Real Ear Probe Microphone Measurement Verification of Hearing Aids in Adults

PURPOSE

Verification procedures are an essential component of successful hearing aid fitting. The purpose of Real Ear Measurements (REMs, also known as "probe-microphone measures") is to quantify the acoustic output or gain of the hearing instrument(s) in the client's ear canal and compare against a validated prescriptive formula.

Using REMs for all hearing instrument fittings ensures that evidence-based standards are followed for the verification of hearing instrument(s) fittings, culminating in an optimal hearing instrument fitting for the client.

SCOPE

All Registered Hearing Instrument Practitioners

BACKGROUND

REMs using a probe tube *in situ* in the client's ear canal have been established as the gold standard for verifying hearing instrument fittings when initially fitting hearing instrument(s) on a client. Verification of a hearing instrument fitting has in the past been achieved using functional gain in a sound field or using simulated real-ear in a 2cc coupler. These other methods have several shortcomings (e.g., simulated real-ear in a 2cc coupler does not take into account any venting effects); therefore, REMs are the recommended verification method in adults. REMs are objective and accurate and offer a more meaningful metric than measures of functional gain. They are critical for assessing audibility, appropriate output for different input levels, and verification of prescriptive fitting formulas (Kochkin et al., 2010).

Prescriptive fitting formulas, such as NAL-NL1, NAL-NL2, and DSL V5a are evidence-based methods for determining how much amplification to provide given a particular hearing loss. Using prescriptive targets measured with REMs at the initial fitting of hearing instrument(s) allows the clinician to ensure audibility for conversational speech, to set appropriate amounts of amplification for soft sounds, and to prevent loud sounds from becoming uncomfortable. In the event that a client rejects the prescribed amount of amplification, the fitting to targets is best thought of as a "starting point." The clinician has established that the hearing instrument is functioning properly and is capable of meeting prescriptive targets. If the client prefers less amplification, the prescriptive targets could now be considered to be an amplification "goal" for the client as they adapt to their hearing instrument(s).

Hearing instrument manufacturers' first-fit algorithms are known to deviate significantly from actual prescriptive targets. Azah and Moore (2007) found that using first-fit, 64% of hearing instruments failed to come within +/- 10 dB of target at one or more frequencies. After adjusting the hearing instruments based on REM results, targets were met 83% of the time within +/- 10 dB. Similar results were found for open-fit hearing aids (Azah, Moore, & Prasher, 2012). There is no way to know if hearing instruments are meeting prescriptive targets without performing REMs, which risks compromising audibility, or potentially over-amplifying at certain frequencies.

Real-Ear-to-Couple Difference (RECD)

A measurement integral to successful REMs is the Real-Ear-to-Coupler Difference (RECD). Best practice is to perform RECD measurements, where appropriate, on adults, and this is a highly recommended component of a successful hearing aid fitting. There are certain situations where RECD measurements must be done and others where the RECD average values may suffice. All RHIPs must be equipped to perform RECD measurements when required.

The RECD allows the accurate conversion of audiometric thresholds collected with insert phones from dB HL to dB SPL (Scollie, Seewald, Cornelisse, & Jenstad, 1998) by adjusting the 2cc coupler calibration values used with insert phones. Hearing instruments and verification equipment all work in dB SPL, making this conversion crucial to ensure that appropriate targets in dB SPL are generated for each individual client. By default, most REM equipment defaults to "average RECDs," but there can be significant variations in adult ear canal sizes. This results in difference in residual ear canal volume, which would require more or less output from the hearing instrument(s) to meet targets (e.g., a smaller than average ear canal will require less amplification to meet a particular target, compared to a larger than average ear canal). The measurement of RECDs allows compensation for variations in middle ear impedance and residual ear canal volume, which can significantly influence the adult RECD (Bagatto, 2001).

Mueller (2014) thoroughly outlined the importance of RECD measurements and the rationale for performing these measurements, along with some excellent examples.

RECDs must be conducted when:

- REMs are to be performed by simulation in a coupler. The RECD measure must be completed prior to the simulated REM
- feedback from the client indicates that the hearing aid fitting results are unsatisfactory
- clinical indicators demonstrate the need (e.g. the physical properties of the ear canal are not consistent with an average ear canal)
- in the HIP's clinical judgment, there is a need for the RECD measures

APPLICATION PARAMETERS

REMS must be performed, and the hearing instrument(s) adjusted appropriately:

- for any new hearing instrument(s) received from the manufacturer to be fit to an adult client at the time of initial fitting
- in situ whenever possible. Simulated REMs should only be used when the live option is not possible, and this variation must be documented including the rationale for the variation.
- when there have been substantial changes in the client's audiometric thresholds (e.g., 20 dB or more at two or more frequencies or more than 30 dB at any single frequency)
- the venting characteristics of the hearing instrument(s) have been significantly altered (e.g., changing from an open-fit to a more occluded fitting).

- a hearing instrument is repaired or remade (i.e., received back from the manufacturer)

INTERVENTION

REM Procedures

Several detailed guides have been published describing the procedures required to successfully perform REMs:

- Real-Ear Measurement: Basic Terminology and Procedures (Pumford & Sinclair, 2001)
- Guidance on the Use of Real Ear Measurement to Verify the Fitting of Digital Signal Processing Hearing Aids (British Society of Audiology, 2007).
- Evaluating the Performance of Digital Hearing Aid Features: A Real-World Approach (Brown, 2008)

Additionally, manufacturers of REM instrumentation have detailed instruction manuals and electronic media (e.g. videos) specific to their equipment, e.g., the Audioscan Verifit.

Performing REMs

- *In situ* REM using probe tubes must be used (rather than coupler measures) unless this is not possible. Every effort must be made to perform REM *in situ*. If not possible, coupler simulated REM or sound field functional gain measurements would be required. Situations where REM is not possible include (but are not limited to) when:
  - The client is physically unable to sit still through the procedure
  - The client is in remote location and unable to come into the office
  - The hearing instrument is a deep-insertion hearing aid such as the Phonak Lyric
- Perform RECD measurements where appropriate rather than using average values.
- Use of Speech Mapping or SPL-O-GRAM type output measures is preferred over Insertion Gain methods.
- Calibrated speech signals should be used whenever available. If the equipment does not provide calibrated speech, a speech-like signal should be used (e.g., modulated speech noise).
- Obtain measures and adjust the hearing instrument(s) to target, at a minimum, for:
  - soft input levels (50-55 dB SPL)
  - average input levels (60-65 dB SPL)
  - loud input levels (70-75 dB SPL)
  - Maximum Power Output (MPO), ideally in conjunction with frequency-specific UCLs, which must not be exceeded

  NOTE: More input levels can be tested when indicated.
- Open-fit hearing instruments or those with very large vents cannot be verified using coupler measures. The reference microphone of the real ear test system must be disabled during measurement, according to the procedure specified by the manufacturer of the real ear equipment.

- Telecoil performance is best measured *in situ*, for example using the Live Speech function of a Verifit.
- REM systems can be used to measure and verify the occlusion effect.
- Directional microphone performance can be assessed using REM test systems.
- Many REM systems have special tests to verify hearing instrument features, for example noise reduction and incipient feedback.

DOCUMENTATION

- REM results showing that the hearing instrument(s) are capable of meeting the chosen prescriptive targets should be saved in the client file (either as print-outs or saved electronically).
- If hearing instrument(s) settings preferred by the client deviate (either much less or much more) significantly from prescriptive targets, those REM results should be saved in the client file (either as print-outs or saved electronically).
- If instruments cannot be programmed or set to provide adequate gain, a clinical note must be entered in the client's file.
- Documentation should be consistent with the clinical practice guideline Documentation and Record Management (CPG-04).

CLINICAL OUTCOMES

Clinical outcomes must include:

- quantifying the acoustic output or gain of the hearing instrument(s) in the client's ear canals, considering the client's specific ear canal acoustics as well as the hearing instrument(s)'s venting characteristics
- converting accurately from dBHL to dBSPL for the purposes of hearing aid fitting when RECDs are used
- matching to prescriptive targets, eliminating manufacturer first-fit deviations from those targets, and providing an evidence-based amplification starting-point for the client. In the process:
    - soft sounds are audible
    - audibility and comfort are maintained for moderate level sounds
    - loud sounds are prevented from becoming uncomfortably loud
- reference against which future electroacoustic output may be measured

REFERENCES

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RELATED CSHHPBC RESOURCES

Adult Ear-Related Red Flags Medical Referral Criteria (PROT-QA-01)

Audiologic Management of Adult Hearing Impairment (ACPG-06)

Clinical Masking for Audiometric Testing in Adults (PROT-QA -03)

Documentation and Record Management (CPG-04)

Documentation and Record Management (SOP-PRAC-01)

Hearing Assessment and Hearing Instrument Fitting and Dispensing for Adults (POLICY-QA-05)