Prescribing, adjusting and evaluating hearing aid performance in children

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Objective assessment of hearing in children
Universal Neonatal Hearing Screening

Auditory Neuropathy Spectrum Disorders
Audiological post diagnosis Follow-up

Conventional hearing aid fitting
Cochlear implant indications
Objective assessment of hearing in children

• Clinical practice - What are we looking for?
  • Best practice – best results for patients
    • Correct diagnosis – for the best medical solution
    • Best possible development of hearing and speech performance
    • To avoid significant errors in: diagnosis, recommendations and rehabilitation process
## Objective assessment of hearing children
- The diagnosis Process – The Degrees of hearing loss -

- Hearing loss / Conventional and Implantable hearing aids

### Classification of hearing loss – PTA

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

<table>
<thead>
<tr>
<th>Hearing loss</th>
<th>Degree</th>
<th>PTA mean</th>
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- **PTA** (Post-Treatment Aided)

### Conventional hearing aids

- **Normal hearing**
- **Mild hearing loss**
  - 1st degree: 41 - 55 dB HL
  - 2nd degree: 56 - 70 dB HL
- **Moderate hearing loss**
  - 1st degree: 71 - 80 dB HL
  - 2nd degree: 81 - 90 dB HL
- **Severe hearing loss**
  - 1st degree: 91 - 100 dB HL
- **Profound hearing loss**
  - 1st degree: 101 - 110 dB HL
  - 2nd degree: 111 - 119 dB HL
- **Total deafness**
  - > 120 dB HL
• Many audiological tests

• None to describe completely the hearing status of the ear

• We need a battery of tests
Objective diagnosis of hearing loss
Objective diagnosis of hearing loss

- Are we waiting for their response???
EARLY DETECTION

FOLLOW-UP

EARLY INTERVENTION
Universal Neonatal Hearing Screening

- SCREENING OAE
- SCREENING BERA

- Risk factors for hearing loss
  - NICU
Objective diagnosis of hearing loss

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

- THE AUDIOLOGICAL PUZZLE
• PRACTICAL VALUE
  • Complementary tool
  • Integrity of ossicular chain
  • Elasticity/stiffness - Ossicular ankylosis

• NO CORRELATION WITH AUDITORY THRESHOLDS
  • Presence of the acoustically reflexes its more valuable than its absence.
OTOACOUSTIC EMISSIONS (OAE)

- Outer auditory hair cells are small mechanical preamplifiers which increase the cochlear energy.

- Outer hair cells (OHC) are not sensorial auditory receptors.
- OHC contract under various stimuli: acoustical or electrical.
OAE: TRANSITORY/DISTORSION PRODUCTS
BRAINSTEM EVOKED RESPONSE AUDIOMETRY (BERA) and Automated BERA
BRAINSTEM EVOKED RESPONSE AUDIOMETRY (BERA) – Automated BERA
ASSR - Auditory steady state response - Estimated audiometry
# Reasons for cross-check diagnosis algorithm

<table>
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<tr>
<th>Test</th>
<th>IDEAL</th>
<th>REAL</th>
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| **OAE** | If presents (pass)  
- Normal hearing thresholds, or mild HL (< 30-35 dB) | - ? Auditory neuropathy spectrum disorder |
| | If absents (refer, Timp A)  
- At least mild hearing loss | - < 5% of normal hearing population |
| **BERA** | Wave V - absent at 100 dB  
- Profound deafness | - Partial deafness  
- Neural dyssynchrony |
| **AABR** | Pass  
- Normal hearing or mild hear loss | - Moderate - severe hearing loss on low frequencies |

Etc.
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)
- Cochlear microphonics - present
- Abnormal or absent BERA responses
- 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

- 2008 – International Newborn Hearing Screening Conference
- Auditory Neuropathy Spectrum Disorder - ANSD
Auditory Neuropathy Spectrum Disorders
- With normal hearing -
Auditory Neuropathy Spectrum Disorders - With fluctuation/progressive hearing loss -
Audiological post diagnosis 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
- VRA
- PTA FF
- Vocal audiometry
- Speech evaluation

- TONAL AUDIOMETRY IN FREE FIELD
- VISUAL REINFORCED AUDIOMETRY
- VOCAL AUDIOMETRY – using simple messages
Periodically hearing assessment - 1/6 months to 3 yo, later 1 session per year

- Observing reactions to noise
- Tympanometry
- Clinical otoacoustic emissions
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- PTA FF
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• The role of parents and educators !!!

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

MIXT HEARING LOSS is the category that covers all degrees.
• 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?
Type of conventional hearing aid

• 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 prosthesis

**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

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

![Venting Diagram](image)

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**Open fitting**

**Closed fitting**
Which kind of earmold?

- Importance of venting -

Venting

-Effects on venting on feedback-

Venting

-Effects on HA gain and MPO-

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 1st degree neurosensory hearing loss
- Medium and severe transmission hearing loss
- Moderate, severe and profound 1st 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
Hearing aids can help

- Sensorineural HL with particular pattern

- **DIFFICULT HEARING AID FITTING**
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

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

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
Implantable Hearing Aids

- Conventional hearing aids ARE NOT INDICATED
  - Cochlear implant OR electro-acoustical stimulation?
THANK YOU !