Conditions for successful application of EAS in children with useful residual hearing

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SOREE EAR CLINIC

Seoul, Korea
1. Most of congenital deaf children has residual hearing even though ABR no response.

2. A period of acoustic stimulation with HA prior to cochlear implant is critical. So early fit HAs and try to auditory training prior to making a decision of CI.

3. Even if a low-frequency residual hearing remains a little, the hearing should be preserved as much as possible and the EAS should be tried.
Deaf children with ABR no response

Behavioral PTA after auditory training
Behavioral PTA after auditory training (ABR no response Pts)

- Bilateral deaf
- Age <12mo
- Total 33 ears
## Residual hearing in children with no ABR response

### Soree Ear Clinic (2013.1 ~ 2017.3)

**ABR no response vs Behavioral PTA**

<table>
<thead>
<tr>
<th>N=27(54 ears)</th>
<th>125Hz</th>
<th>250Hz</th>
<th>500Hz</th>
<th>125~500Hz Average</th>
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<tbody>
<tr>
<td>&lt;50dB</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>3 (5.6%)</td>
</tr>
<tr>
<td>50-60dB</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>6 (11.1%)</td>
</tr>
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<td>7</td>
<td></td>
<td></td>
<td>7 (13%)</td>
</tr>
<tr>
<td>70~80dB</td>
<td>5</td>
<td></td>
<td></td>
<td>9 (16.7%)</td>
</tr>
<tr>
<td>80~90dB</td>
<td>22</td>
<td>8</td>
<td>9</td>
<td>10 (18.6%)</td>
</tr>
<tr>
<td>&gt;90dB</td>
<td>0</td>
<td>21</td>
<td>28</td>
<td>16 (29.6%)</td>
</tr>
<tr>
<td>NR (Maximum level)</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3 (5.4%)</td>
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EAS trial: Postop. residual hearing (POD. ~3mo)

Gr 1.
30dB at 250Hz

Gr 2.
65dB at 250Hz

Gr 3.
90dB at 250Hz

Gr 4.
Flat type
70-85dB at <1KHz
Optimizing maps for electric acoustic stimulation users

Standard EAS: MEET mode

Extended EAS 1: (Narrow) Overlap

Extended EAS 2: Full Overlap

Non PD-EAS: Full Overlap+

Acoustic cut off

EPS: GAP mode
EAS CI in Pediatrics: Questions?

Q 1. How much benefit does EAS have when used for children with variable ranges of post-operative residual hearing?

Q 2. What conditions affect the benefits of pediatric EAS users?
### Subjects

- 11 patients (15 ears) with EAS mode in Soree Ear Clinic. (2011~2019.2)
- Unilateral EAS (7)/Bilateral EAS (4)
- Age aver. 4-10 yrs

<table>
<thead>
<tr>
<th>Electrode</th>
<th>Flex$^{28}$</th>
<th>Flex$^{24}$</th>
<th>CI422</th>
<th>CI522</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=20</td>
<td>3</td>
<td>1</td>
<td>13</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Processor</th>
<th>Duet II</th>
<th>Sonnet EAS</th>
<th>N6</th>
<th>N7</th>
<th>Kanso</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=20</td>
<td>2</td>
<td>2</td>
<td>12</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>
Methods

1) Period when tested: pre-op, 1m, 3m, 6m, 12m, 24m, 36m
2) Test condition: Pre-op HA, Electric only (without HA), EAS
3) Performance
   • Unaided / aided PTA check (In booth)
   • Speech Test
     ▪ Monosyllabic, sentence, hearing in noise test (SNR 10dB)
   • Music
     ▪ Timbre recognition, Pitch ranking test
   • Localization
     ▪ 360 degree, 8 speakers
     ▪ Percent of correct trials, Root mean square
EAS user group: PTA (postop. 1-3mo)

Children (N=15 ears)
Q 1. How much benefit does EAS have when used for children with variable ranges of post-operative residual hearing?

Speech in quiet & noise, Music appreciation, Localization
Fig. 1. Word recognition at 6mo after EAS fitting
Fig. 2, Sentence in quiet at 6mo after EAS fitting
Fig. 3, Sentence in noise at 6mo after EAS fitting
Fig. 4, music

Pitch Ranking Test (PRT)

Timbre Recognition (%)

- TR(%) HA
- TR(%) E only
- TR(%) EAS

Pitch Ranking Test (%)

- PRT(%) HA
- PRT(%) E only
- PRT(%) EAS
speech benefit(+) → Music benefit ?

Child(N=7)

music benefit(+) 7 /7case
speech benefit(-) → Music benefit?

Child (N=2)

C18 KYC

music benefit (+)

1 case

C16 KJW

music benefit (-)

1 case
Fig. 5. Localization (PCT) benefit or not

EAS vs CI

Child (N=7)

Benefit(+): 4

*EAS benefit
Follow-up

The stability of RH preservation
# RH preservation in children group (POD#1mo)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Complete HP</th>
<th>Partial HP</th>
<th>Minimal HP</th>
<th>No hearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of residual hearing</td>
<td>95%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>preserved</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;75%</td>
<td>7 (35%)</td>
<td>12 (60%)</td>
<td>1 (5%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>&gt;25–75%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1–25%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No measurable hearing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N = 14 (20 ears)
## RH preservation in children group (POD#6mo)

### Percent of residual hearing preserved

<table>
<thead>
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<th>Complete HP</th>
<th>Partial HP</th>
<th>Minimal HP</th>
<th>No hearing</th>
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</thead>
<tbody>
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<td>&gt;75% Complete HP</td>
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<td>10 (55.5%)</td>
<td>3 (16.6%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>&gt;25–75% Partial HP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1–25% Minimal HP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No measurable hearing</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</table>

N = 12 (18 ears)

**HP rate**

- Complete HP: 5 (27.7%)
- Partial HP: 10 (55.5%)
- Minimal HP: 3 (16.6%)
- No Hearing: 0 (0%)

- **Percent of residual hearing preserved**: 83.2%
Follow-up

**children**

**Calculated HP**

- HP Overtime
  - Pre-op: 100
  - 1m: 54
  - 3m: 59
  - 6m: 51
  - 1Y: 53
  - 2Y: 52
  - 3Y: 53
  - 4Y: 48

**HP overtime**
- Pre-op: 100
- 1m: N=9
- 3m: N=9
- 6m: N=9
- 1Y: N=9
- 2Y: N=9
- 3Y: N=9
- 4Y: N=9
Long-term speech perception

monosyllable word

Sentence
Long-term music appreciation (Timbre Recognition)

Progress on Timbre Recognition

- Pre-op
- 3M
- 6M
- 1Y
- 2Y
- 3Y
- 4Y
- 5Y
- 6Y

- C2
- C3
- C5
- C6
- C7
- C8
- C9
- C10
- C11
- C12
- C13
- C16
Most of the subjects preferred to use amplified acoustic sound, in which EAS mode was better than CI only mode in one or more parameters in speech, directionality, and music appreciation.

In some cases, there are also music benefit in the case of residual hearing, which is difficult to show speech benefit.

After a long period of time, the remaining hearing was well preserved, and the EAS benefit was well maintained.
Q 2. What conditions affect the benefits of pediatric EAS users?
Result:
Speech understanding benefit (N=15)

Speech benefit (+) 13 case
*Speech benefit (-) 2 case
No speech benefit:
Case #1 (Cochlear Kanso + BTE HA)

<table>
<thead>
<tr>
<th>CI OP age</th>
<th>Pre-CI HA use</th>
<th>Parent support</th>
<th>Postop. Hearing change(Lt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 yo</td>
<td>Full time</td>
<td>limited</td>
<td>++</td>
</tr>
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Aural preference: Rt

HA(+++)

HA(+-)

EAS(-)

Pre-CI

Post-CI
* No speech benefit : Case 2.(Cochlear N6)

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<thead>
<tr>
<th>CI OP age</th>
<th>HA information</th>
<th>Parent support</th>
<th>Postop. Residual Hearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>10yro</td>
<td>Pre-CI HA use</td>
<td>Using time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>+/-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>low</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>+/-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>++</td>
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</table>
In all cases where EAS use showed no speech benefits, there was no or limited use of pre-operative HA, the amount of residual hearing, and lacked parent's understanding of using cochlear implant and HA together.
Conclusion

• Our experiences of pediatric EAS trials showed that EAS could give a significant benefit to congenital deaf children with residual hearing at lower frequencies just like to adult EAS.

• Especially, early hearing rehabilitation through hearing aids prior to CI is also essential for successful EAS use.
Suggestion:
Functional residual hearing for EAS possible in children

Try EAS as possible!
<Acknowledgement>

Medical Doctors (Otolologist, M.D) :
CS Kim, KS Lee, YM Chun,
YR Shin, SC Bae, YS Kang

Audiology Specialists (Audiologists) :
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CI Mapping & auditory training team, Pediatric audiologists,
Vestibular rehabilitation team
JM Kim, JY Kim, JH Kim,
HR Jeong, NR Kim, YJ Lee
HN Kim, EH Lim, SJ Kim, DS Yu,
MJ Kong, KY Yoon, YJ Kim, EC Shin
MS Ahn, SY Kang, YI Cho

Speech Language Pathologists
HR Kwon, YK Kim, SW Shin,
SH Jeong, EH Yang, YJ Eom

Music therapists :
EY Lee, YBN Lee,
HN Kim

Thanks for your attention!