Indication and Verification of Hearing Implants for Conductive and Mixed Hearing Loss

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Auditory implants in conductive/mixed hearing loss

- If reconstructive surgery is not an option or (sub)total closure of the air-bone gap cannot be guaranteed
- If conventional hearing devices cannot be used or should not be used (aural atresia/chronic running ear) or a poor result is expected

Then, implantable hearing device, bypassing the impaired outer/middle ear, can be applied
Bone conduction devices (BCD)

Baha Attract

Sophono

Bonebridge

Active middle ear implant (MEI) with actuator coupled directly to the cochlea
Some basics: fitting hearing devices

Aim of hearing aid fitting: optimize **audibility of speech**, while environmental sounds are at acceptable levels and loud sounds are not uncomfortable (irrespective of the type of hearing loss and type of device used)

- *The ‘audibility of normal speech’, an example taken from the literature*
Speech area (speech banana) in the audiogram. Overall level of the speech is 60 dB SPL.
How are we doing; fitting implantable hearing devices in conductive-mixed hearing loss

BCD and MEI with actuator coupled to the cochlea stimulate directly the cochlea, bypassing the impaired middle ear

- So, concerning the fitting, we are dealing with the cochlear loss not the mixed loss. Consequence: we can build on our experience in fitting BTE in SNHL
Consequence: to fit hearing devices in conductive/mixed hearing loss, use the same procedures and fitting rules* as those to fit BTEs in SNHL, with the cochlear thresholds (bone-conduction) as input. Such procedures/fitting rules are based on optimizing the audibility of speech.

However, BCDs and MEI have limitations, e.g. limited gain and output, audible internal noise... in contrast to BTEs. Although great, impressive technology, thanks to the industry; in audiological terms: poor hearing devices.

* Like half-gain rule, NAL or DSL
Capacity of auditory implants for conductive/ mixed hearing loss; source of variance

Categorization based on (objective) MPO measurements

BCDs:
• Transcutaneous devices (Sophono, Baha Attract)
• Active transcutaneous device (Bonebridge)
• Percutaneous devices (Baha/Ponto)

MEI
• Middle ear implants with actuator coupled to a cochlear window
### Transcutaneous device

<table>
<thead>
<tr>
<th>Device</th>
<th>MPO dB HL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sophono 1-2</td>
<td>53</td>
</tr>
<tr>
<td>Bonebridge</td>
<td>67</td>
</tr>
<tr>
<td>Baha Attract BP110</td>
<td>63</td>
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</table>

**4 kHz, 1-2 kHz**

<table>
<thead>
<tr>
<th>Device</th>
<th>MPO dB HL</th>
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<tbody>
<tr>
<td>Baha Divino</td>
<td>69</td>
</tr>
<tr>
<td>BP110</td>
<td>74</td>
</tr>
<tr>
<td>Ponto power pro</td>
<td>78</td>
</tr>
<tr>
<td>Cordelle</td>
<td>80</td>
</tr>
</tbody>
</table>
## Summary

<table>
<thead>
<tr>
<th>Percutaneous device</th>
<th>MPO: 0.5-4 kHz, dB HL</th>
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<tr>
<td>Baha Divino</td>
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<td></td>
</tr>
<tr>
<td>BP110</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>Baha 5 super power</td>
<td>85</td>
<td></td>
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Zwartenkot et al., 2013; [www.snikimplants.nl](http://www.snikimplants.nl)
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<tr>
<th>MEI</th>
<th>MPO</th>
</tr>
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<tbody>
<tr>
<td>VSB</td>
<td>85 dB HL</td>
</tr>
</tbody>
</table>
Example: mixed loss, cochlear thresholds of 31 dB HL

\[ T: \text{discomfort levels} \]

Storey & Dillon 1998
Example: mixed loss, cochlear thresholds of 31 dB HL

S: MPO transcutaneous BCD

T: discomfort levels
Example: mixed loss, cochlear thresholds of 31 dB HL

Not used dynamic range of hearing owing to low MPO

Inaudible
Outside world

Patient’s auditory window to the world

Not used dynamic range of hearing owing to low MPO

From: Acoustic Hearing, Clinics
Outside world

Patient’s auditory window to the world

Hearing thresholds (dB HL)

Frequency (Hz)

Descriptions of hearing loss

Normal Hearing

Mild

Moderate

Severe

Profound

Baha SP5

inaudible
How ‘wide’ should the aided dynamic range of hearing be?

- Best option: 100% of the patient’s dynamic range of hearing is utilized: thus MPO equals loudness discomfort level (only possible with Codacs)

- Milder criterion (compromise): 2/3 of the dynamic range of hearing should be available, with a minimum of 35 dB (www.snikimplants.nl)
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<tr>
<th>Device</th>
<th>MPO dB HL</th>
<th>Cochlear loss (SNHL component)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sophono Alpha 1-2</td>
<td>53</td>
<td>&lt;5 dB HL</td>
</tr>
<tr>
<td>Baha Attract with BP110</td>
<td>63</td>
<td>&lt;15</td>
</tr>
<tr>
<td>Bonebridge</td>
<td>67</td>
<td>&lt;20</td>
</tr>
<tr>
<td>Baha/Ponto standard</td>
<td>67-69</td>
<td>&lt;25</td>
</tr>
<tr>
<td>BP110, Ponto power</td>
<td>74-76</td>
<td>&lt;35</td>
</tr>
<tr>
<td>Baha 5 SP</td>
<td>85</td>
<td>&lt;50</td>
</tr>
<tr>
<td>VSB</td>
<td>85</td>
<td>&lt;50</td>
</tr>
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</table>

*according to the 2/3 rule
Aided versus unaided (cochlear) thresholds

Audibility calculated word score

Cochlear hearing loss, mean 0.5, 1, 2, 4 kHz (dB HL)
Why such a large spread

• Use of devices/processor with insufficient capacity; application information provided by the companies is often not well-documented and over-enthusiastic

• Variability in fitting procedures: each company has its own fitting software that tries to optimize the outcome while minimizing/masking the limitations of the devices

• Coupling-efficiency of the actuator of MEIs is variable
Aided versus unaided (cochlear) thresholds

Obviously, the devices are not equivalents and in some studies applied ineffectively.
Why such a large spread

- Use of devices/processor with insufficient capacity; application information provided by the companies is often not well-documented and over-enthusiastic
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The fitting protocol; to be revised?

- **Companies** suggest a ‘first fit’ based on (not always) NAL or DSL or ‘one-third-rule’, however, all with a ‘company flavor’

- Therefore, fine-tuning by an experienced independent audiologist

- ✓ *To help with fitting: a new pragmatic fitting procedure was developed to optimize the audibility for all types of implantable devices, based on NAL rule*
What we did next: study the frequency-specific aided thresholds (Snik et al., 2019)

- Of the 51, 33 studies presented frequency-specific aided- and cochlear (bone-conduction) thresholds

- We studied the aided thresholds as a function of cochlear loss, per octave frequency

- According to the well-validated NAL-RP rule*, aided thresholds should be equal to approx. 0.45 times the cochlear threshold

* first-order, conservative approach assuming linear amplification
### Tool for validation of outcomes (Snik et al., 2019)

<table>
<thead>
<tr>
<th>Cochlear loss or SNHL component, dB HL at 1, 2, or 4 kHz</th>
<th>5</th>
<th>15</th>
<th>25</th>
<th>35</th>
<th>45</th>
<th>55</th>
<th>65</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target aided threshold, dB HL</td>
<td>&lt;25</td>
<td>&lt;25</td>
<td>&lt;25</td>
<td>&lt;25</td>
<td>&lt;30</td>
<td>&lt;35</td>
<td>&lt;40</td>
</tr>
</tbody>
</table>

**Conductive loss**

**Target word scores***:

<table>
<thead>
<tr>
<th>Mean cochlear loss (0.5, 1, 2, 4 kHz), dB HL</th>
<th>5</th>
<th>15</th>
<th>25</th>
<th>35</th>
<th>45</th>
<th>55</th>
<th>65</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target word score %</td>
<td>&gt;95</td>
<td>&gt;95</td>
<td>&gt;95</td>
<td>&gt;95</td>
<td>&gt;80</td>
<td>&gt;45</td>
<td>&gt;20</td>
</tr>
</tbody>
</table>

* *Using the audibility index, 10 dB/octave sloping; 5 dB above target aided thresholds*
Conclusions; auditory implants for conductive or mixed HL

- Great technology, however, MPO is a limiting factor (and gain)
- Transcutaneous BCDs should only be used in predominant conductive HL in contrast to percutaneous BCDs and VSB
- Many patients are under-amplified. Appropriate devices should be applied. Use fine tuning not just the manufacturer’s software prescriptions
  - Conclusions will change when new processors/coupling options are introduced
  - For quality purposes, implant teams should comprise an otologist and audiologist working closely together during selection and evaluation phases
Important factors for decision making

• Amplification options available nowadays are not equivalents; especially for children, choose powerful devices

• To be discussed with the parents/child during selection: reimbursement issues; burden (and invasiveness) of the surgery, possible complications, aftercare, MRI compatibility, handling and cosmetics....

• Audiological results should be leading, not cosmesis
Thank you for listening

auditory implants
Where do we stand at present?

www.snikimplants.nl

snikimplants.nl

Regularly updated, free website.
Info based on (as much as possible) objective facts.
Concerns implantable bone conductors, middle-ear implants and devices directly stimulating the cochlea (not CI).
Bimonthly, a recently published paper is discussed.

www.snikimplants.nl