Innovations in Verification of Hearing Aid Fitting in Children

ANSI-standard for RECD, use of MAOF and SII normative range compared in common measurement systems

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Requirements in Verification

- Standardization of the RECD measurement
  - ANSI S3.46-2013 / RECD

- SII Normative Values for children
  - PaedAmp, University of Western Ontario

- MAOF-range as target for frequency lowering
  - Maximum Audible Output Frequency Range
  - PaedAmp, University of Western Ontario

www.dsl.io.com
Innovation, accuracy, application and implementation

RECD
RECD “classic”

Basic measurement principle since 1995 by use of the HA2 coupler:

\[
\text{dB SPL(real ear)} - \text{dB SPL(HA2 coupler)} = \text{RECD}
\]
ANSI Standard S3.46-2013 / RECD

- ANSI S3.46: North American Standard for REM
  - 2013: RECD included in S3.46 recommends to
    - use of HA1 coupler
    - use of a high-impedance transducer for signal application
    - use of ear mold / foam tip for both – coupler and on ear measurement

  - Why?

  - Consequences?

  - Changes in Application?
RECD – Accuracy of method

Type of coupler

Figure 2
The RECDs obtained from the data in Figure 1. These were obtained by subtracting the SPL generated in the occluded ear canal from the SPL generated in the HA1 (open circles) and the HA2 (black circles) 2-cc coupler.

- HA1-RECD with ITE-coupler
- HA2-RECD with BTE-coupler

Bagatto et al. 2005: Clinical Protocols for Hearing Instrument Fitting
RECD – Accuracy of method
Transducer and earmold tubing length

Earmold tubing length: 45 mm

Earmold tubing length: 35 mm

The shorter the earmold tubing length:
➢ The fewer resonances
➢ the lower the impact of different RECD transducers

Bagatto et al. 2005: Clinical Protocols for Hearing Instrument Fitting
RECD – Accuracy of method
RECD with foam tip vs. individual earmold

- Earmold tubing length
  - Short and standard for ear tips
  - Longer and individual in earmolds

- Used for
  - Audiometry with inserts: ear tips
  - HA fitting: earmold

- Consequence for RECD:
  - High precision requires two RECDs!
RECD – Accuracy of method
Foam tip to earmold difference

- Age-related RECD averages exist for foam tip and for earmold
- the hearing loss may have been measured with foam tip, while the HA is couple with earmold
  - Measure RECD twice?
  - Develop correction values!

- Corrective Values developed and implemented in Verifit VF2

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New RECDs and New ANSI Standards: Revisiting RECD Basics and Applications, Susan Scollie, 2015 (www.audiology-online.com)
Variances of couplers – used for RECD

- **HA(2)-RECD**
  - Recalculated

- **HA1-RECD**
  - Coupler measured

- **HA1-RECD**
  - Recalculated with RECD SPL-probe
  - Child 0-24 months

- **WRECD**
  - Recalculated to HA1-RECD

- **Verifit1, RM500SL, Axiom**

- **Aurical, Verifit**

- **Affinity 2.0**

- **Verifit2 VF-2 with 0.4 cm³ Kuppler**

- **New software**

- **HA2-RECD**

- **HA2-RECD**

- **New software**
WRECD with Verifit VF2 (Video)
RECD SPL-Probe in Affinity
influence of insertion depth for RECD SPL probe vs. tube length in HA2-RECD

Source: Interacoustics

Age-related RECD measured with RECD-tip

Comparable with HA1-RECD

Age-related RECD with earmold measured with HA2-coupler

Source: Interacoustics
RECD with SPL probe (Video)
Example from Affinity 2.0
HA2-RECD with earmold (Video)
Example from Aurical
Normative Values for Paediatric Fitting Verification

SII
Fitting Evaluation: SII normative values only for pediatric fitting! (DSL child)


https://www.uwo.ca/nca/research/research_areas/cal/Publications.html

www.dslio.com
PedAMP → “Aided SII Normative Values Form PDF”
PTA & SII

Calculation of PTA

\[ PTA = \frac{HTL_{500\,Hz} + HTL_{1000\,Hz} + HTL_{2000\,Hz}}{3} \]

Calculation SII
Normative Values for SII
Example from Audioscan Verifit VF2: calculation evaluated

PTA: 48 dB HL

SII_{55\text{dB}} 65\%

SII_{65\text{dB}} 74\%
Comparison of Equipment used for Verification

VERIFICATION
Common REM Equipment in Pediatrics

- Software Versions of REM equipment used:
  - Affinity2.0: Affinity Suite Software Vers. 2.11.0
  - Aurical HIT & FreeFit: Otosuite Software Vers. 4.84.00
  - Verifit & Verifit2: Verifit2 Software Vers. 4.16.5

- Essential:
  - Simulated REM measurements in test box with infants and young children
  - RECD: Real-Ear-to-Coupler measurement → Gold standard: measured
  - ISTS International Speech Test Signal
  - Percentile analysis used to display measurement results: LTASS, 99th percentile and 30th percentile used to display dynamics of speech
Formally, all measure in the same way!

**Question:** Does that also mean that the display shows exactly the same measurement results?
Introduction to the graphical display of REM simulated, coupler based Verification of Hearing Aids in:

Verifit2, Aurical PMM, Affinity2.0,
Verifit2 / Verifit: Display coupler based REAR

*** UCL calculated (Pascoe) in dB SPL + (W)RECD = dB SPL<sub>Real Ear simulated</sub> 

++ BOLT target for MPO DSLv5

MPO measured in dB SPL<sub>HA4-coupler</sub> + (W)RECD

HA measured with ISTS 65 dB in dB SPL<sub>HA4-coupler</sub> + (W)RECD = dB SPL<sub>Real Ear simulated</sub>

Hearing threshold right/left in dB HL + RETSPL<sub>transducer</sub> + (W)RECD = dB SPL<sub>Real Ear simulated</sub>

Implementation of (W)RECD (average or measured):
- Hearing threshold and UCL in dB SPL<sub>Real Ear simulated</sub>
- dB SPL<sub>HA4-coupler</sub> + (W)RECD = dB SPL<sub>Real Ear simulated</sub>
- DSLm5 Zielkurve Original
- MLE applied to the speaker signal
Aurical PMM: Display coupler based REAR

UCL estimated (Pascoe) in dB SPL + RECD = dB SPL\textsubscript{Real Ear simul.}

BOLT target for MPO DSLv5 Original

MPO measured in dB SPL\textsubscript{HA2 coupler} + RECD

HA measured with ISTS 65 dB in dB SPL\textsubscript{HA2-coupler} + RECD = dB SPL\textsubscript{Real Ear simul.}

---- LTASS

Dynamics of ISTS

Residual Dynamic Range

Implementation of RECD (average or measured):
- Hearing threshold and UCL in dB SPL\textsubscript{Real Ear simul.}
- dB SPL\textsubscript{HA2-coupler} + RECD = dB SPL\textsubscript{Real Ear simul.}
- DSLm5 targets Original
- MLE ??
Affinity 2.0: Display coupler based REAR

UCL estimated (Pascoe) in dB SPL + RECD = dB SPL\(^{Real\ Ear\ Simulated}\)

BOLT target for MPO DSLv5

MPO measured in dB SPL\(^{HA2-coupler}\) + RECD

DSL-target for 65 dB speech DSLv5 Original

HA measured with ISTS 65 dB in SPL\(^{HA2-coupler}\) + RECD = dB SPL\(^{Real\ Ear\ simulated}\)

Residual Dynamic Range

Implementation of RECD (average or measured):
- hearing threshold and UCL in dB SPL
- dB SPL\(^{HA2-coupler}\) + RECD = dB SPL\(^{Real\ Ear\ simulated}\)
- DSLm5 target Original
- MLE ??
Case study for comparison of results

*Affinity2.0, Aurical, Verifit2*
Case Study: Comparison of REM equipment

- Child 6 years old:
  - Audiometry with headphones
  - RECD age-related averages
  - BTE hearing aids
  - Closed earmold
  - DSLv5 child
  - HA fitted and fine tuned with Verifit (precondition for comparison)

Calculation of PTA:

\[
PTA = \frac{HV_{500Hz} + HV_{1000Hz} + HV_{2000Hz}}{3}
\]

\[
PTA = \frac{40 \text{ dB} + 45 \text{ dB} + 60 \text{ dB}}{3} = 48 \text{ dB}
\]
First-Fit and Fine tuning with Verifit2 VF-2
First Fit and Fine tuning with Verifit2 VF-2

SII-Werte:
ISTS 65 dB: 74%
ISTS 55 dB: 62%
PTA: 48 dB

SII₅₅dB 62%
SII₆₅dB 74%
PTA: 48 dB HL
HA fitted with VF2 measured in Aurical
HA fitted with VF2 measured in Aurical

Verifit2 fit measured with Aurical
Otosuite Software Version 4.84.0.61

Verifit2 fit
Verifit2 Software Version 4.12.4
Fit & fine tuning to target in Aurical

PTA = 48 dB HL

SII_{55\text{db}} 56%

SII_{65\text{db}} 73%
HA fitted with VF2 measured with Affinity

At 2-4 kHz around 7-10 dB are missing

Verifit2 fit measured with Affinity
Affinity Suite Software Version 2.11.00

Verifit2 fit
Verifit2 Software Version 4.16.5
Fit and fine tuning with Affinity: SII

PTA = 48 dB HL

SII_{55\text{dB}} 73%

SII_{65\text{dB}} 73%

?
Comparison of SII values after Fine tuning

Verifit2 / Verifit 1

Aurical / Calisto

Affinity / Equinox

PTA = 48 dB HL

SII_{65db} 73%/74%
Comparison of SII values after Fine tuning

- **Verifit2 / Verifit 1**
  - Aurical / Calisto
  - Affinity / Equinox

PTA = 48 dB HL

- SII_{55\text{db}} 73%
- SII_{55\text{db}} 62%
- SII_{55\text{db}} 56%
- SII_{65\text{db}} 73%/74%
Maximum Audible Output Frequency Range

MAOF
Verification of Frequency Lowering

- Guideline for Pediatric Fitting
  - UWO, Kanda 2014

- Use of Frequency Lowering & Verification
  - Check & verify audibility for fricatives
  - Guidance
    - Signals: UWO /s/ & /sh/
    - Addendum 2, page 44-62

Quelle: www.dslio.com

University of Western Ontario, Susan Scollie et al.: Ontario Infant Hearing Program OIHP
Signals for Verification: /s/ & /sh/

- Frequency specific speech signals
- Extracted from ISTS
- Filtered and adapted
  - for better differentiation
  - adapted to level in speech
    - /s-10dB/ and /sh-6dB/ when selecting 65 dB speech level

Spectrum of the ISTS at 65 dB and LTASS from UWO /s/ and /sh/

Determination of MAOF range
in measurement results from ISTS 65 dB without Frequency Lowering

- Fitting & fine tuning to DSLm5[child]
  - Without FL activated

- Determination of MAOF range:
  - Dynamic range of ISTS 65 dB
    - intersection between LTASS and HTL
    - intersection between 99th percentile and HTL
MAOF in Verifit2:
check audibility of /s/ without Frequency Lowering activated

• Preconditions:
  – ISTS 65 dB result optimized
  – Select /s/ for next test
• Display MAOF-range in VF2
  – Select /s/
  – Select view “MAOF”
  – Record measurement

Result:
/s/ is below MAOF-range and may in normal speech not be audible
MAOF in Verifit2: Fit Frequency Lowering

- **Fit & Finetune**
  - Activate frequency lowering
  - Select /s/ for further test
  - Move the output for /s/ into MAOF range by help of frequency lowering
  - Back shoulder of /s/ should be placed in the MAOF range
MAOF in Verifit2: optimize Frequency Lowering

- Optimize FL:
  - Measure /sh /
  - /sh/ and /s/ must show clear deviation
  - If necessary reduce /s/ in clarity to ensure differentiation
  - Find a balance between utmost audibility and speech distortion

- Efficacy needs to be validated
  - Phoneme Perception Test
Verification with MAOF (Video)
Conclusions

- Measure RECD is “Best practice in HA fitting for children”, monitor quality of RECD outcome and the consequences on target match in verification.
- Verify fitting with simulated REAR in test box:
  - Minor deviations from target in certain frequencies are natural.
  - Monitor deviations from target match in high frequencies in relation to earmold quality and feedback issues.
  - SII Normative Values can help to assess own verification results in comparison to standards.
  - Average RECD is based on statics → it is expected, that individual values deviate dependent on frequency.
  - Import RECD values to fitting software → ease of recalculation for changes.

Measure & verify regularly to monitor and adapt for consistent audibility!
Thank you for listening!

Questions? Discussion?