB)

- R = -.177
- p > .05

**Before 2nd CI**

- 2nd CI-preop PTA
  - SSQ (%)
  - 100
  - 80
  - 60
  - 40
  - 20
  - 0
  - 70
  - 80
  - 90
  - 100
  - 110
  - 120 (dB)

- R = .187
- p > .05

(Pearson correlation coefficient)
Correlations between age of operation & SSQ scores in Sequential Bilateral CI

RESULTS

(Pearson correlation coefficient)
Correlations between inter-implant intervals & SSQ scores in Sequential Bilateral CI

\[ R = 0.133 \]
\[ p > 0.05 \]

*(Pearson correlation coefficient)*
SSQ score percentage according to time interval of CIs

RESULTS

- **Group 1** (interval < 4 yrs)
- **Group 2** (4 yrs ≤ interval < 7 yrs)
- **Group 3** (interval ≥ 7 yrs)

<table>
<thead>
<tr>
<th></th>
<th>Speech Perception</th>
<th>Spatial Hearing</th>
<th>Other Qualities of hearing</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1</strong></td>
<td>68.4%</td>
<td>65.4%</td>
<td>65.2%</td>
<td>68.5%</td>
</tr>
<tr>
<td><strong>Group 2</strong></td>
<td>62.6%</td>
<td>61.5%</td>
<td>72.2%</td>
<td>68.5%</td>
</tr>
<tr>
<td><strong>Group 3</strong></td>
<td>61.5%</td>
<td>71.4%</td>
<td>78.7%</td>
<td>71.5%</td>
</tr>
</tbody>
</table>

- **p = 0.666**
- **p = 0.724**
- **p = 0.411**
- **p = 0.686**
Correlations between CI usage period & SSQ scores in Sequential Bilateral CI

**Results**

Period of 1\textsuperscript{st} CI use

- SSQ (%) vs. SSQ (%)
- Pearson correlation coefficient: $R = 0.155, p > 0.05$

Period of 2\textsuperscript{nd} CI use

- SSQ (%) vs. SSQ (%)
- Pearson correlation coefficient: $R = 0.009, p > 0.05$

(Pearson correlation coefficient)
Device Usage Habits in Patients with Sequential Bilateral CI

- Daily Bilateral CI use: 94.7% (36pts)
- Only 1st CI use: 2.6% (1pt)
- Only 2nd CI use (none): 2.6% (1pt)
- Daily partial use of single CI: 2.6% (1pt)
Patients’ Device Preference among Children with Sequential Bilateral CI

- 42.1% (16 pts) No Preference
- 13.2% (5 pts) Prefers 1st CI
- 44.7% (17 pts) Prefers 2nd CI
Patients’ Device Preference according to inter-implant interval in Sequential Bilateral CI

Group 1
(interval < 4 yrs)

Group 2
(4 yrs ≤ interval < 7 yrs)

Group 3
(interval ≥ 7 yrs)

RESULTS

Patients’ Device Preference according to inter-implant interval in Sequential Bilateral CI

Group 1
(interval < 4 yrs)

Group 2
(4 yrs ≤ interval < 7 yrs)

Group 3
(interval ≥ 7 yrs)

No Preference
Prefers 1st CI
Prefers 2nd CI
Best Condition of Device Use (Subjective)

- 89.5% (34 pts) Bilateral CI use
- 10.5% (4 pts) Only 1st CI use
- 0% Only 2nd CI use (none)

CAP score (2nd CI only)

- 68.4% (26 pts)
- 21% (8 pts)
- 5.3% (2 pts)
- 5.3% (2 pts)
Experience of CI rehabilitation with only 2\textsuperscript{nd} CI

- Experience(-) 5.3\% (2pts)
- Experience(+) 94.7\% (36pts)

Period of CI rehabilitation with only 2\textsuperscript{nd} CI

- 1 – 3 months 55.3\%
- 4 – 6 months 23.7\%
- 6 – 12 months 15.8\%
- > 1 year 5.3\%
## Details of Patients that Prefer only 1st CI use

<table>
<thead>
<tr>
<th>Gr.</th>
<th>Site</th>
<th>Age of CI</th>
<th>Interval</th>
<th>Preop ABR</th>
<th>CI implant</th>
<th>Hearing Age</th>
<th>CAP score</th>
<th>HA</th>
<th>Re-hab.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1st</td>
<td>4y 2m</td>
<td>8y 9m</td>
<td>91.7</td>
<td>Nucleus CI24RCS</td>
<td>10y 4m</td>
<td>7</td>
<td>91%</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>2nd</td>
<td>13y 1m</td>
<td></td>
<td></td>
<td></td>
<td>1y 5m</td>
<td>6.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1st</td>
<td>8y 0m*</td>
<td>13y 9m*</td>
<td>NR</td>
<td>Nucleus CI422(SRA)</td>
<td>15y 6m</td>
<td>7</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>2nd</td>
<td>21y 8m*</td>
<td></td>
<td>NR</td>
<td>Nucleus CI422(SRA)</td>
<td>2y 0m</td>
<td>5*</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>1st</td>
<td>1y 5m</td>
<td>10y 11m*</td>
<td>NR</td>
<td>Nucleus CI24RCS</td>
<td>13y 11m</td>
<td>7</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>2nd</td>
<td>12y 4m</td>
<td></td>
<td>NR</td>
<td>Nucleus CI422(SRA)</td>
<td>3y 0m</td>
<td>4*</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>1st</td>
<td>1y 8m</td>
<td>13y 2m*</td>
<td>NR</td>
<td>Nucleus CI24RCS</td>
<td>13y 6m</td>
<td>7</td>
<td></td>
<td>No</td>
</tr>
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<td></td>
<td>2nd</td>
<td>14y 10m*</td>
<td></td>
<td>NR</td>
<td>Nucleus CI422(SRA)</td>
<td>4m*</td>
<td>2*</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>1st</td>
<td>3y 0m</td>
<td>7y 0m</td>
<td>NR</td>
<td>Clarion HiRes90K</td>
<td>11y 3m</td>
<td>7</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>2nd</td>
<td>10y 0m</td>
<td></td>
<td>NR</td>
<td>MED-EL Mi1000 +FLEX28</td>
<td>4y 3m</td>
<td>7</td>
<td></td>
<td>Yes</td>
</tr>
</tbody>
</table>
Details of Patients that Prefer only 1\textsuperscript{st} CI use  
(Subjective Opinions)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
</table>
| **S1** | • Mostly only uses 1\textsuperscript{st} CI  
• Only uses bilateral CI at public places or listening sessions  
• “Its \textit{uncomfortable} to use bilateral CI in quiet conditions because I can even hear small noises.” |
| **S2** | • “Bilateral CI helps me at school.”  
• “Most of the times it \textit{too noisy causing me a headache}.”  
• “Now, I only use the 1\textsuperscript{st} CI.” |
| **S3** | • “I \textit{only hear noise} from the 2\textsuperscript{nd} CI which disturbs the hearing of the 1\textsuperscript{st} one.” |
| **S4** | • “The sound processor of the 2\textsuperscript{nd} CI \textit{falls off a lot} which is quite uncomfortable.”  
• “I can hear much clearer from the 1\textsuperscript{st} CI.” |
Listening ability of children with only 2\textsuperscript{nd} CI
(Evaluation from \textit{Parents/Guardians})

- 1st>2nd (only sound detection): 5.3\% (2 pts)
- 1st>2nd (comprehends daily sentences): 7.9\% (3 pts)
- 1st>2nd (conversation possible): 36.8\% (14 pts)
- 1st=2nd: 26.3\% (10 pts)
- 1st<<2nd: 23.7\% (9 pts)
### Details of Patients that Prefer only 2nd CI use

<table>
<thead>
<tr>
<th>Gr.</th>
<th>Site</th>
<th>Age of CI</th>
<th>Interval</th>
<th>Preop ABR</th>
<th>CI implant</th>
<th>Hearing Age</th>
<th>CAP score</th>
<th>HA</th>
<th>Re-hab.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2</td>
<td>1st</td>
<td>3y 1m</td>
<td>3y 1m</td>
<td>90.5</td>
<td>Clarion HiRes90K</td>
<td>5y 9m</td>
<td>6.8</td>
<td>85%</td>
<td>100 %</td>
</tr>
<tr>
<td></td>
<td>2nd</td>
<td>6y 2m</td>
<td></td>
<td>89</td>
<td></td>
<td>2y 9m</td>
<td>6.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S1</td>
<td>1st</td>
<td>3y 6m</td>
<td></td>
<td>90</td>
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<td>7y 7m</td>
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1) There was no difference in improvement of daily life listening abilities between different inter-implant interval of sequential bilateral CIs.

2) Subjective listening abilities did not correlate with pre-operative hearing status, interval period between CIs, age of implantation, or the period of prior CI usage.

3) Patients tend to prefer the 1\textsuperscript{st} CI as the interval period between the CIs were longer.

4) In the group with longer inter-implant intervals, the unsatisfactory outcomes were related to unused HAs and lack of rehabilitation.

SUMMARY
CONCLUSION

- From this study, we were able to acknowledge that when the speech perception performances are good after the 1\textsuperscript{st} CI, the outcomes of the 2\textsuperscript{nd} CIs may also be excellent despite the time interval between the sequential bilateral cochlear implantations.

- In patients with long inter-implant intervals, preoperative use of HAs & postoperative rehabilitation have to be emphasized for excellent outcomes of sequential bilateral CIs.
Thank you for your attention.