Prescribing adjusting and evaluating hearing aid performance in children

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Outline

- Objective assessment of hearing in children
- Auditory Neuropathy Spectrum Disorders
  - Audiological Follow-up
- Conventional hearing aid fitting
  - Cochlear implant indications
**Objective assessment of hearing in children**

**Diagnosis Process – Hearing loss degrees**

- Hearing loss / Conventional and Implantable hearing aids

<table>
<thead>
<tr>
<th>Hearing loss</th>
<th>Degree</th>
<th>PTA mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal hearing</td>
<td></td>
<td>&lt; 20 dB HL</td>
</tr>
<tr>
<td>Mild hearing loss</td>
<td>1st degree</td>
<td>41 - 55 dB HL</td>
</tr>
<tr>
<td></td>
<td>2nd degree</td>
<td>56 - 70 dB HL</td>
</tr>
<tr>
<td>Moderate hearing loss</td>
<td>3rd degree</td>
<td>71 - 80 dB HL</td>
</tr>
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**Classification of hearing loss – PTA**

(BIAP recommendations / May 2005 - no. 02/1 bis)
Many audiological tests

• None of them fully describes the hearing status
• A battery of tests is needed
Objective diagnosis of hearing loss

• Objective assessment of hearing in small children
Objective diagnosis of hearing loss

- THE AUDIOLOGICAL PUZZLE
# Reasons for cross-check diagnosis algorithm

<table>
<thead>
<tr>
<th>Test</th>
<th>IDEAL</th>
<th>REAL</th>
</tr>
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<tbody>
<tr>
<td>OAE</td>
<td>If presents (pass)</td>
<td>- ? Auditory neuropathy spectrum disorder</td>
</tr>
<tr>
<td></td>
<td>- Normal hearing thresholds, or mild HL (&lt; 30-35 dB)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If absents (refer, Timp A)</td>
<td>- &lt; 5% of normal hearing population</td>
</tr>
<tr>
<td></td>
<td>- At least mild hearing loss</td>
<td></td>
</tr>
<tr>
<td>BERA</td>
<td>Wave V - absent at 100 dB</td>
<td>- Partial deafness</td>
</tr>
<tr>
<td></td>
<td>- Profound deafness</td>
<td>- Neural dyssynchrony</td>
</tr>
<tr>
<td>AABR</td>
<td>Pass</td>
<td>- Moderate - severe hearing loss on low frequencies</td>
</tr>
<tr>
<td></td>
<td>- Normal hearing or mild hearing loss</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Etc.</td>
</tr>
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</table>
Objective diagnosis of hearing loss
- NO SINGLE PROTOCOL -

Usual situations
- No middle ear pathology
- No malformations

Special patients
- Malformations of external or/and middle ear
- Complex malformations, including inner ear
- Fluctuating hearing
- Maturation problems

Standard protocol

Adaptative protocol
But be careful !!!

• THE MOVING HEARING !!!

• Evolutivity of hearing loss – increases the thresholds (progressive hearing loss)

• Auditory system maturation – decreases the thresholds

• Fluctuating hearing loss – unstable thresholds
Auditory Neuropathy Spectrum Disorders - ANSD -

• Auditory neuropathy

• Neural dyssynchrony

• AUDITORY NEUROPATHY SPECTRUM DISORDERS

First description
- Starr et al. – 1996 : ”auditory neuropathy”
Auditory Neuropathy Spectrum Disorders
- Audiologic assessment characteristics -

- OAE present (at least for some time)
- Abnormal or absent BERA responses
- Cochlear microphonics - present
- Mismatch BERA-ASSR-VRA
Dysfunction can be determined by:

- Corti's dysfunctions - internal ciliated cells
- Synaptic dysfunctions - neural sensory junction pathology
- Dysfunction of the auditory nerve
Auditory Neuropathy Spectrum Disorders
- With normal hearing -
Auditory Neuropathy Spectrum Disorders - With fluctuation/progressive hearing loss -
Periodically hearing assessment - 1/6 months to 3 yo, later 1 session per year

- Observing reactions to noise
- Tympanometry
- Clinical otoacoustic emissions
- BERA
- ASSR
- VRA
- PTA FF
- Vocal audiometry
- Speech evaluation

- TONAL AUDIOMETRY IN FREE FIELD
- VISUAL REINFORCED AUDIOMETRY
- VOCAL AUDIOMETRY – using simple messages
Audiological Follow-up

Periodically hearing assessment - 1/6 months to 3 yo, later 1 session per year

- Observing reactions to noise
- Tympanometry
- Clinical otoacoustic emissions
- BERA
- ASSR
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- PTA FF
- Vocal audiometry
- Speech evaluation

• The role of parents and educators !!!

• SPEECH AUDIOMETRY - the use of simple messages
• Perceiving Simple Sounds / MESSAGE UNDERSTANDING
Audiological Follow-up

- Auditory neuropathy
  - PTA/ speech audiometry: **audiological follow up +++**
  - Limited efficacy of conventional hearing instruments for language development: **speech therapist’ follow-up +++**
  - Consider cochlear implant indication
Which child is eligible for hearing aid fitting?

- Sensorineural HL: All degrees in theory
- Conductive HL: All degrees
- MIXT HEARING LOSS: All degrees
### Objective assessment of hearing in children

#### Diagnosis process – Hearing loss degree

- **Hearing loss / Conventional and Implantable hearing aids indication**

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**Classification of hearing loss – PTA**

*(BIAP recommendations / may 2005 - no. 02/1 bis)*

- Determining hearing loss in dB HL is done according to ISO standards
- The average of tonal loss in dB HL on 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz
- The loss is calculated for each individual ear
- It is also possible to calculate a global loss (for both ears)
Conventional hearing aid

• WHO IS ADDRESSED?
  • Patients with unilateral or bilateral auditory loss without any other medical or surgical options
  • AIDABLE with acceptable results
  • !!! PROFOUND HEARING LOSS

• WHAT SHOULD BE TAKEN INTO ACCOUNT?
  • Degree of deficiency
  • The type of hearing loss
  • The shape of the tonal audiometric curve
  • The shape of the voice audiometric curve (masking)
  • Local aspect of the ear, anatomy and pathology
• Follow-up/control

  • Verification of hearing aid fitting quality in the clinical phase (using measuring chain)

  • Questionnaires for parents - observational study at home

  • Logopedic evaluation

  • Profound neurosensory hearing loss
    • Mandatory hearing aid trial before cochlear implant recommendation ?
    • How long should we wait ?

Conventional hearing aid

CONVENTIONAL HEARING AIDS - considerations
**Types of conventional hearing aids**

- Conventional hearing aids
  - Air conduction hearing aids
    - Retro-auricular:
      - Behind the Ear (BTE)
      - Receiver in canal (RIC)
    - Intra-auricular

- Bone conduction hearing aids
Which type of hearing aid?

**CONVENTIONAL HEARING AIDS**
- Digital
  - Retro-auricular
  - Intra-auricular
    - In ear
    - CIC
    - microcanal
  - Bone vibrators (BC - contact)

**IMPLANTABLE HEARING AIDS**
- Passive
  - Middle ear/ossicular prostheses
- Digital Active HA
  - Middle ear implants
  - Cochlear implants
  - Bone conduction implants
  - Retrocochlear implants
Type of hearing aid depends on age

• From 0 to 6 year-old:
  • BTE with soft earmold (skull fracture might happen with rigid earmold in case of head trauma!)
  • RIC if enough room in the ear canal for the receiver
  • No intra-auricular devices which are too rigid!
  • BAHA with headband

• From 6 to 12 year-old:
  • BTE
  • RIC
  • Still no intra-auricular devices
  • BAHA with headband
Conventional BC hearing aids

- Bone conduction hearing aid
  - Mastoidian vibrator:
    - Glasses
    - Hearband BAHA
    - Ad Hear
    - Crown and sound arch
  - DEPEND ALSO ON THE AGE (bone density)
Connectivity
Which kind of earmold?

Soft Silicon (Shore hardness of maximum 30 to 40) is mandatory.
Which kind of earmold?

Earmolds must be adapted to the type and degree of hearing loss

**Standard**
- Classic
- Open-fit

**Customized**
- In ear – full shell
- Skeleton
- Intracanal
- Adaptable with RIC (receiver in canal)
- With vent
  - comfort
  - acoustic

Earmold styles

- Skeleton (Acrylic, silicone)
- Full Shell (Acrylic, silicone, soft silicone)
- Half Shell (Acrylic, silicone, soft silicone)
- Semi-Skeleton (Acrylic, silicone)
- Canal (Acrylic, silicone, soft silicone)
- Canal Lock (Acrylic, silicone)
- CBIG (Acrylic, silicone)
- Hollow Sleeve (Acrylic)
- Solid Sleeve (Acrylic, silicone, soft silicone)
- eShell (Acrylic, silicone)

General Types of Open “Molds”

- Tube Fitting
- Free-Final Mold
- Mold With Large Vent
- Fitting Tip With Multiple Large Vents
Which kind of earmold?
- Importance of venting -

Venting

- A vent is often an intentional component of a earmold/earshell
- Simply a column of air which provides a channel between the air within the ear canal and the air external to the ear canal

Open fitting

Closed fitting
Which kind of earmold?
- Importance of venting -

**Venting**
- Effects on venting on feedback -

**Venting**
- Effects on HA gain and MPO -

![Graph showing maximum insertion gain before feedback.](image1)

![Graph showing vent effect on frequency response.](image2)

*Figure 5.11 Effect of different sized vents on the frequency response of amplified sound, relative to the response with a tightly fitting earmold or earshell.*
Hearing aids can help

- Medium, severe and profound 1\textsuperscript{st} degree neurosensory hearing loss
- Medium and severe transmission hearing loss
- Moderate, severe and profound 1\textsuperscript{st} degree mixed hearing loss
  - (>41 < 90 dB HL)
  - Conventional hearing aid
    - Retroauricular – earmolds adaptation

- Medium and severe HL – good results
- Severe and profound HL – limited performance
Conventional Hearing Aids

• Efficacy of hearing aid fitting
  • Anamnesis
  • Free field tonal audiometry – for each fitted ear!!!!
  • Free field speech audiometry – adapted to the age – sometimes impossible
  • Behavioral audiometry / Visual reinforced audiometry – age related
    • Function of the speech development - exercises to indicate shapes, objects …

• In some patients – just hearing sounds can be considered as a success
Conventional Hearing Aids

• ONE OR TWO ???

• Calculation of global hearing aid performance

\[
7 \times \text{PTA mean (0.5, 1, 2, 4 KHz) on better ear} + \\
3 \times \text{PTA mean (0.5, 1, 2, 4 KHz) on worse ear} / \\
10
\]

No sound perception –120 dB lost
Conventional Hearing Aids

• Conditions:
  - The hearing aid fitting
    • For each ear which needs it
  - Only if potential development of speech production and comprehension fits conventional Hearing Aid recommendation
    • Speech audiometry – more than 60 – 70% intelligibility
    • In children – HA trial for a period with speech therapy and follow-up
    • EXCEPTIONS
Conventional Hearing Aids

- The conventional hearing aid offers the amplified sounds to the INTERNAL EAR
  - Damaged organ - possible source of distortion.
• Less than 50% of speech discrimination at 60 dB in free field with appropriate hearing aid fitting = cochlear implant indication

• Pay attention to ANSD (Neural dissynchrony)

• Conventional hearing aid indications in borderline cases must be discussed by a multidisciplinary team
Conventional Hearing Aids

- Specials fittings -

- Bimodal hearing aids

- CROS – transcranial hearing
• The mild neurosensory hearing loss at the limit with normal
  • The mild conduction hearing loss at the limit with normal
    • Not indication for hearing aids

• Mild neurosensory hearing loss
• Mild conduction hearing loss
  • (>30 dB HL)

  • Conventional hearing aid
    • Retroauricular – earmolds adaptation
Contraindications

- Contraindications
  - Local chronic infections
  - Intolerance to earmold material / allergies
- Active / relapsing suppurative infectious disease
- PRESENCE of allergies / intolerances
- External ear malformations - agenesis

- Audiological criteria / medical criteria
• Conventional hearing aids ARE NOT INDICATED
  • Cochlear implant OR electro-acoustical stimulation?
THANK YOU!