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Single Sided Deafness and Asymmetric Hearing Loss in Adults and Children

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Medical Center - University of Freiburg, Germany

ENT Dept. and Implant Centrum Freiburg (ICF)

- CI, ABI, implantable hearing aids
- Re-habilitation and long time rehab
- ~250 CI surgeries/yr
- >3000 CI patients
- adults and children incl. SSD

- Interdisciplinary team: ENT, audiologists, speech therapists, psychologists, music therapists, engineers
Learner Outcomes

1) identify the different treatment options for single sided deafness (SSD).

2) differentiate the indication for CROS/BiCROS and cochlear implant (CI) surgery in adults with single-sided deafness and asymmetric hearing loss.

3) explain considerations for pre-evaluation for a cochlear implant in children with congenital single-sided deafness.

Topics

- General information
- Treatment options
- Freiburg SSD/AHL study

Results with:

1. Bilateral Contralateral Routing of Signal Hearing Aids (Bi-/CROS)
2. Osseointegrated Bone Conduction Hearing Implants (BCI)
3. Cochlear Implants in adults
   1. Rehabilitation results and comparison to other treatment options
   2. Comparison of rehabilitation results depending on duration of deafness > vs. < 10 years
4. Cochlear Implants in children

- CI patients’ compliance regarding speech processor use
Common complaints of patients with unilateral deafness

- 70-93%: high degree of difficulties in hearing in background noise (Coletti et al. 1988; Ruscetta et al. 2005; Priwin et al. 2007; Wie et al. 2010)

- Difficulties in localization (Wie et al. 2010, Hol et al. 2010, Flynn et al. 2010)

- 54-84%: tinnitus (Quaranta et al. 2004; Priwin et al. 2007; Wie et al. 2010)

- Frequent headaches, stress, fatigue (Borton et al. 2010, Wie et al. 2010)

- Social isolation, psychological problems (Borton et al. 2010, Wie et al. 2010)

Special problems in children with unilateral deafness

- 12-41%: need of additional educational assistance (Bess & Tharpe 1986; Bovo et al. 1988)

- Increased need for speech therapy in comparison to their normal-hearing peers (Lieu et al., 2010, 2012)

- 22-35%: increased rate of grade failures (Bess and Tharpe 1988; Brockhauser et al. 1991; Cho Lieu et al. 2004)

- Low self-esteem and increased fatigue; negative affect on academic success of children (Kuppler 2013)
Effects of 2 ears on Normal Hearing

“The physiologic advantage of having 2 normally hearing ears can be summarized as:
• binaural summation,
• binaural release from masking
• and the head shadow effect. “


Binaural summation/redundancy

True Binaural hearing!
Double at look at the same sound
2-3 dB increase in loudness
Binaural squelch

True binaural hearing!
Helps separate sounds into auditory components
Average effect of 2dB improvement on hearing threshold.

Head diffraction /Shadow

A physical effect
speech and noise signals are separated spatially

The magnitude of the head diffraction effect is up to 17dB interaural difference
Impact of deafness in one ear

• The headshadow effect cannot be overcome.
  • Decrease in sound level up to 17 dB, especially for high frequencies presented to the deafened side

• Binaural hearing cues are simply not available!

• Daily hearing difficulties
  • for understanding speech in noise
  • for localisation of sound

Treatment options
Rehabilitation in patients with SSD/AHL 1

**Treatment options**

- **Contralateral Routing of Signals ((Bi)CROS)-Hearing aids**
  - Advantage: non invasive, no artefacts in MRI examination
  - Disadvantage: occlusion of the better ear, no binaural hearing, no prevention of unilateral auditory deprivation

- **Percutaneous osseointegrated Bone Conduction hearing Implants (BCI)**
  - Advantage: minimally invasive, in local anesthesia, minimal artefacts in MRI
  - Disadvantage: wound infection, no binaural hearing, no prevention of unilateral auditory deprivation

Rehabilitation in patients with SSD/AHL 3

**Treatment options**

- **Cochlear Implant**
  - Advantage: binaural hearing possible, intact skin (transcutaneous), no (further) deprivation of auditory pathway
  - Disadvantage: invasive, rehabilitation, excessive artefact in MRI
Freiburg study of the treatment options in adult patients with SSD/AHL

Aim:
- Recommendation and selection of treatment options on the basis of objective and subjective evaluations
- Comparison of the results after 12 months device use

- Evaluation schedule
  - Unaided test
  - Aided test after 3-week trial period with Bi-/CROS HA (Phonak CROS)
  - Aided test after 3-week trial period with BCI mounted on head band

- CI recommendation if patients meet CI inclusion criteria
  - Duration of deafness ≤ 10 years (for the first 20 patients), then increased during course of study, (range: 4 - 480 mths)
  - Intact auditory nerve, patent cochlea

Comparison of objective and subjective benefit with chosen device after 12 months of device use

- Objective evaluations:
  - Speech discrimination in noise
  - Localization ability

- Subjective evaluation:
  - Speech, Spatial & Qualities of Hearing Scale (SSQ)
    (Gatehouse and Noble, 2004)
Methods: Speech recognition in noise

Presentation conditions

<table>
<thead>
<tr>
<th>SsdNnh</th>
<th>SN0N0</th>
<th>SnhNsd</th>
</tr>
</thead>
<tbody>
<tr>
<td>speech</td>
<td>noise</td>
<td>SNR 0 dB</td>
</tr>
<tr>
<td>-45°</td>
<td>0°</td>
<td>45°</td>
</tr>
<tr>
<td>ssd</td>
<td>nh</td>
<td>speech (S) and noise (N)</td>
</tr>
<tr>
<td>ssd</td>
<td>nh</td>
<td>noise</td>
</tr>
</tbody>
</table>

ssd: single-sided deaf ear, nh: normal hearing ear

Test

- HSM sentence test (Hochmaier-Desoyer et al. 1997):
  - sentences and CCITT noise at 65 dB SPL → SNR 0 dB
  - adaptive OISa sentences in noise: SNR @ 50%

Methods: Sound localisation

Setup

Stimuli

- sentences of OISa (Wagener et al. 1999)
- mean sound pressure level: 65 dB SPL
- level randomization: ± 6 dB
- outcome measure: localisation error / °
Impairment of unilateral deafness

- Hearing Handicap Inventory for Elderly (HHIE): short version

- 108 adults with SSD (2007-2012)
  - mean age: 45.92 yrs
  - mean duration of deafness: 10.31 yrs (1 month – 47.6 yrs)

<table>
<thead>
<tr>
<th>points</th>
<th>Level of handicap</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-8 pts.</td>
<td>no handicap</td>
<td>10</td>
</tr>
<tr>
<td>10-24 pts.</td>
<td>mild to moderate handicap</td>
<td>41</td>
</tr>
<tr>
<td>26-40 pts.</td>
<td>significant handicap</td>
<td>57</td>
</tr>
</tbody>
</table>

Freiburg study of the treatment options in adult patients with SSD/AHL

Impairment of unilateral deafness according to device decision

- Highest impairment in patients with decision for BCI and CI
- Lowest impairment: decision for CROS HA or nothing
Results: Cause of deafness and decision of SSD/AHL patients after test trials

Cause of deafness: 269 adult patients

<table>
<thead>
<tr>
<th>Cause of deafness</th>
<th>Number of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sudden hearing loss</td>
<td>103</td>
</tr>
<tr>
<td>Labyrinthitis</td>
<td>27</td>
</tr>
<tr>
<td>Acoustic trauma</td>
<td>13</td>
</tr>
<tr>
<td>Ear surgery</td>
<td>21</td>
</tr>
<tr>
<td>Otosclerosis</td>
<td>16</td>
</tr>
<tr>
<td>Otospongiosa</td>
<td>29</td>
</tr>
<tr>
<td>Childhood</td>
<td>16</td>
</tr>
</tbody>
</table>

Patients decision after test trials and counseling:

<table>
<thead>
<tr>
<th>CROS</th>
<th>BCI</th>
<th>CI</th>
<th>nothing</th>
<th>unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>19</td>
<td>130</td>
<td>68</td>
<td>16</td>
</tr>
</tbody>
</table>

Mean duration of deafness/month:
- 142 months (1-571)
- 143 months (5-480)
- 67 months (1-600)
- 235 months (2-840)
- 194 months (2-596)

Age/yrs:
- 53 years (29-78)
- 52 years (25-73)
- 52 years (23-80)
- 52 years (20-80)
- 52 years (20-80)
- 45 years (23-65)

Binaural benefits with conventional CROS HA?

n=7 adults; 12 months device experience; HSM sentence test, localization

- significant improvement of speech recognition in only one configuration representing the head shadow effect
- deterioration of speech SR when noise presented to poorer ear (n.s.)
Binaural benefits with percutaneous bone conduction implants?
n=17 adults; 12 months device experience; HSM sentence test, localization

- significant improvement of speech recognition in one configuration representing the head shadow effect

CI in SSD and AHL-patients:
Definition of SSD/ AHL; Demographics of patients
- Patients were assigned to two groups with respect to the pure tone audiometric hearing ability in their better-hearing ear

<table>
<thead>
<tr>
<th>single sided deafness (SSD)</th>
<th>asymmetric hearing loss (AHL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HL up to 4 kHz ≤ 30 dB</td>
<td>HL up to 4 kHz ≤ 60 dB</td>
</tr>
<tr>
<td>criterion of asymmetry:</td>
<td></td>
</tr>
<tr>
<td>PTA4 of poorer ear - PTA4 of better ear ≥ 30 dB</td>
<td></td>
</tr>
</tbody>
</table>

- n = 48 (SSD patients)
- n=40 (AHL patients)
- Mean deafness duration (range) / months
  - 18 (1 - 408)
  - 40 (4 - 480)
CI in SSD and AHL-patients:

pure tone audiometric data

**SSD-patients (n=48)  AHL-patients (n=40)**

---

Binaural benefits with CI in SSD patients?

n=48 adults; 12 months device experience; OLSa, localization

- significant improvement with CI in two speech in noise situations representing the head shadow and summation effect
- significant improvement with CI in localisation compared to unaided

---
Binaural benefits with CI in AHL patients?
n=40 adults; 12 months device experience; OISa, localization, measurement
binaural with hearing aid on better ear

- significant improvement with CI in two speech in noise configurations representing
  the head shadow effect and squelch effect
- significant improvement with CI in localisation compared to unaided

SSQ in SSD and AHL patients
SSD, n= 48  
AHL, n= 40

Arndt et al. 2016 [Epub ahead of print].
Comparison of the different treatment options

Unaided vs. CROS-test vs. BCI-test vs. CI (12 months)

21 adult SSD patients with acquired hearing loss
Unaided vs. CROS-test vs. BCI-test vs. CI (12 months)

21 adult SSD patients with acquired hearing loss

- with CROS and BCI significant superior results (blue brackets) vs. unaided in only one speech in noise condition
- CROS and BCI reduce SNR in one condition (blue brackets), no improvement in localization

<table>
<thead>
<tr>
<th>Monaural</th>
<th>CROS</th>
<th>BCI</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>SssdNnh</td>
<td>S0N0</td>
<td>SnhNssd</td>
<td></td>
</tr>
</tbody>
</table>

localization error

Unaided vs. CROS-test vs. BCI-test vs. CI (12 months)

21 adult SSD patients with acquired hearing loss

- with CROS and BCI significant superior results (blue brackets) vs. unaided in only one speech in noise condition
- CROS and BCI reduce SNR in one condition, no improvement in localization
- with CI significant superior results (red brackets) in all SR conditions in noise compared to all treatment options and localization
- CI is the only option to increase the SNR in all conditions due to (partial) restitution of binaural hearing
17 adult AHL patients

- Significant superior results with CI in all conditions compared to all treatment options but not for SssdNnh compared to Bi-CROS (red brackets)
- Benefit with CROS and BCI vs. unaided in only one speech in noise condition (blue brackets)
- Significant difference between BCI and Bi-CROS

Influence of duration of deafness on binaural benefit?
Comparison of benefit of CI treatment compared to the untreated condition depending on duration of deafness

<table>
<thead>
<tr>
<th>Total number of patients</th>
<th>SSD n=48</th>
<th>AHL n=40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of deafness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 10 years</td>
<td>44</td>
<td>29</td>
</tr>
<tr>
<td>&gt; 10 years</td>
<td>4 (10 - 34)</td>
<td>11 (10 - 40)</td>
</tr>
<tr>
<td>Statistical calculation</td>
<td>no</td>
<td>yes</td>
</tr>
</tbody>
</table>

(Mann-Whitney-U-Tests for unpaired samples)

Comparison of SR results according to deafness duration in AHL patients: < 10 yrs vs. > 10 yrs

\[
\text{benefit} = \text{aided} - \text{unaided}
\]

- No significant difference in the benefits for SR and localization after 12 months with CI vs. preoperative monaural results between long-term deaf patients and patients with shorter deafness duration.

\[
\begin{align*}
\text{SRT} / \text{dB SNR} & \quad \text{Localization} \\
5.0 \text{ dB vs.} 4.2 \text{ dB} & \quad 23.14^* \quad \text{vs.} \quad 21.86^* \\
0.8 \text{ dB vs.} 0.7 \text{ dB} & \quad \text{n.s.} \\
0.4 \text{ dB vs.} 0.9 \text{ dB} & \quad \text{n.s.}
\end{align*}
\]
Summary: **Treatment of SSD/AHL in Adults**

- Cochlear implantation treatment is significantly superior to alternative therapy options (Bi-/CROS and BCI) in terms of speech comprehension in background noise and sound localization.

- Cochlear implantation treatment represents an appropriate option for rehabilitation of binaural hearing in patients with SSD and AHL.

- In acquired deafness, cochlear implantation is indicated with corresponding positive pre-therapeutic diagnostics, regardless of the duration of deafness.

- Bi-/CROS and bone conduction implants are alternative options in patients who do not meet CI candidacy criteria. Counseling of potentially limited improvement in speech comprehension in noise and localization is necessary.

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**Cochlear implantation in SSD/AHL Children**
Freiburg study of CI treatment in SSD/AHL Children

Pre-examination in SSD

- Subjective (paed)audiometry comprising thresholds, SR of monosyllables, sentences in quiet and noise (if measurable in respect to age)
- Objective audiometry including ABR thresholds, ABR latencies, electrocochleography
- HR-CT and MRI
- Neuropediatric examination, if other developmental disorders are known or suspected

Extensive counselling with regard to

- Ramifications for daily life (localization, SR in noise)
- Availability of BCI /(BI)-CROS and other assistive technologies
- Necessity for participation in a mandatory re-habilitation phase

Freiburg study of CI treatment in SSD/AHL Children

Audiometric tests

- Tests according to the children’s age difficult to compare the results
- Speech tests in children (Mainz -, Göttingen speech test, Oldenburg sentence test for children: OlKiSa)
- If possible: OlSa for adults in 3 test conditions with background noise
- Categories of auditory performance (CAP; Archbold et al. 1998)
- CI-usage time indicates potential benefit in children.

Subjective evaluation

- For children younger than 9 years: Child self-report and a parent report using the adapted SSQ-version for children and parents (Galvin 2007)
- For children older than 9 years: adult version of the SSQ originally developed by Gatehouse and Noble
Cause of deafness of all SSD/AHL pre-Evaluations
n=60 children

Children with acquired SSD/AHL n=28

Children with congenital SSD/AHL n=32

Cochlear nerve hypo-/aplasia; n= 18

Cochlear implant indications in SSD/AHL-children

<table>
<thead>
<tr>
<th></th>
<th>Congenital SSD/AHL (PE: n=32)</th>
<th>Acquired SSD/AHL (PE: n=28)</th>
</tr>
</thead>
<tbody>
<tr>
<td>number of indicated CI's</td>
<td>11</td>
<td>28</td>
</tr>
<tr>
<td>number of CI surgeries</td>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>age at surgery/years</td>
<td>5.7 (1.5 – 13.8)</td>
<td>11.1 (5.7-17.9)</td>
</tr>
<tr>
<td>duration of deafness/years</td>
<td>5.7 (1.5 – 13.8)</td>
<td>2.4 (0.3-10)</td>
</tr>
</tbody>
</table>
Results: **acquired SSD/AHL in children**
CI-OP: 24 children; results 12 months post-activation: OISa (n=10); OIKiSa (n=4)

- results comparable to adult CI patients with acquired SSD

---

> Speech recognition OISa (n=10)

> Localization (n=10)

- significant improvement in all subscores of child and parent version of SSQ
- **Use of CI all day long in all children!!**
Different situation in congenital SSD children

- The development of auditory pathways is determined by neural plasticity and needs auditory input
- asymmetric hearing influences brainstem development and poses hurdles for the realization of true binaural processing

It is still unclear in congenital SSD

- whether the normal hearing ear sustains the formation of pathways at least partially
- or if the extensive asymmetry accelerates lateral inhibition and reduces the window for successful intervention

Assumption

- age for cochlear implantation in children with asymmetric hearing loss would not differ much from those with bilateral hearing loss

Overview: congenital SSD in children

<table>
<thead>
<tr>
<th>Child</th>
<th>age @ diagnosis (year; month)</th>
<th>age @ surgery (year; month)</th>
<th>Etiology</th>
<th>BERA threshold (SSD ear, dB)</th>
<th>BERA threshold (better ear, dB)</th>
<th>education</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NHS 1;10</td>
<td>CMV &gt;90</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>NHS 1;9</td>
<td>unknown &gt;90</td>
<td></td>
<td></td>
<td></td>
<td>kindergarten</td>
</tr>
<tr>
<td>3</td>
<td>NHS 3;0</td>
<td>hypoxia &gt;90</td>
<td></td>
<td></td>
<td>30</td>
<td>kindergarten</td>
</tr>
<tr>
<td>4</td>
<td>2;6</td>
<td>3;2</td>
<td>CMV &gt;90</td>
<td></td>
<td>20</td>
<td>kindergarten</td>
</tr>
<tr>
<td>5</td>
<td>NHS 4;0</td>
<td>unknown &gt;90</td>
<td></td>
<td></td>
<td>20</td>
<td>kindergarten</td>
</tr>
<tr>
<td>6</td>
<td>NHS 4;4</td>
<td>CMV &gt;90</td>
<td></td>
<td></td>
<td>20</td>
<td>kindergarten</td>
</tr>
<tr>
<td>7</td>
<td>NHS 4;8</td>
<td>EVA &gt;90</td>
<td></td>
<td></td>
<td>20</td>
<td>kindergarten</td>
</tr>
<tr>
<td>8</td>
<td>NHS 5;2</td>
<td>unknown &gt;90</td>
<td></td>
<td></td>
<td>20</td>
<td>kindergarten</td>
</tr>
<tr>
<td>9</td>
<td>4;5</td>
<td>6;8</td>
<td>ototoxic  &gt;90</td>
<td></td>
<td>20</td>
<td>school</td>
</tr>
<tr>
<td>10</td>
<td>0;4</td>
<td>13;10</td>
<td>CMV &gt;90</td>
<td></td>
<td>20</td>
<td>school</td>
</tr>
</tbody>
</table>
# Results I

<table>
<thead>
<tr>
<th>Child</th>
<th>Age (y/m)</th>
<th>Time after 1st fitting (y/m)</th>
<th>CI-usage</th>
<th>CAP</th>
<th>Speech test @ 65 dB</th>
<th>Speech comprehension with CI only</th>
<th>Subjective evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2;1</td>
<td>1.0</td>
<td>all day</td>
<td>-</td>
<td>too young</td>
<td>-</td>
<td>Delayed general and motor development</td>
</tr>
<tr>
<td>2</td>
<td>2;7</td>
<td>1.0</td>
<td>all day</td>
<td>3</td>
<td>Mainzer I</td>
<td>100%</td>
<td>Repeats words and imitates sound heard by CI only</td>
</tr>
<tr>
<td>3</td>
<td>3;4</td>
<td>0.6</td>
<td>all day</td>
<td>-</td>
<td>Mainzer I</td>
<td>60%</td>
<td>Repositions transmission coil, shows localization</td>
</tr>
<tr>
<td>4</td>
<td>5;1</td>
<td>2.0</td>
<td>all day</td>
<td>5</td>
<td>Göttinger II</td>
<td>80%</td>
<td>Describes hearing with CI similar to unimpeded ear</td>
</tr>
<tr>
<td>5</td>
<td>5;0</td>
<td>1.0</td>
<td>all day</td>
<td>5</td>
<td>Göttinger II</td>
<td>70%</td>
<td>Asks for speech processor, immediate feedback when batteries are empty</td>
</tr>
<tr>
<td>6</td>
<td>7;8</td>
<td>3;6</td>
<td>non-user</td>
<td>3</td>
<td>Göttinger II</td>
<td>0%</td>
<td>No speech discrimination with CI only, non-user</td>
</tr>
<tr>
<td>7</td>
<td>5;2</td>
<td>0.6</td>
<td>all day</td>
<td>5</td>
<td>Göttinger II</td>
<td>0%</td>
<td>Improved speech discrimination, localization improved</td>
</tr>
<tr>
<td>8</td>
<td>5;9</td>
<td>0.6</td>
<td>all day</td>
<td>5</td>
<td>Göttinger II</td>
<td>0%</td>
<td>Mainstream school planned</td>
</tr>
<tr>
<td>9</td>
<td>7;5</td>
<td>0.6</td>
<td>all day</td>
<td>5</td>
<td>Freiburg monosyl.</td>
<td>20%</td>
<td>Checks status, changes batteries</td>
</tr>
<tr>
<td>10</td>
<td>15;2</td>
<td>2.0</td>
<td>school</td>
<td>5</td>
<td>Freiburger monosyl.</td>
<td>0%</td>
<td>Focus on contralateral side, tendency towards non-use</td>
</tr>
</tbody>
</table>

## Treatment of SSD/AHL in Children

### Acquired SSD/AHL
- Comparable results to adult CI patients with acquired SSD/AHL

![CI: Favourable treatment option for this special group of SSD children, as it is the only opportunity to restore binaural hearing abilities](image)

### Congenital SSD/AHL
- Anatomy should be evaluated with caution: app. 60% aplasia of the auditory nerve
- Limited results in children > age 4 yrs (as a result of their CMV infection in 2 children?)
- Promising results in children with implantation before age of 4 yrs
- Outcomes of auditory habilitation with CI vary significantly

![Intensive counseling of parents and patients is indispensable!](image)  

### CROS hearing:
- Decrease of SNR in most conditions, difficult for the child during speech development - indicated in school aged children (age > 12 yrs), preferable digital FM-systems (also in combination with CI!!)
Speech processor usage in SSD/AHL patients

- Daily usage is a measure of treatment success!
- Does daily usage time differ comparing SSD/AHL CI patients to bilateral impaired unilateral & bilateral CI-users?
- Use of data logging with Nucleus 6 CP910 & CP920 speech processors enables the recording of time on air and environmental conditions in: Music, Wind, Speech-in-noise, Speech, Quiet, and Noise.
- Matched pair subgroups from larger patient pool: 4/27 SSD vs. 11/114 unilateral vs 13/65 bilateral CI users

<table>
<thead>
<tr>
<th>Matched CI Subgroup</th>
<th>Age range (yrs)</th>
<th>SSD/AHL (n=27)</th>
<th>Unilateral (n=114)</th>
<th>Bilateral (n=65)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0-8</td>
<td>4</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>&gt;8-18</td>
<td>2</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>&gt;18-65</td>
<td>17</td>
<td>49</td>
<td>32</td>
</tr>
<tr>
<td>4</td>
<td>&gt;65</td>
<td>4</td>
<td>45</td>
<td>14</td>
</tr>
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</table>
Speech processor usage in SSD/AHL patients

Time on air

- SSD-patients are on average over all age groups 34.9% on air = 8.5 hours/ day (7.3% shorter than uni- or bilateral CI users = 10 hours/ day)
- Age group 3 (age 19-65 yrs): SSD patients significantly shorter time on air compared to unilateral and bilateral CI-patients

Noise environment

- No significant differences between SSD CI users vs. unilateral and bilateral CI users between all environmental conditions
Summary: **Speech processor usage**

- Overall: significantly longer sound processor usage in bilateral CI-users compared to SSD/AHL.
- No significant difference in noise environments between subgroups.
- Speech processor usage in CI-SSD/AHL patients is for age group 3 (19-65 yrs) significantly shorter compared to unilateral and bilateral CI-users.
- Results are expected, since we assume that bilateral profoundly deaf CI users rely more on their CIs than SSD/AHL-patients need to.
- CI-SSD/AHL patients use their CI more than 8 h per day:

  Huge subjective benefit in SSD patients and successful treatment!

### Summary I: general indication for CI in SSD

*Cause of deafness with no indication for CI surgery*

- **No indication**
  - cochlear nerve hypo-/aplasia
  - cochlear obliteration
  - complex malformation

- **Considerable indication**
  - mild malformation
  - negative promontorial test
  - loss of vestibular function on contralateral side
  - intralabyrinthine schwannoma
Summary II: Patient selection

Most important:

• Extensive counseling of the patients (and parents)
  • about treatment options (BCI /(BI)−CROS and other assistive technologies)
  • possible expectations esp. in difficult cases (neg. promontorial test, long duration of deafness, children etc.)
• Motivation
  • to underwent surgery
  • to participate in a mandatory re-habilitation phase!
  • to practise only the implanted ear
    • via audio input of the speech processor; occlusion of the normal hearing ear
  • Motivation for daily use (indicates potential benefit)!

Conclusion: Treatment of Single-Sided Deafness in Adults and Children

- CI in SSD/ AHL patients is a superior treatment option after positive pre-therapeutic diagnostics, independent of the duration of deafness in adults and children with acquired hearing loss.
- We still don’t know the optimal time window for favorable outcomes in children with congenital SSD - is it wider or narrower than in bilateral hearing loss?
- The presurgical counseling and motivation of the patient are an important prerequisite for success of Cochlear implantation in SSD/AHL patients.
- In all other cases (no CI-indication, refusal of CI-surgery) the Bi-/CROS and osseointegrated bone conduction systems are still an option. Counseling of limited benefit and no prevention of unilateral auditory deprivation is necessary.
Many thanks to our research team in Freiburg

Roland Laszig  Antje Aschendorff  Frederike Hassepass  Rainer Beck

Thomas Wesarg  Stefanie Kröger

ICF team