Prescribing, adjusting and evaluating hearing aid performance in children

Prof. Hung THAI-VAN
Department of Audiology & Otoneurological Evaluation, Lyon University Hospital
President of the French Society of Audiology
International Bureau of Audiophonology board
Paris Hearing Institute, Inserm UMR1120

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Outline

- 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 -

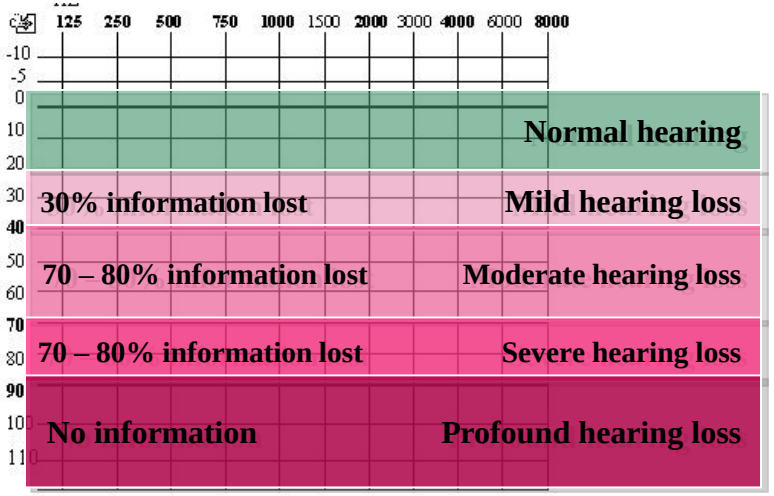
- Hearing loss / Conventional and Implantable hearing aids

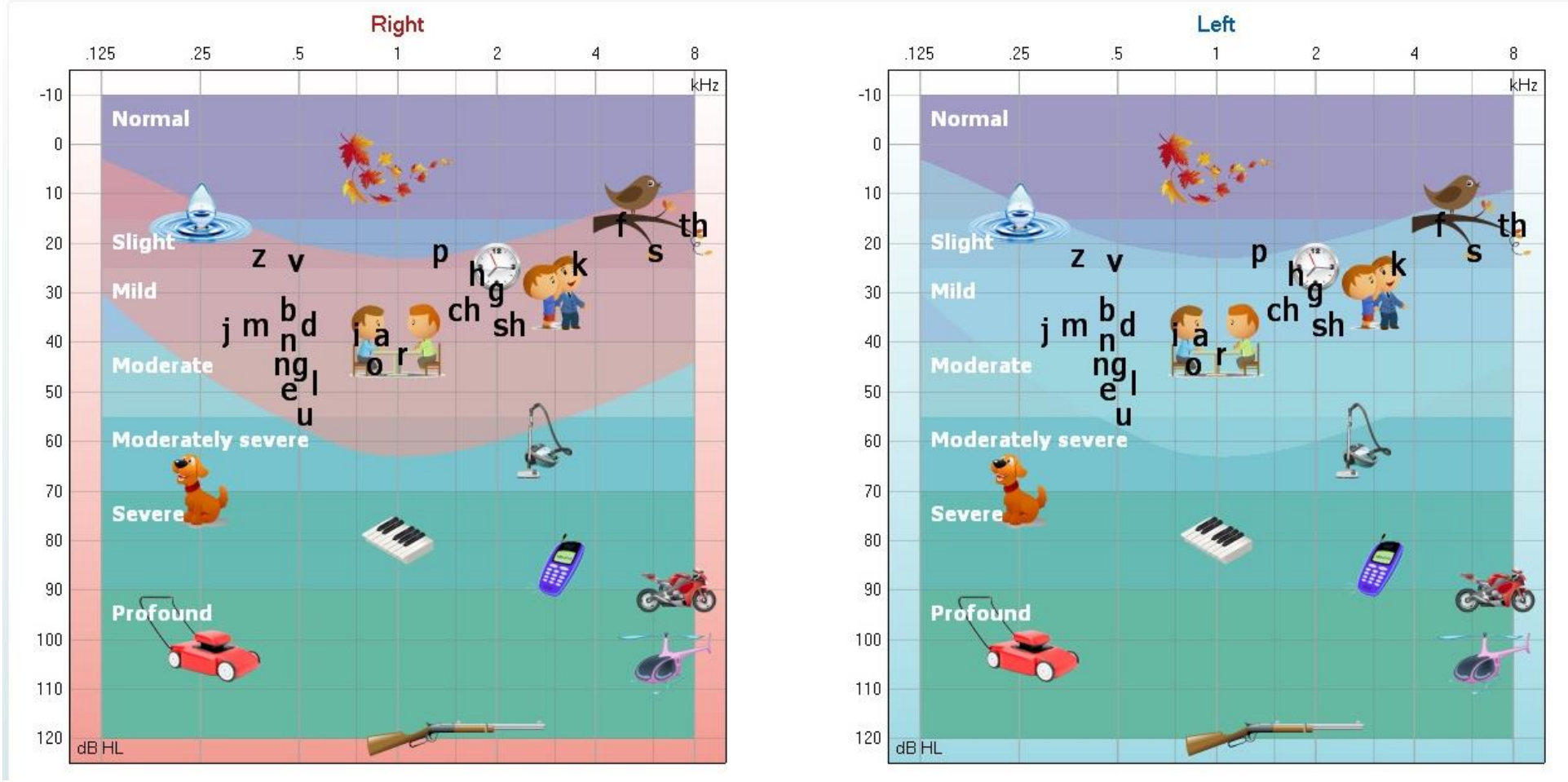
Hearing loss	Degree	PTA mean
Normal hearing		< 20 dB HL
Mild hearing loss		21 - 40 dB HL
Moderate hearing loss	I st degree II nd degree	41 - 55 dB HL 56 - 70 dB HL
Severe hearing loss	I st degree II nd degree	71 - 80 dB HL 81 - 90 dB HL
	I st degree	91 - 100 dB HL
Profound hearing loss	II nd degree III rd degree	101 - 110 dB HL 111 – 119 dB HL
Total deafness		> 120 dB HL

Conventional hearing aids

Classification of hearing loss – PTA

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

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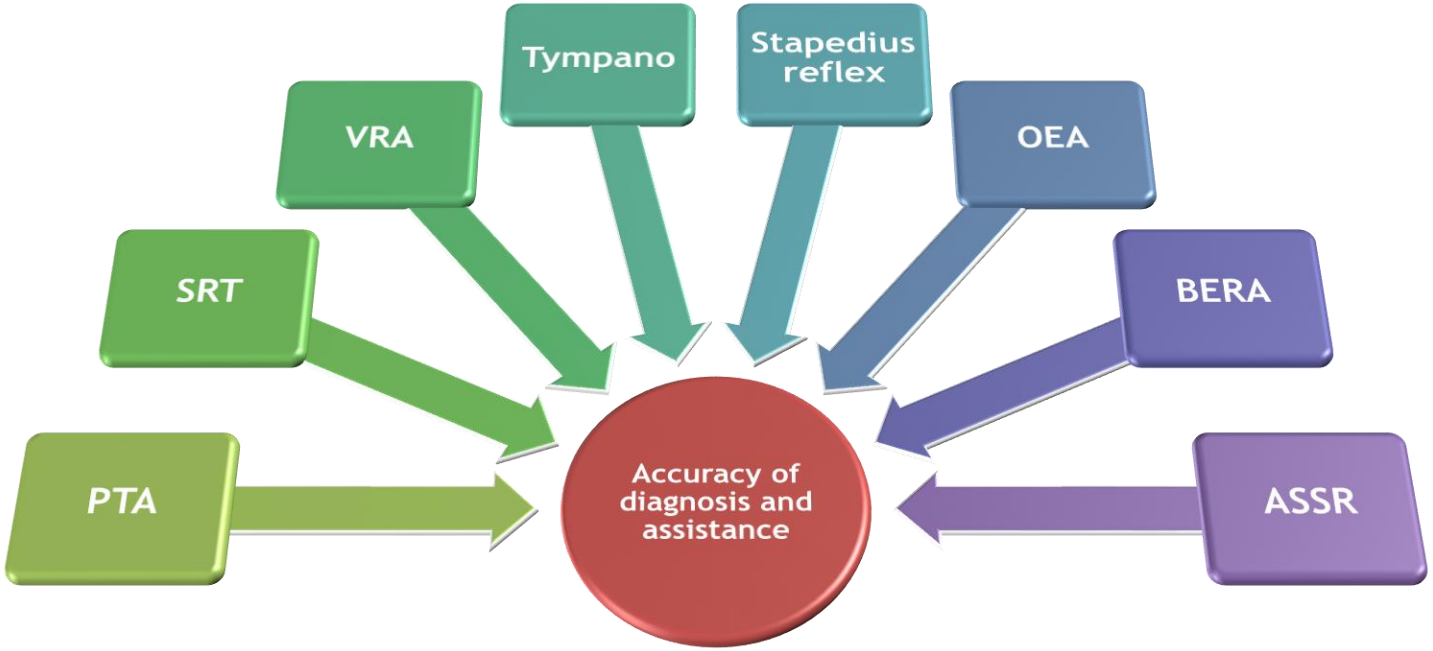
Audiological Assessment

- Many audiological tests
  - None to describe completely the hearing status of the ear
  - **We need a battery of tests**



Objective diagnosis of hearing loss

Newborn

Small child

Big child

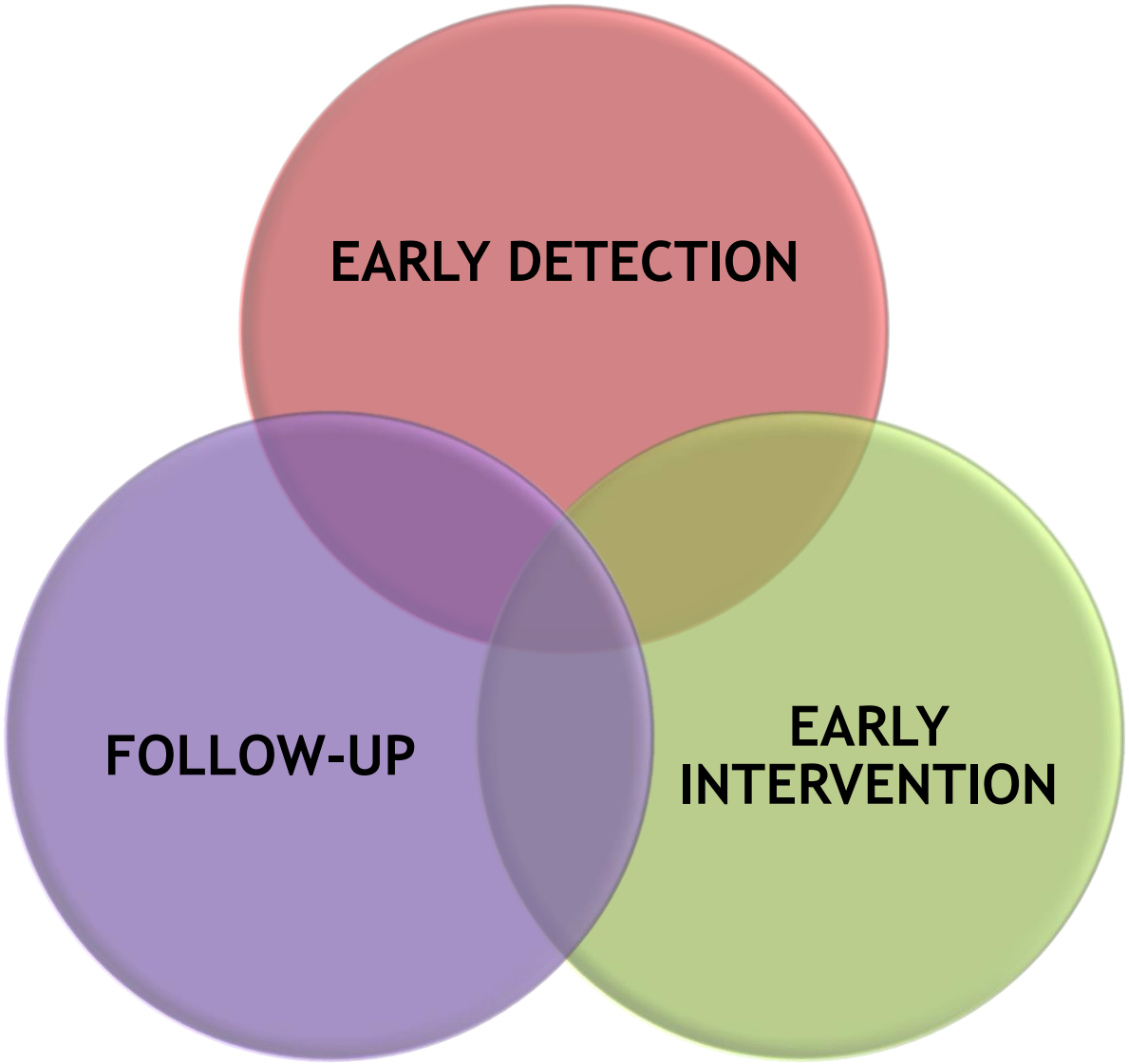
Teenager

Adult

Objective diagnosis of hearing loss

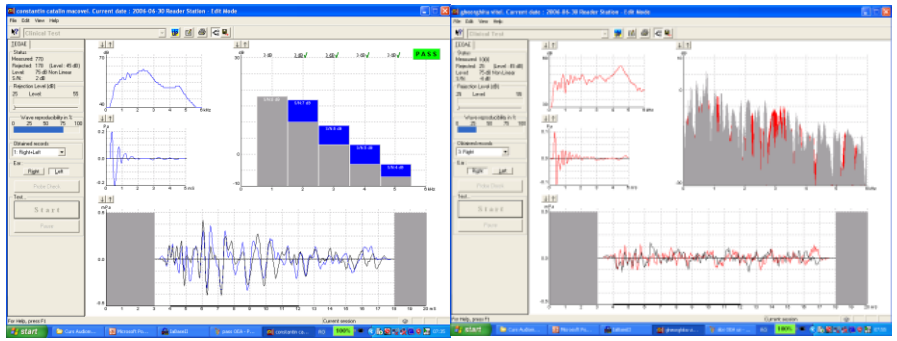
- Are we are waiting for ...

their response ???

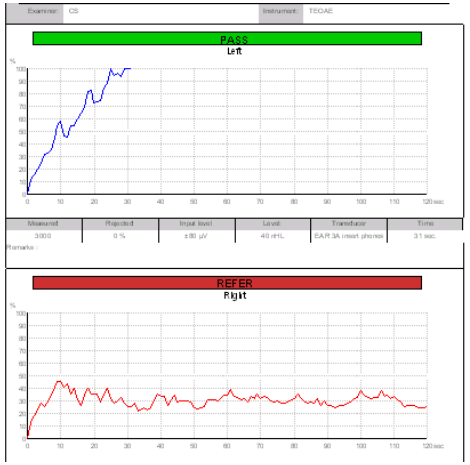

EARLY DETECTION
FOLLOW-UP
EARLY INTERVENTION

Universal Neonatal Hearing Screening

- SCREENING OAE
- SCREENING BERA

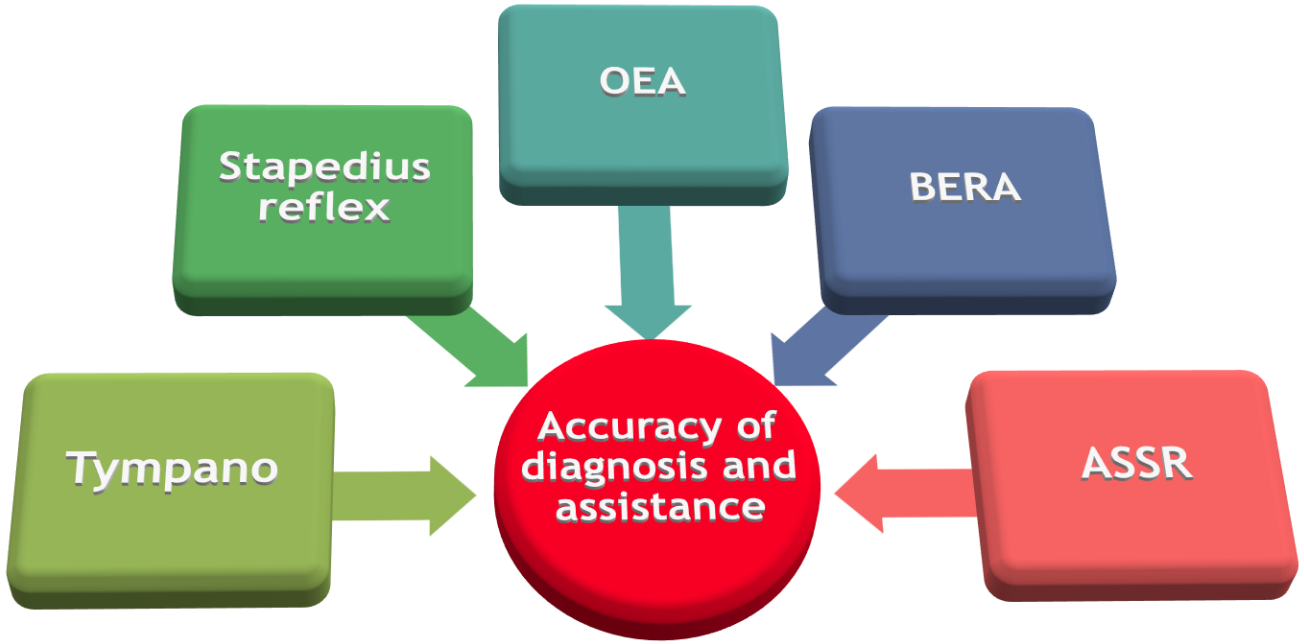


- **Risk factors for hearing loss**
  - **NICU**



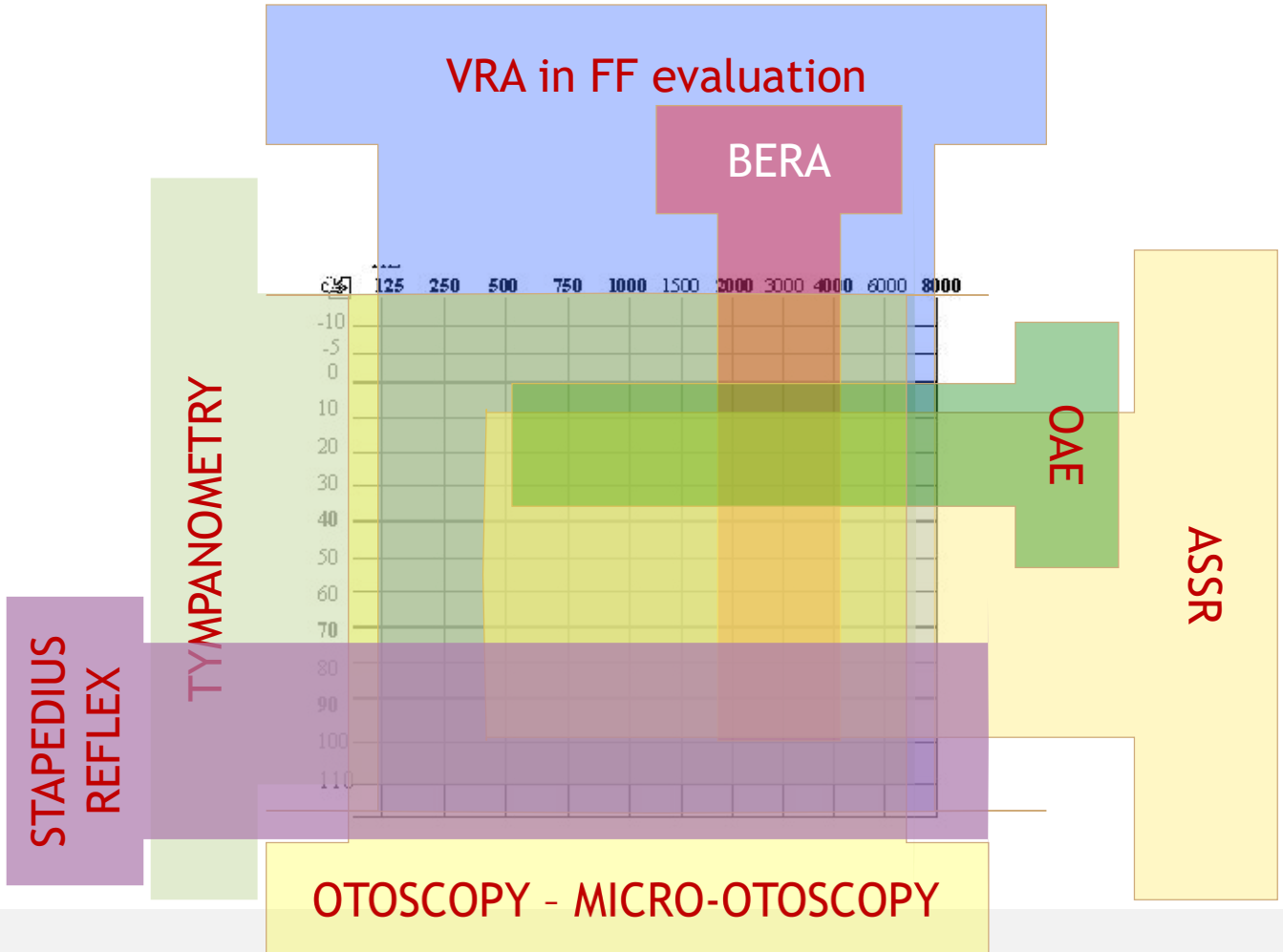
Objective diagnosis of hearing loss

- Objective assessment of hearing in small children



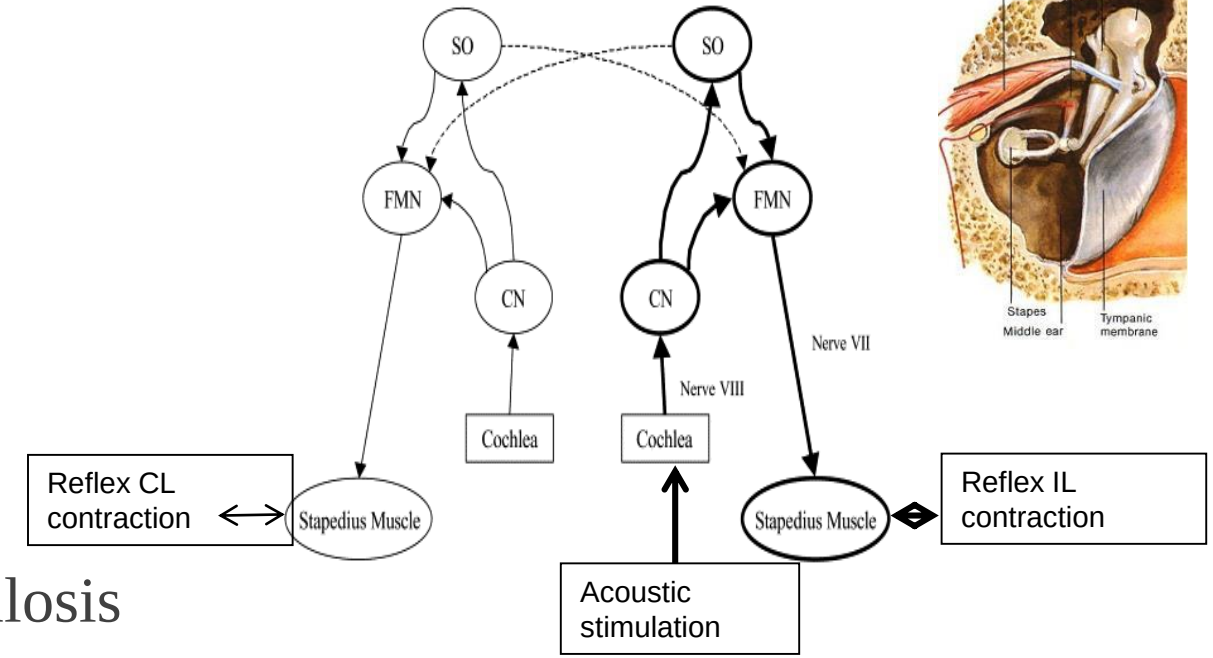
Objective diagnosis of hearing loss

- **THE AUDIOLOGICAL PUZZLE**



ACOUSTIC STAPEDIUS REFLEX

- PRACTICAL VALUE
  - Complementary tool
  - Integrity of ossicular chain
  - Elasticity/stiffness - Ossicular ankilosis

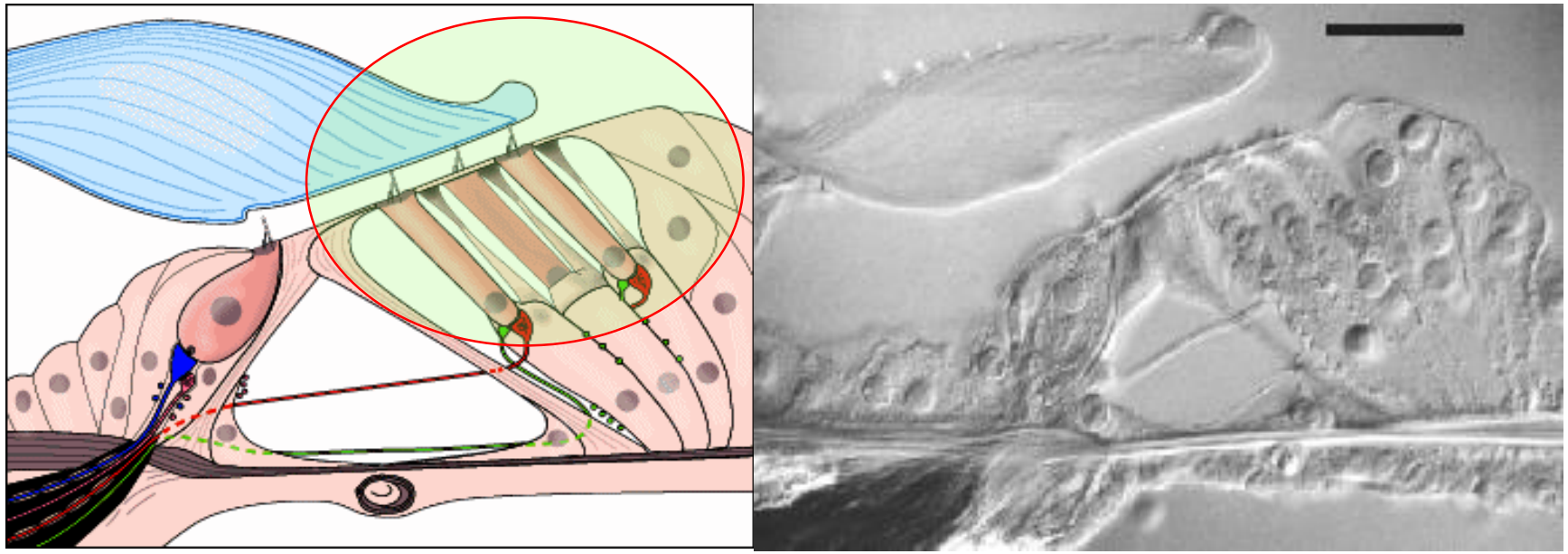


- NO CORRELATION WITH AUDITORY THRESHOLDS
- Presence of the acoustically reflexes its more valuable than its absence.

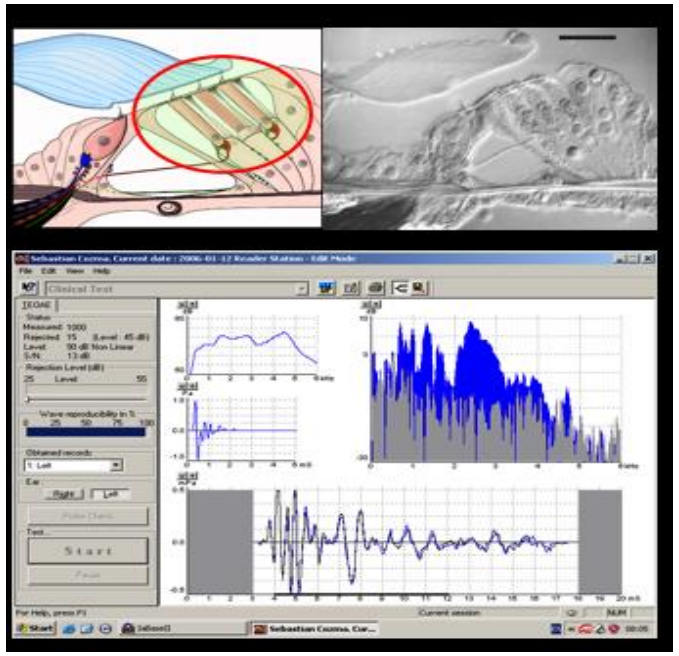
OTOACOUSTIC EMISSIONS (OAE)

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

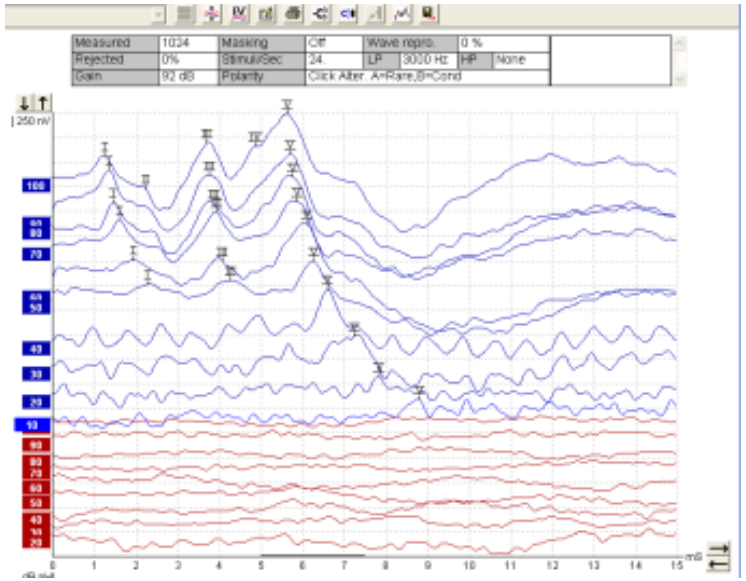
- Outer hair cells (OHC) are not sensorial auditory receptors
- OHC contract under various stimuli: acoustical or electrical

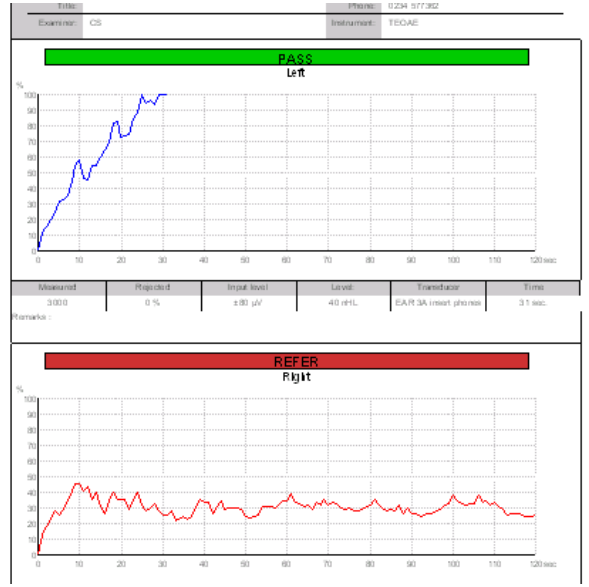


OAE: TRANSITORY/DISTORSION PRODUCTS

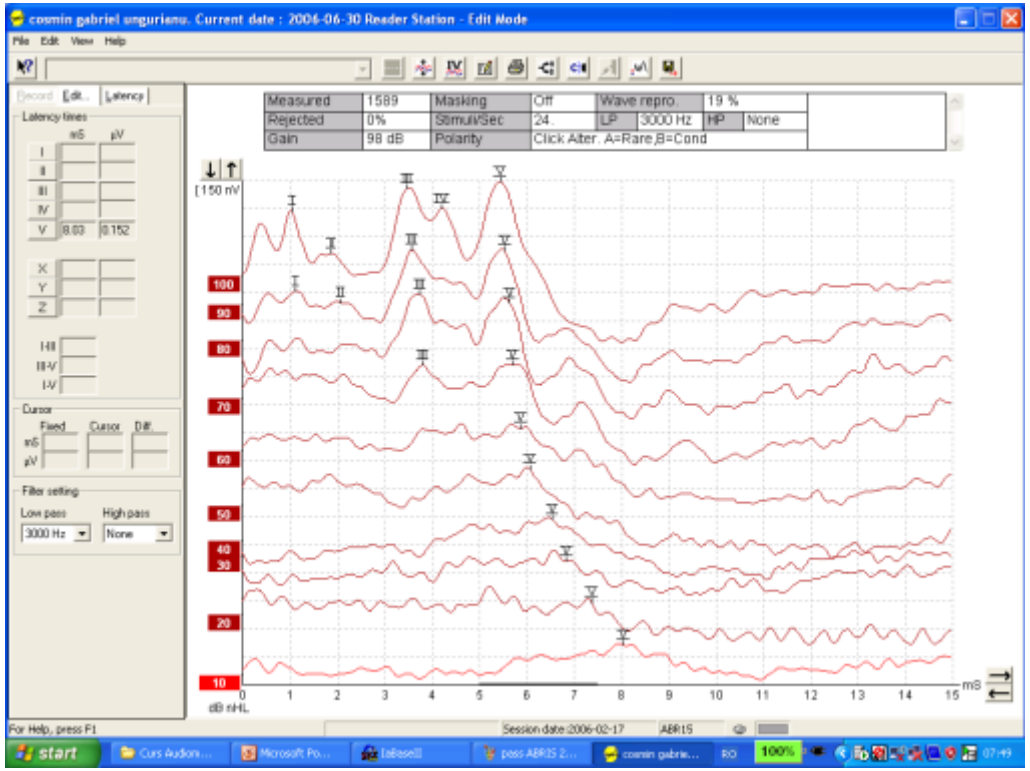


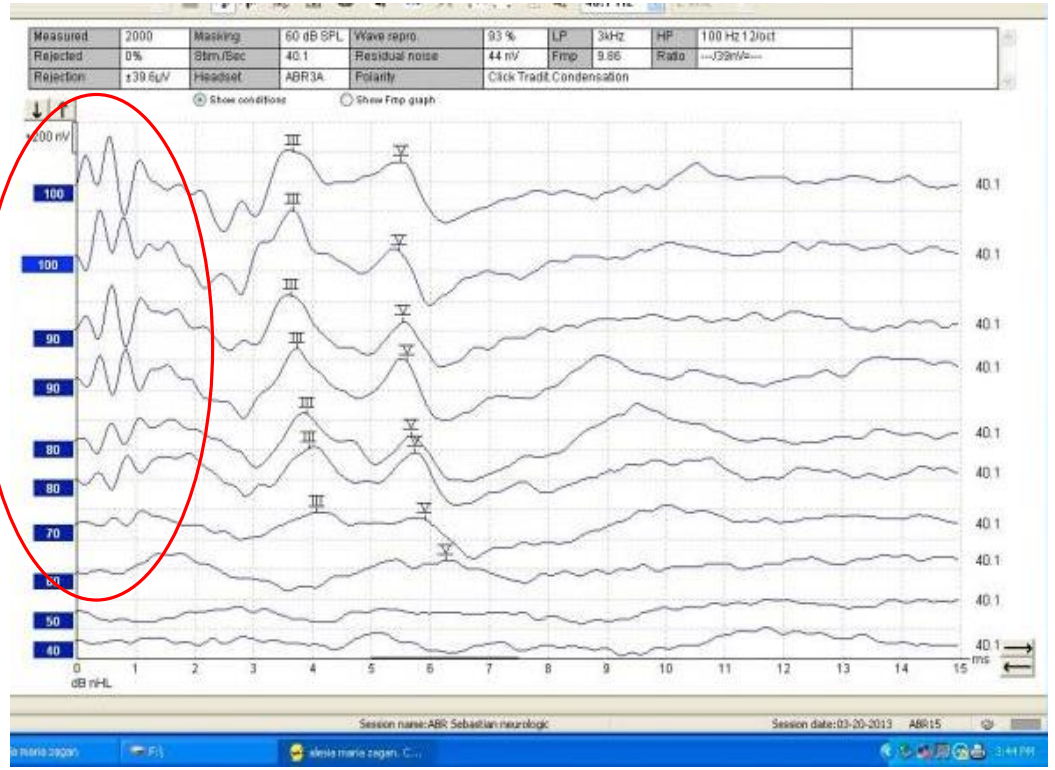
BRAINSTEM EVOKED RESPONSE AUDIOMETRY (BERA) and Automated BERA



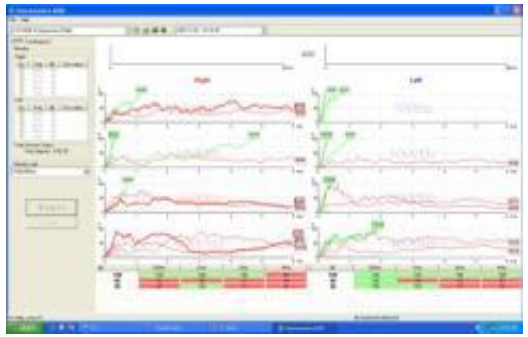


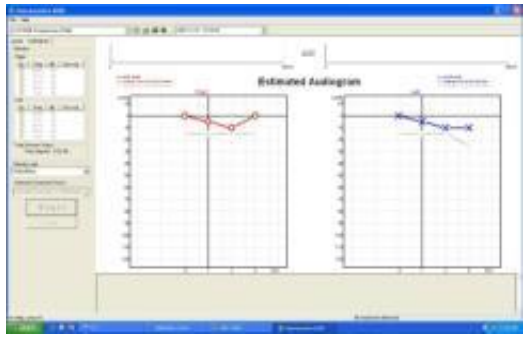
BRAINSTEM EVOKED RESPONSE AUDIOMETRY (BERA) – Automated BERA

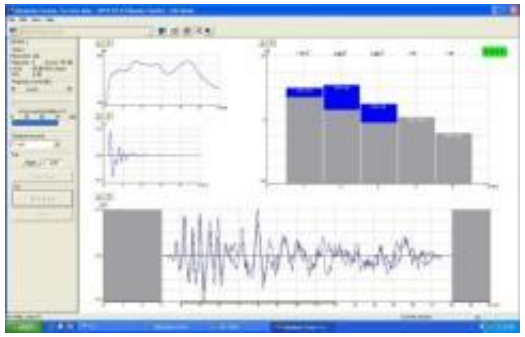


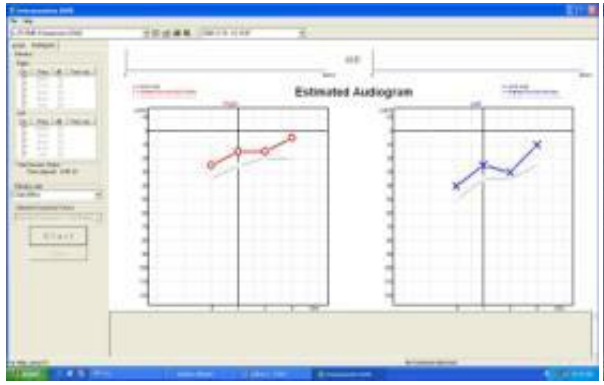


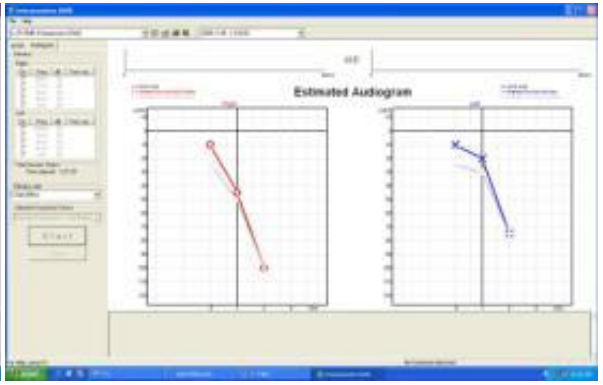
ASSR - Auditory steady state response - Estimated audiometry

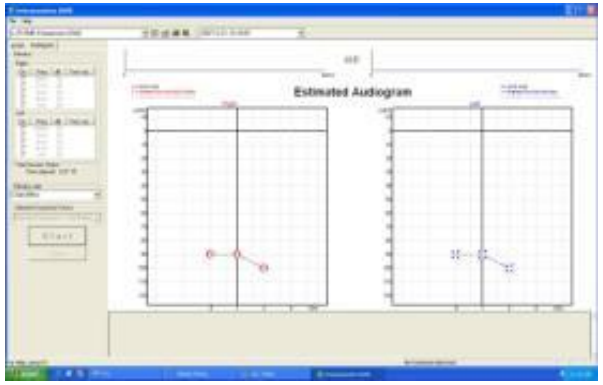


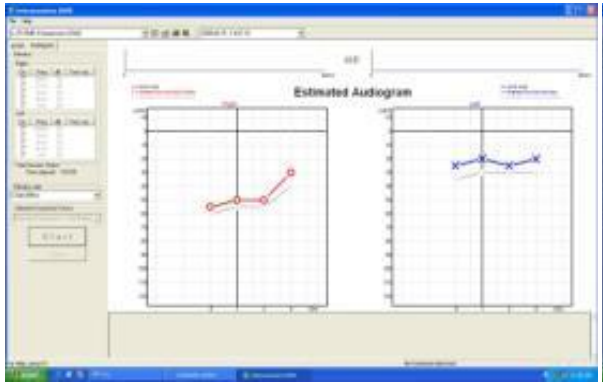


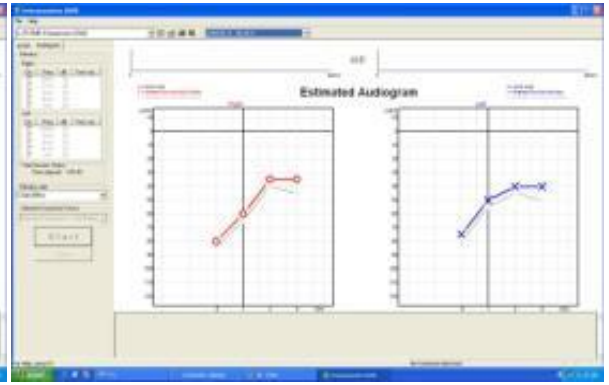












Reasons for cross-check diagnosis algorithm

Test	IDEAL	REAL
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 -

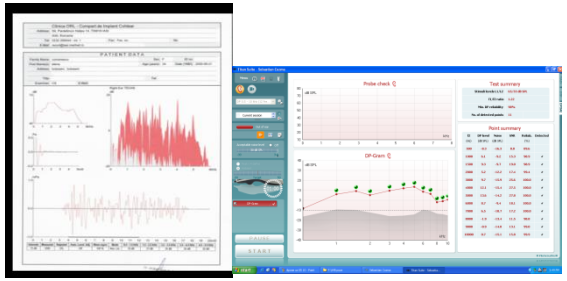
- Auditory neuropathy
- Neural dyssynchrony
- AUDITORY NEUROPATHY SPECTRUM DISORDERS

- First description
  - Starr et al. – 1996 : ”auditory neuropathy”

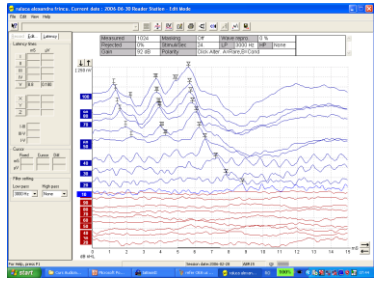
Auditory Neuropathy Spectrum Disorders

- Audiologic assessment characteristics -

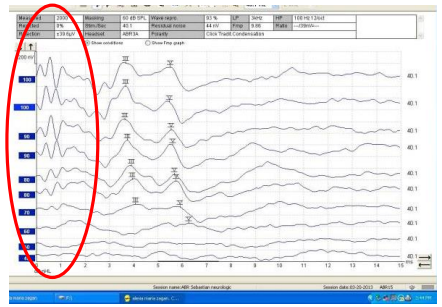
- OAE present (at least for some time)



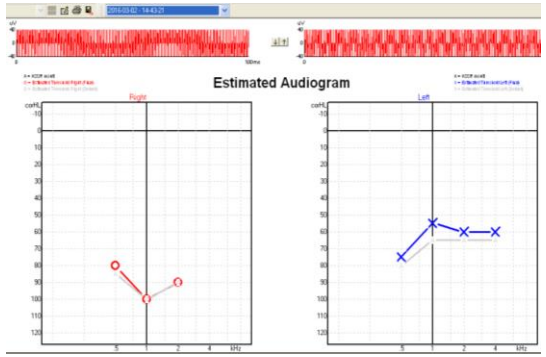
- Abnormal or absent BERA responses

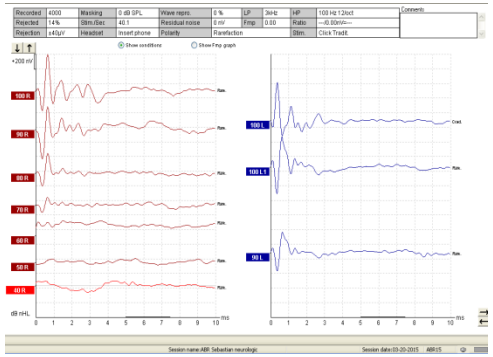


- Cochlear microphonics - present

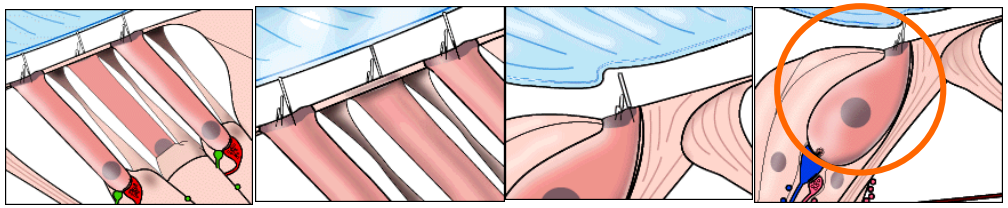


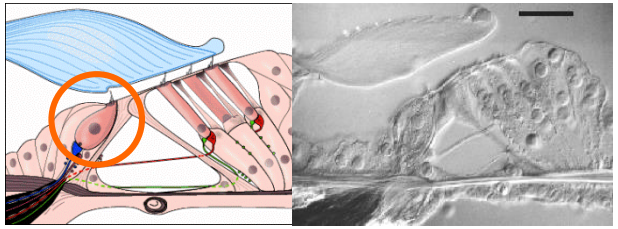
- Mismatch BERA-ASSR-VRA



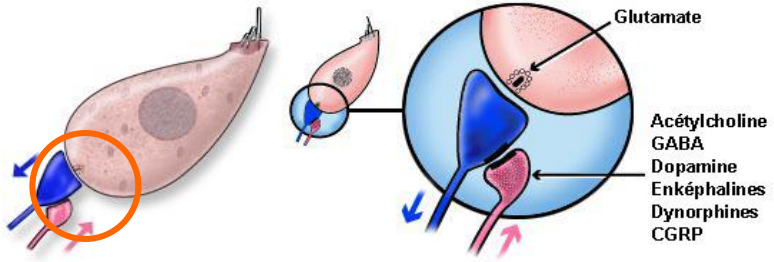


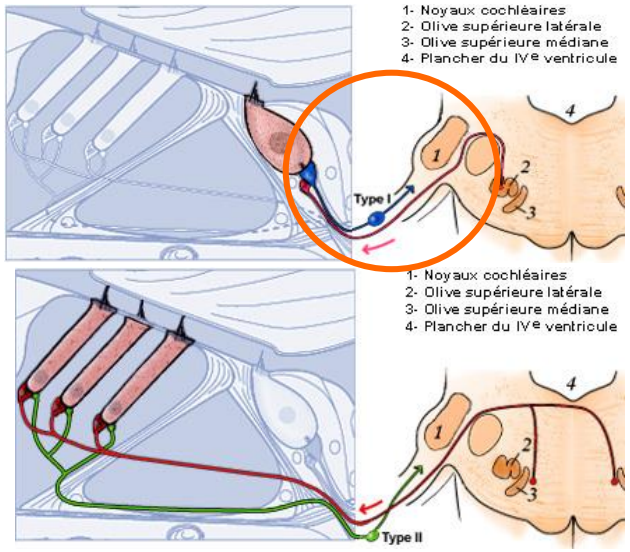
Auditory Neuropathy Spectrum Disorders
- Different origins -





- 2008 – International Newborn Hearing Screening Conference
  - Auditory Neuropathy Spectrum Disorder - ANSD

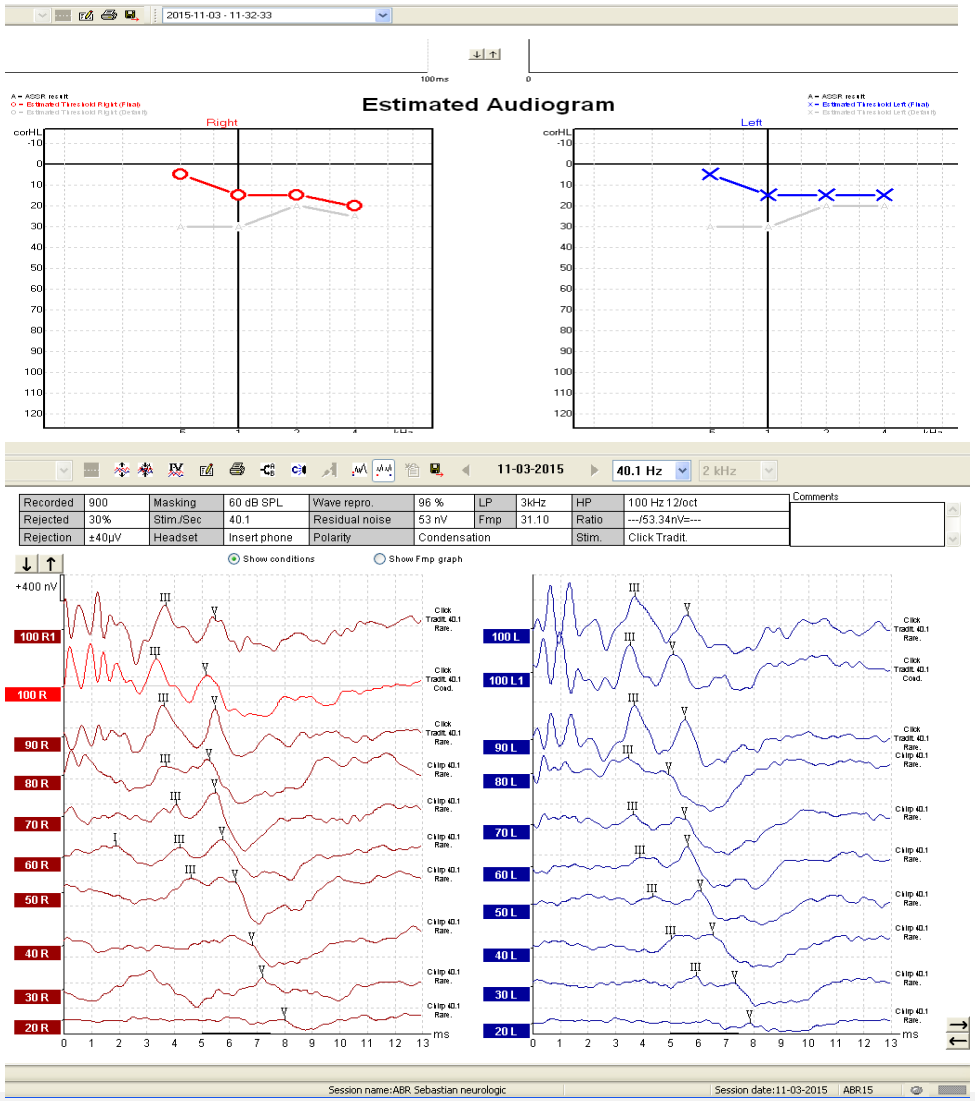


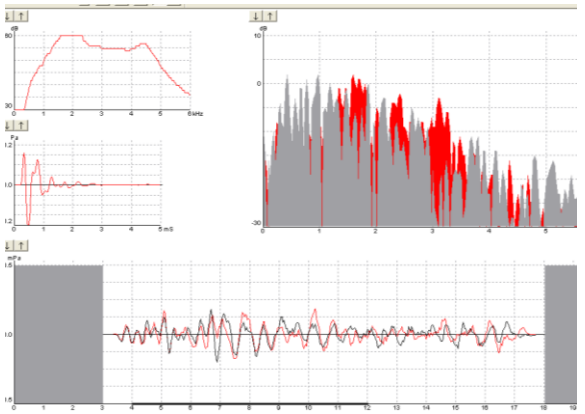


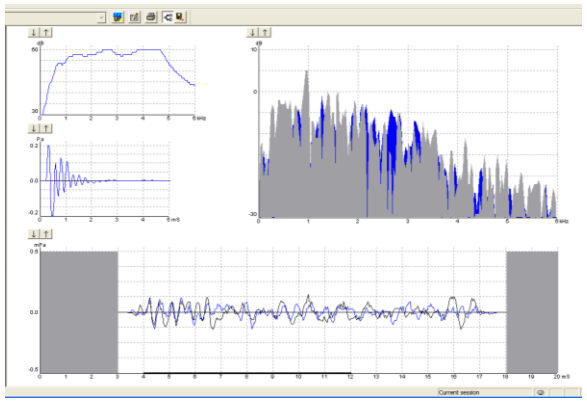
- Dysfunction can be determined by :
  - Corti's dysfunctions - internal ciliated cells
  - Synaptic dysfunctions - neural sensory junction pathology
  - Dysfunction of the auditory nerve

Auditory Neuropathy Spectrum Disorders

- With normal hearing -



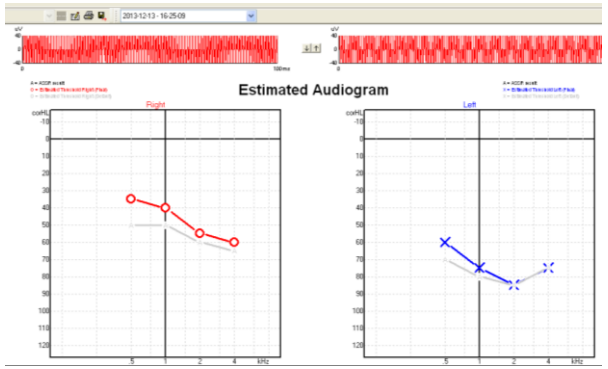


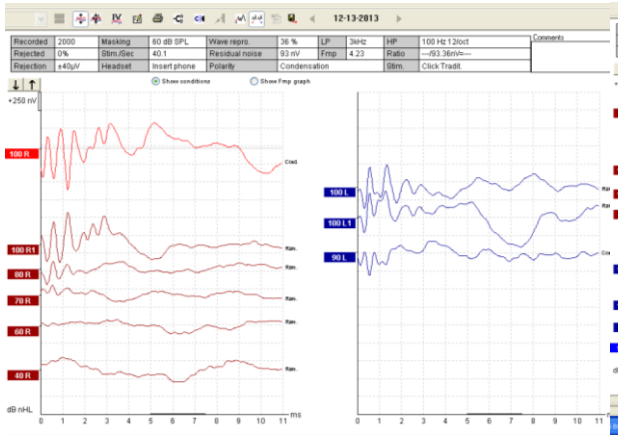


Auditory Neuropathy Spectrum Disorders

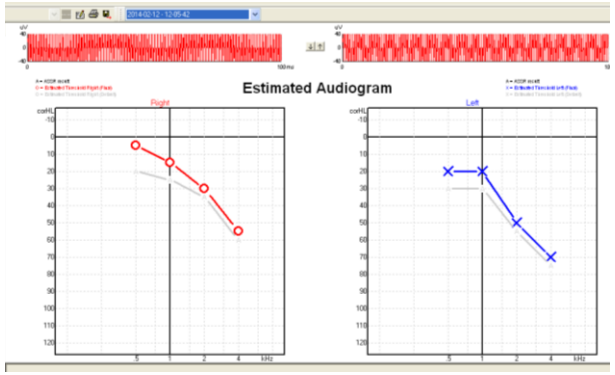
- With fluctuation/progressive hearing loss -

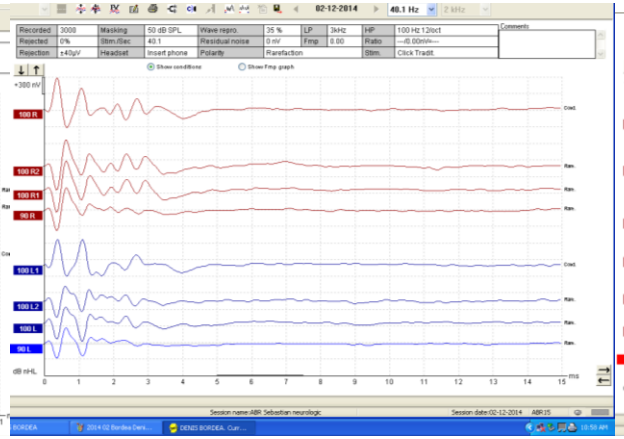
2013



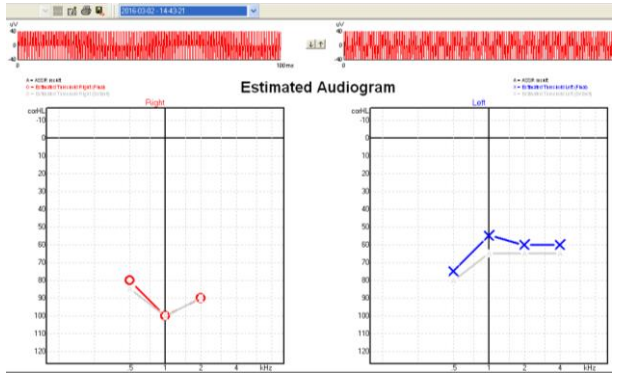


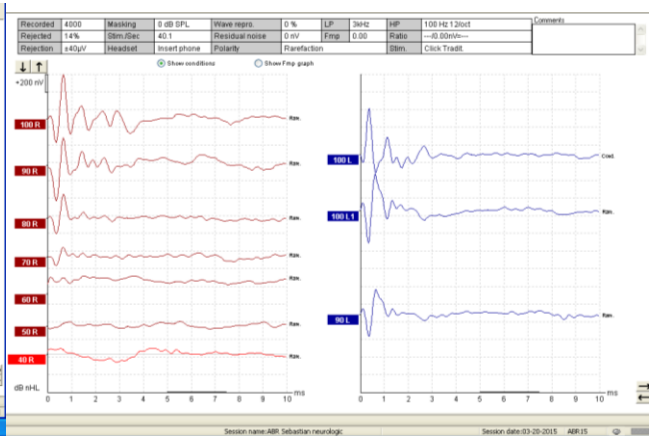
2014





2015





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

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	VRA	PTA FF	Vocal audiometry	Speech evaluation

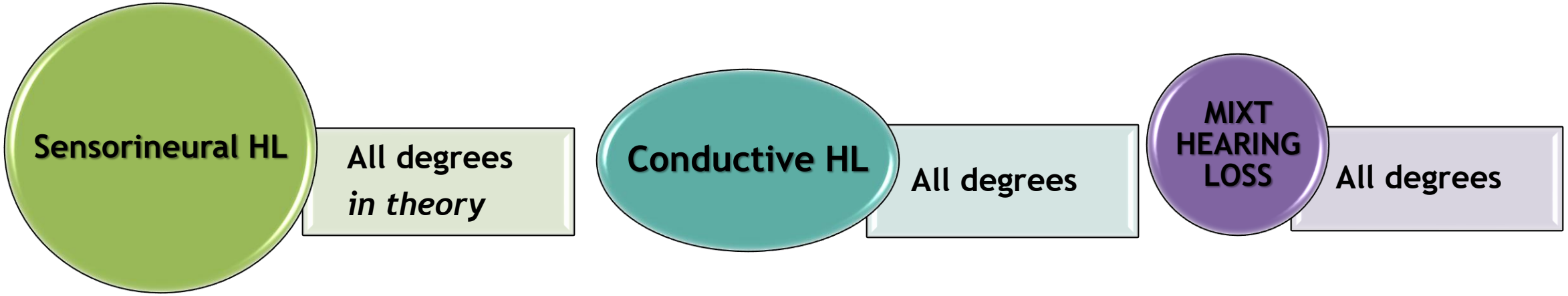
- The role of parents and educators !!!

- 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 ?



Objective assessment of hearing in children

Diagnosis process – Hearing loss degree

- Hearing loss / Conventional and Implantable hearing aids indication

Hearing loss	Degree	PTA mean
Normal hearing		< 20 dB HL
Mild hearing loss		21 - 40 dB HL
Moderate hearing loss	I st degree II nd degree	41 - 55 dB HL 56 - 70 dB HL
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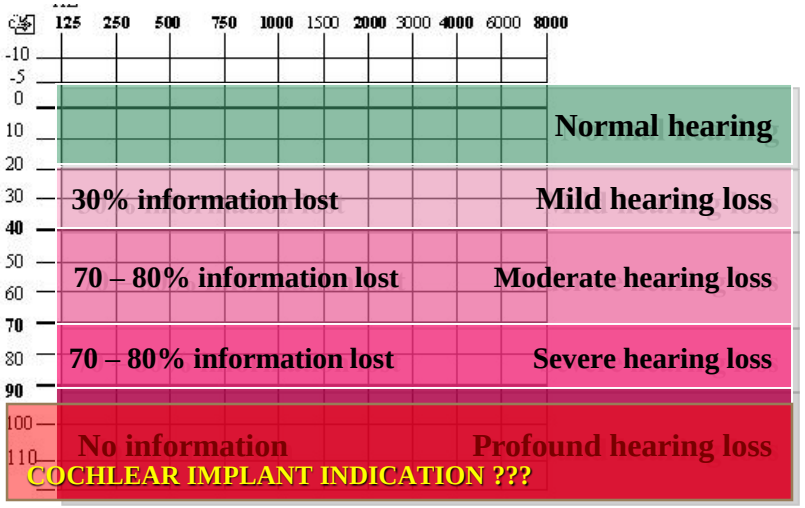
Total deafness		> 120 dB HL

Conventional hearing aids

Classification of hearing loss – PTA

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



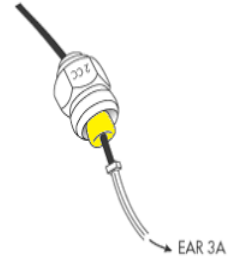
- Determining hearing loss in dB HL is done according to ISO standards
- The average of tonal loss in dB HL on 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz
- The loss is calculated for each individual ear
- It is also possible to calculate a global loss (for both ears)

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

Conventional hearing aid

- 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 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

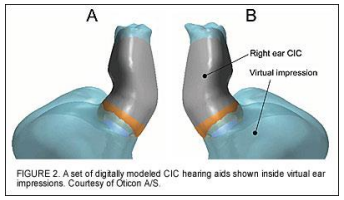
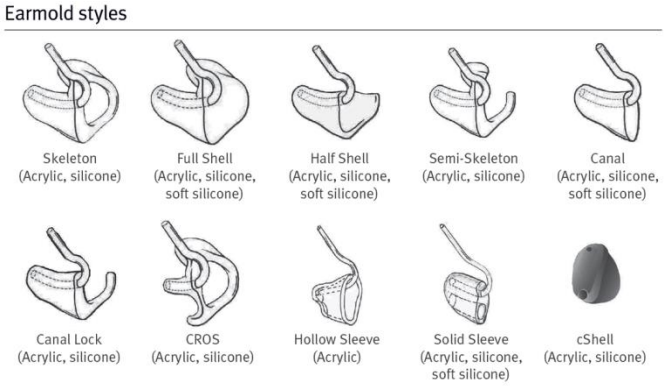
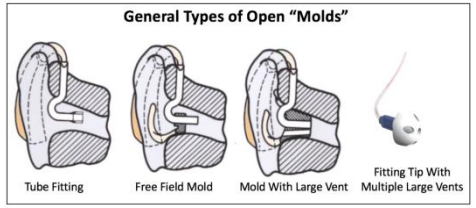


FIGURE 2. A set of digitally modeled CIC hearing aids shown inside virtual ear impressions. Courtesy of Oticon A/S.

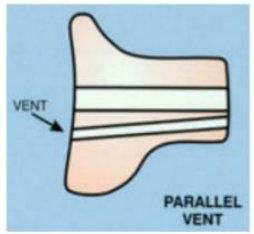


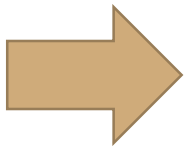


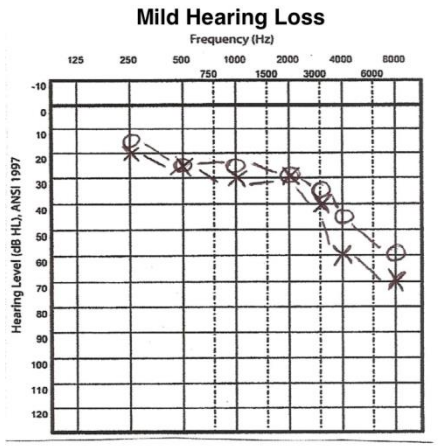
Which kind of earmold ?
- Importance of venting -

Venting

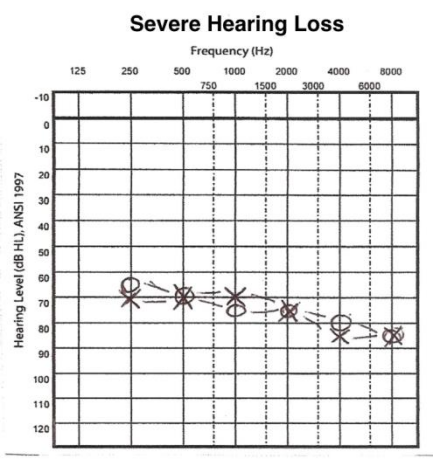
- A vent is often an intentional component of a an earmold/earshell
- simply a column of air which provides a channel between the air within the ear canal and the air external to the ear canal







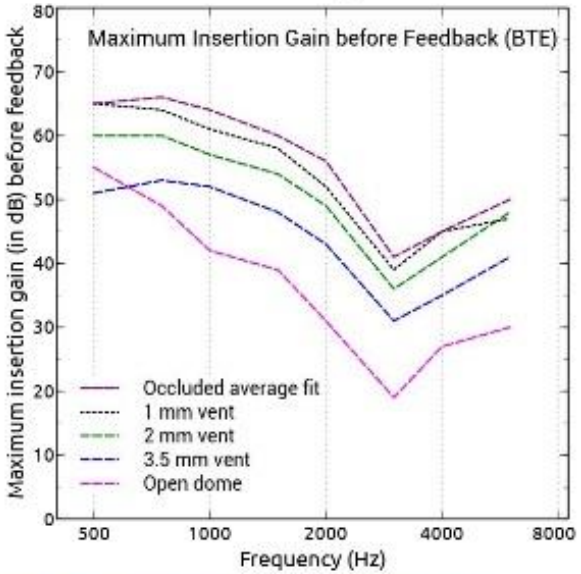
Open fitting



Closed fitting

Which kind of earmold ?
- Importance of venting -

Venting
-Effects on venting on feedback-



Venting
-Effects on HA gain and MPO-

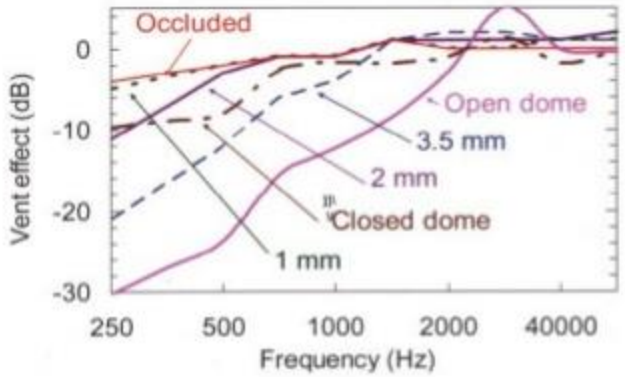
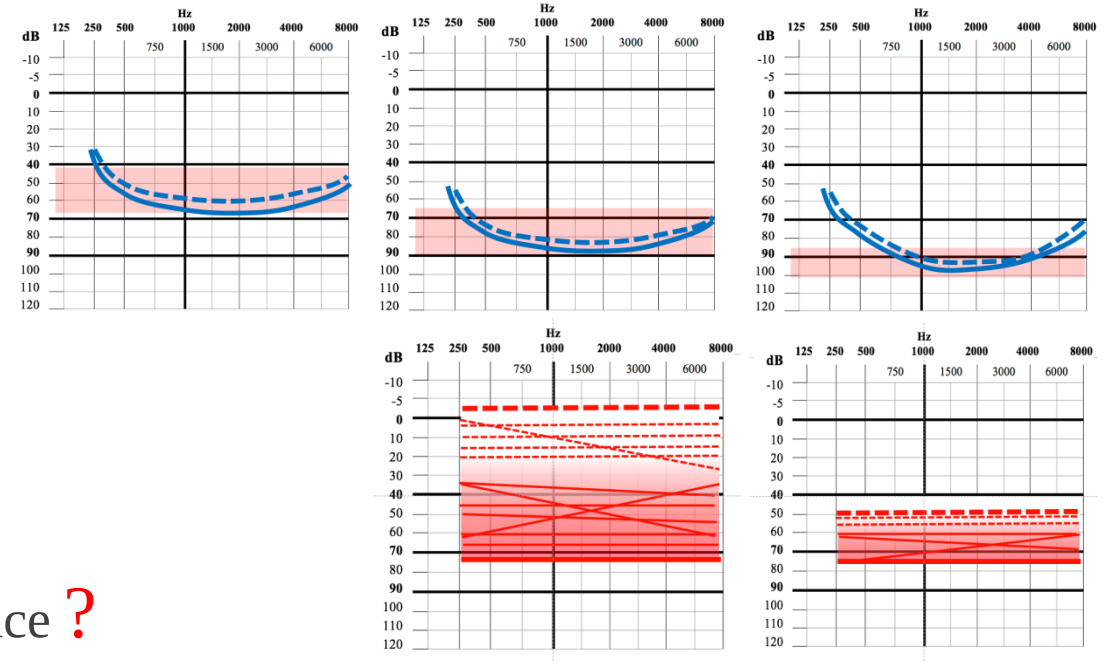


Figure 5.11 Effect of different sized vents on the frequency response of amplified sound, relative to the response with a tightly fitting earmold or earshell.[430, 431, 1355]

Hearing aids can help

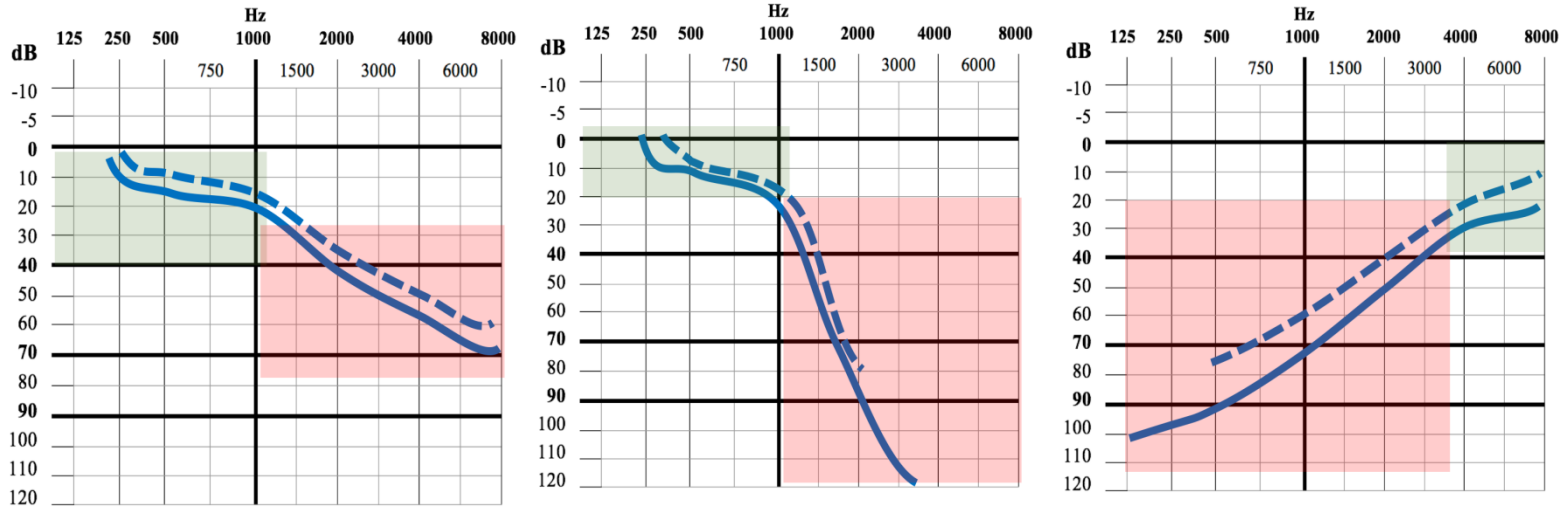
- Medium, severe and profound 1st degree neurosensory hearing loss
- Medium and severe transmission hearing loss
- Moderate, severe and profound 1st degree mixed hearing loss
  - (>41 < 90 dB HL)
  - Conventional hearing aid
    - Retroauricular – earmolds adaptation



  - 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**



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 x PTA mean (0.5, 1, 2, 4 KHz) on better ear
+
3 x PTA mean (0.5, 1, 2, 4 KHz) on worse ear
/
10

No sound perception –120 dB lost

Conventional Hearing Aids

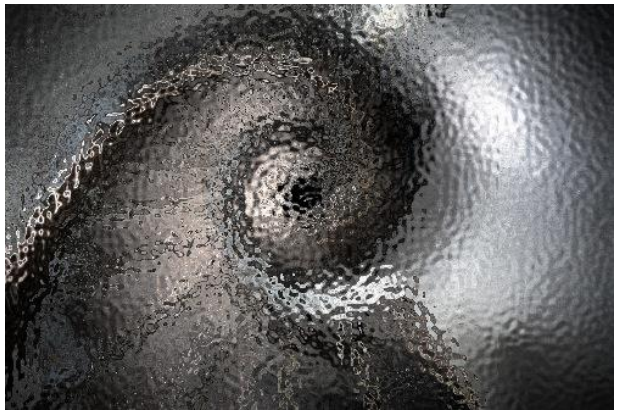
- Conditions:

- 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.**



Sebastian Cozma

TAKE HOME MESSAGES

- 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

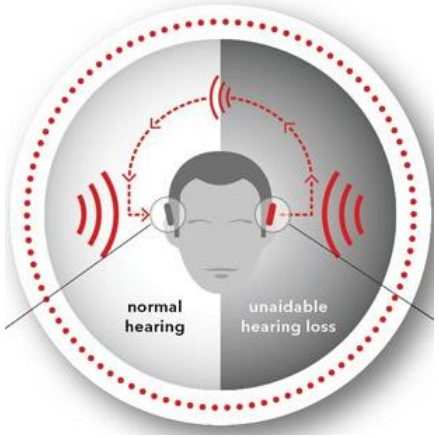
- Specials fittings -

- Bimodal hearing aids

Cochlear implant

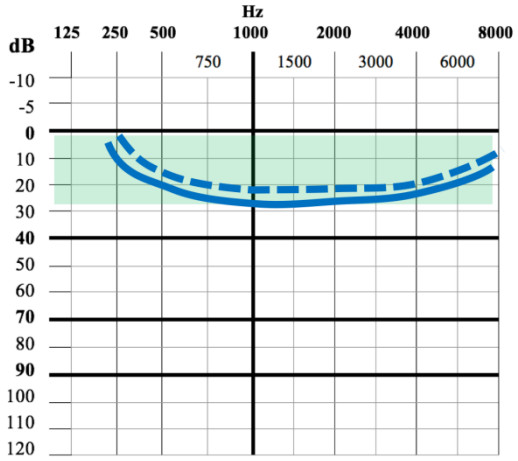
conventional hearing aid

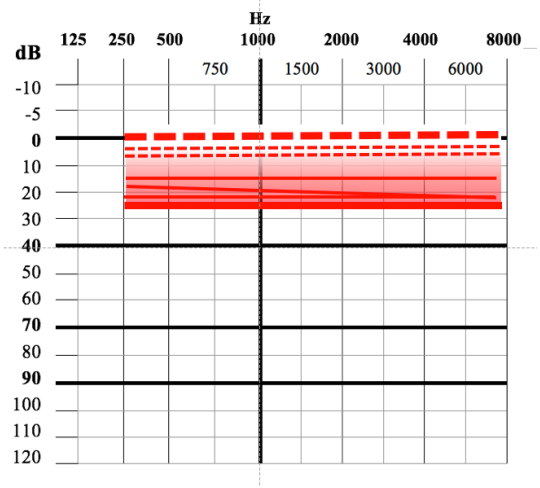
- CROS – transcranial hearing



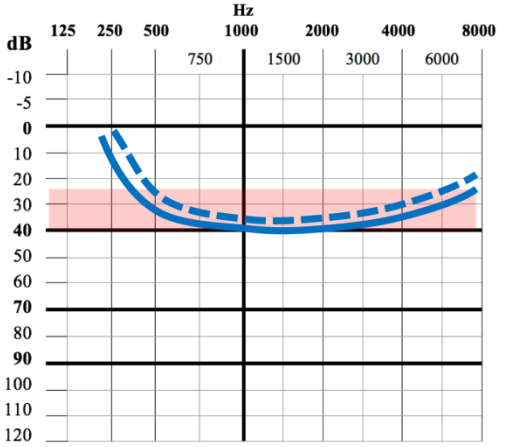
Hearing aids limits

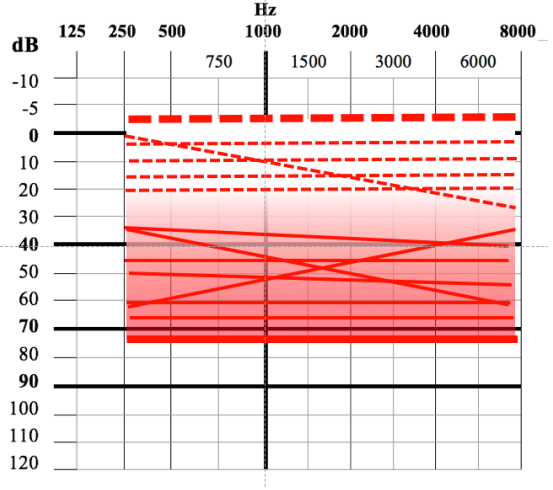
- The mild neurosensory hearing loss at the limit with normal
- The mild conduction hearing loss at the limit with normal
  - Not indication for hearing aids





- Mild neurosensory hearing loss
- Mild conduction hearing loss
  - (>30 dB HL)
  - Conventional hearing aid
    - Retroauricular – earmolds adaptation

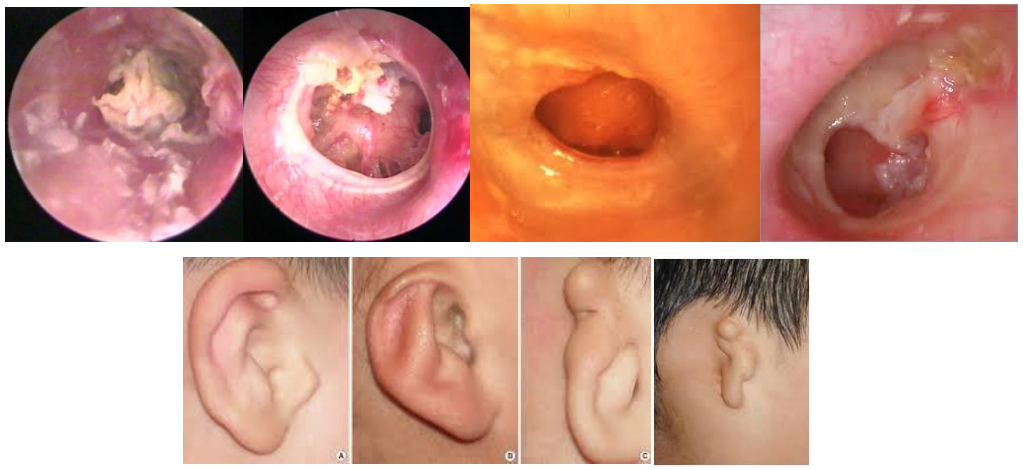




Contraindications

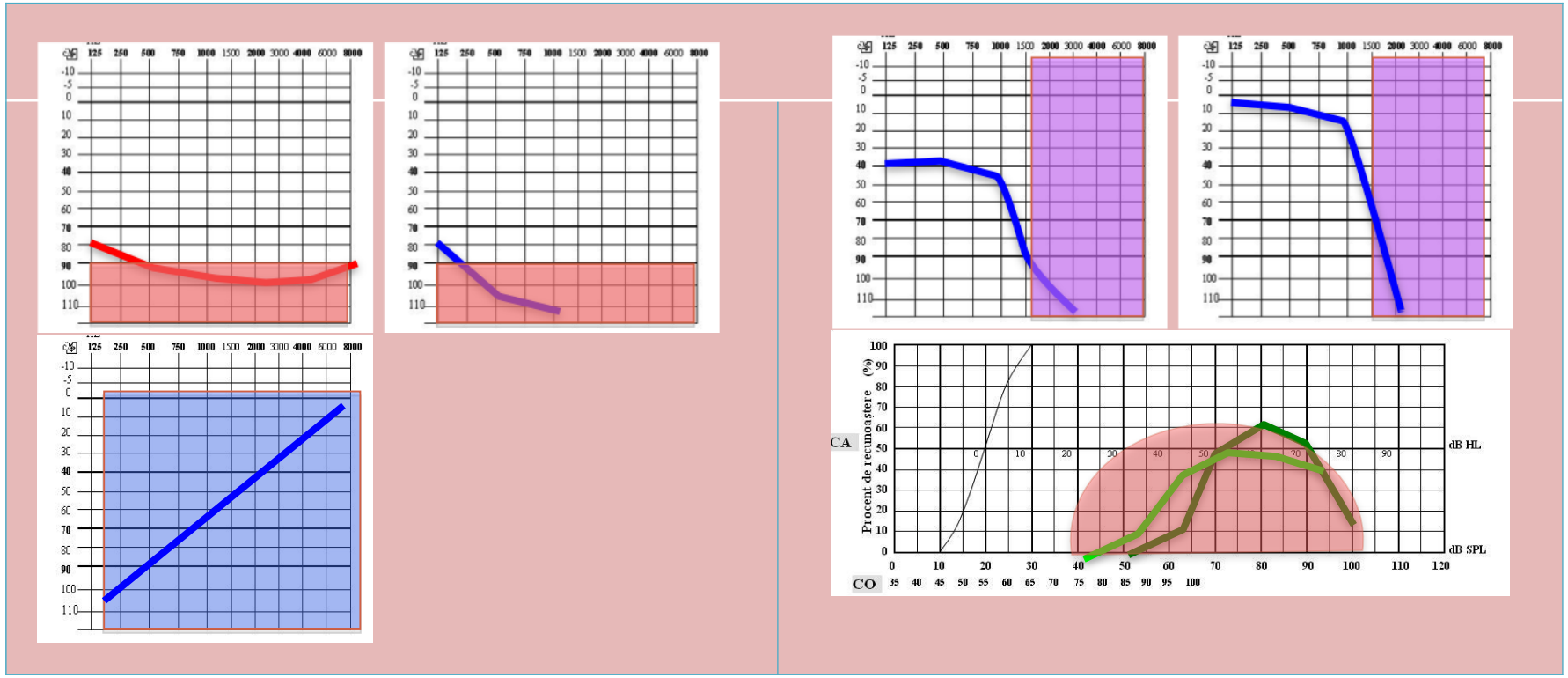
- Contraindications
  - Local chronic infections
  - Intolerance to earmold material / allergies
- Active / relapsing suppurative infectious disease
- PRESENCE of allergies / intolerances
- External ear malformations - agenesis

- Audiological criteria / medical criteria



Implantable Hearing Aids

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



THANK YOU !