Hearing Instrument Verification and Validation: Practical Advice That Will Improve Your Fittings

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DISCLOSURES

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What is hearing aid fitting verification?
Why is verification so important?
When should verification be done?
Verification terminology
How is verification done?
Speech Mapping
Verification of Advanced Features
“Open” setting vs. “Regular” setting
Clinical Protocols
Validation measures
What is Verification?

- **Verification** = determine if the hearing aids meet a particular standard and are performing as expected. Example: does gain match a validated, prescriptive target?
- **Validation** = Determine how effective the hearing aids are or how much benefit the patient is receiving from hearing aids in their daily life. Ex: COSI, APHAB, word recognition in noise tests, etc.
**What are Verification Tools?**

- **REM** = Real Ear Measurements = measuring gain at the eardrum vs. a prescriptive target such as NAL or DSL for various input levels

- **PMM** = Probe Microphone Measurements = REM, Speech Mapping, Advanced Feature Demonstration
Why Verify?

- Discrepancy between simulated gain and actual gain in a patient’s ear canal
- PMM are an objective ways of quantifying the amplification of a hearing instrument
- Demonstrate performance of advanced hearing aid features
- Diagnose problems when instruments are in need of repair
- Improve counseling regarding hearing aid use and expectations
- Documentation of performance
MarkeTrak survey (Hearing Journal, June 2011) showed successfully fit patients required fewer office visits.

Fewer office visits were needed when Verification AND Validation procedures were completed.

This could potentially increase the amount of time you have to see new patients.
Verification & Validation Stats

- 34% Verification & Validation
- 36% Verification Only
- 22% Neither Verification nor Validation
- 9% Validation Only

Kochkin, The Hearing Review June 2011
Time is Money

Kochkin, The Hearing Review June 2011

Patient Visits (Average)

- Verification & Validation: 2.41
- Validation Only: 2.55
- Verification Only: 2.82
- Neither Verification or Validation: 3.57
Top 10 Reasons Why Clinicians Choose Not to Verify

- Don’t own up-to-date equipment
- The patient is happy, who cares?
- There is no CPT code
- “My return rate is really low, I don’t need it”
- Changing technology (open, digitals ...) negates real ear
- Probe placement may be uncomfortable for patients
- Difficult to interpret and explain to patients
- Not knowing when to verify
- Lack of confidence in procedures
- Time
What are the goals of HA verification?

- Provided gain matches a validated, prescriptive target per the pt’s hearing loss.
- Speech is audible and comfortable.
- Amplification does not exceed tolerance.
- HI’s perform as the manufacturer specifies.
- Advanced features work as they should.
Verification Terminology and Test Signal Considerations
Real Ear Measurements

- **Response**: SPL measurement in the ear canal
  - REUR=Real Ear Unaided Response
  - REAR=Real Aided Response
- **Gain**: Derived value
  - REUG=Real Ear Unaided Gain
  - REIG=Real Ear Insertion Gain
- **Other terms**
  - REOR/REOG=Real Ear Occluded Response/Gain
  - RECD=Real Ear to Coupler Difference
Gain is the traditional way of describing HA benefit.

Gain is a DIFFERENCE measure:

Gain = Output Measurement at TM minus Input

Usually graphed from 0-60dB.

Examples: REUG, REIG, REAG
Response is graphed in dB SPL.
- Is an **ABSOLUTE** measure.
- REUR, REOR, REAR
- *Patient’s hearing loss* can also be plotted along with the probe microphone response.
- In this example, the patient has a mild to moderate hearing loss.
Another Example: Gain VS Response View
Some Test Signals

- Pure-tone: Swept up or down in frequency
- White-noise: Equal energy at all frequencies
- Pink-noise - Energy decreases with increasing frequency
- Speech-shaped noise: Spectral shape of an average speech signal
- Modulated speech shaped noise: spectral & temporal shape similar to that of speech
- ISTS: International Speech Test Signal
Performing Probe Mic Measures for Verification
Measurement Equipment

Loudspeaker (internal or external)

Reference Mic

Tube Microphone (or measurement microphone)
Today – Many systems available
Probe Tube Calibration

**Purpose:** Calibration removes the acoustic effects the probe tube can introduce during PMM...makes the probe tube/probe mic acoustically invisible.

- Place the end of the tube in the middle of the reference microphone as shown below.
- Hold the headset approx 1.5 feet from the front of the loudspeaker, run the calibration.
Probe Tube Calibration

- Place the probe tubes on top of the reference microphones.
- The calibration stops automatically when successful.

Reference Level: 63 dB

Calibration successful.

Show for new client  Start  Close  Help
Probe Tube Insertion

- Insertion of the probe: Otoscopic Exam
- Goal: Tip of the probe tube should be placed 3-5 mm from the TM
- Mark the probe tube for the appropriate measurement depth—about 28mm for females, 30mm for males.
- Insert the probe tube until the marker reaches the tragal notch as shown.
Ear Canal SPL Variability per Frequency and Distance

(Adapted from Gilman and Dirks, 1986, with permission)
How do you know?

- Measurement gives you an approximate idea
- Otoscopy
- Measure the REUG—probe mic in the ear with no hearing instrument
- Visualize the resonance of the ear canal
- Average REUG = approx 17 dB at 2700
- Video is of a live response
Probe Tube Placement
Speech Mapping
Speech Mapping

- Provides information regarding targets for aided listening
- Uses output (frequency response) rather than gain
  - Includes interactions from various algos
  - “real world” test signals can provide a more personal fitting technique
    - Spouse’s voice
    - Environmental sounds (paper rustling etc)
- Display of results provides a useful talking point for counseling
Goals of Level Dependent Amplification

- Soft Sounds should be audible
- Moderate sounds should be comfortable
- Loud sounds should be loud but not intolerable
- Test signals can be presented at levels comparable to “soft” “medium” and “loud”
- Provides real-time analysis of hearing aid performance with features activated or deactivated as desired
To verify soft speech is audible
- Deliver babble stimulus (50 to 55dB SPL)
- Response curve should be at the lower level of the audibility area

To verify moderate speech is comfortable
- Deliver babble stimulus (65 to 70dB SPL)
- Response curve should be covering the audibility area

To verify loud sounds are tolerable
- Deliver babble stimulus (~90 dB SPL)
Speech Mapping - Aurical VSM

10 dB threshold Speech Banana

Customized Speech banana
Speech Mapping - Aurical VSM
Speech Mapping
Another Reason to Verify: First Fits
Settings for first time, comfort, experienced linear, experienced non-linear have a significant effect on the gain and compression of the hearing aid.
Experience with amplification affects acceptance
Initially acceptable gain may be suboptimal for speech understanding
First fit was never meant to be “last fit”
Comfort User
Experienced Non-Linear User
Effect of Experience Level Setting: First Fit for Two Manufacturers—same audiogram

Mild sloping to moderately-severe HL

2 cc coupler output with 65 dB SPL ISTS (international speech test signal)
Verifying Advanced Algorithms
Using Speech Mapping to Verify Features

- Digital Feedback Suppression
- Noise Reduction
- Wind Noise Reduction
- Directional Microphones
Demonstrates how DFS can reduce feedback while not notching out the frequency response
Also demonstrates the amount of headroom that can be gained through the use of DFS technology
Enable probe mic but do not use any stimulus
Turn off all algos
Increase gain to the point of feedback measure output
Turn on DFS measure output
Turn up gain if headroom demonstration is desired
Digital Feedback Suppression
Demonstrates how noisy signal levels are reduced through the use of this algorithm

- Use continuous noise
  - White noise
  - Test with all other algorithms disabled
  - Obtain 2 measurements
    - 1st with noise reduction disabled
    - 2nd with noise reduction set to strong

- Use speech babble
- Patient may hear as well as see the impact of this algorithm
Modulation Detection vs Spectral Subtraction
Hearing aid wind noise is caused by turbulent air flow around the microphone. This turbulence will result in movement of the microphone diaphragm that will in turn be amplified. This amplification can overload the hearing aid resulting in wind noise. The amount of wind is dependent on wind speed. An effective demonstration can be performed in office using a motorized fan. The effect of the wind generated by the fan can be measured using a probe microphone system. Compare the measurements with and without WNR activated. Can also be used to demonstrate how microphone placement effects wind noise.
Wind Guard
Directionality

- Incorporates 2 or more microphones into the hearing instrument in order to determine the direction of the signal of interest
  - Typically monitors the time difference between microphones
- In directionality mode, the hearing instrument will reduce gain of signals presented from behind and/or to the sides of the individual
- 3% of time hearing instruments are wired backwards
  - Verifying directionality before fitting will catch this problem
Directional Test Setup

- Verify with a single noise signal presented behind the patient
  - Turn chair to 180°
- Present ANSI speech noise or babble at 65 dB SPL
  - Present stimulus with directionality ON
  - Present stimulus with directionality OFF
- Curve obtained with directionality ON will have a smaller amplitude than the curve obtained with directionality OFF
Directional Test Setup
Directional Microphone Noise

2-mic directionality with low frequency roll off

Traditional Low frequency compensation

- Good Audibility
- High Noise

- Low Noise
- Reduced Audibility
2-mic directionality with bass roll off
Traditional L/f compensation
Split Band Processing

Noise-free directionality

Omni  Directional
Directionality and Split Band
Environmental Steering
Multiple Environmental Listening Utility (MELU) Critical to Satisfying Consumers

Kochkin – MarkeTrak V
Environmental Steering Demo

- Modified pressure method using concurrent equalization regulates the loudspeaker signal to provide a constant sound pressure level.
- A reference microphone is placed near the patient's ear, and measures the sound pressure level.
- If a deviation from the desired sound pressure level occurs, the loudspeaker output is instantly adjusted.
- Therefore relatively unaffected by small head movements.
Why change to the “open” setting?

  - “One risk with the pressure method is that when an open fitting is made, amplified sound leaks out and may affect the reference microphone and thus the sound field from the loudspeaker”.
  - This causes the front speaker to adjust its levels downwards resulting in an underestimation of insertion gain.
  - The error gets larger with increasing levels of gain.
Why change to the “open” setting?

- The “open” setting uses the data collected when the REUR was run and saves that as a reference for the following measurements.
- Any leaking gain will not have an effect on the loudspeaker levels.
Why change to the “open” setting?

REIG with regular/concurrent setting (green) and with open/stored setting (red) for a profound loss
Define: Why do you want verify?
- To show what’s in the ear canal
- To demonstrate optimal settings
- To assess the performance of certain device features

Considerations
- REUG, REIG (50dB & 80 dB inputs)
- Speech Mapping (soft, medium and loud speech)
- Demonstrations (Directionality, Noise Reduction, Feedback Cancellation)
Real Ear Protocol

- Incorporate verification into your normal fitting routine
- Use a combination of gain verification and speech mapping techniques
Sample Protocol

- REUG
- REIG
  - 50 dB input
  - 80 dB input
- Speech Mapping
  - 3 levels representing soft, medium and loud speech
- Other testing/demonstrations
  - Demonstrate Noise reduction
  - Demonstrate directionality
  - Demonstrate benefits of feedback cancellation
Communicating Your Findings

- Patient is happy but Real Ear below target
  - Indicates fine tuning may be needed in the future

- Patient is having difficulty but PMM looks great
  - Realistic expectations based on audiometric testing
  - Is the hearing instrument functioning correctly
Validation
Acceptable Noise Level

- Acceptable noise level (ANL) is defined as the maximum level of background noise that an individual is willing to accept while listening to speech.
- The ANL measure assumes that speech understanding in noise may not be as important as is the willingness to listen in the presence of noise.
The ANL is established by adjusting a recorded story to the listener’s most comfortable listening level (MCL). Then the background noise is added and adjusted to the highest acceptable background noise level (BNL) while the listener is following the words of the story. The ANL, in decibels, is calculated by subtracting the BNL from the MCL.
What Can It Tell You?

- Predictor of hearing aid success
- People who accept background noise have smaller ANLs and tend to be "good" users of hearing aids
- People who cannot accept background noise have larger ANLs and may only use hearing aids occasionally or reject them altogether
- Useful for counseling and setting realistic expectations
- Mueller et al., 2006 reported reduced ANLs when digital noise reduction was activated
- Freyaldenhoven et al., 2005 showed ANLs can be improved with the use of directional hearing aid technology
Hearing Aid Outcomes

Introduction

- Issues in Evaluating the Effectiveness of Hearing Aids in the Elderly: What to Measure and When
  - Larry Humes, Ph.D.
  - Seminars in Hearing, 2001

In clinical practice if one can identify those that are not benefiting from their hearing aids, then it might be possible to intervene with more counseling, rehabilitation, or different technology.
7 Independent Dimensions of Hearing Aid Outcome

- **Subjective benefit and Satisfaction**
  - Hearing Aid Performance Inventory (HAPI)
  - Hearing Aid Satisfaction Survey (HASS)
  - Satisfaction with Amplification in Daily Life (SADL)
- **Aided performance**
  - Connected Speech Test (CST)
- **Hearing Aid Use**
  - Use Diary and/or Datalogging
- **Objective Benefit**
  - Aided-Unaided CST scores
- **High-intensity Speech in Noise**
  - CST score at 80 dB SPL, 0 dB SNR
  - Aided-Unaided CST-80 score
- **Handicap Reduction**
  - Aided-Unaided HHIE (Hearing Handicap Inventory for the Elderly) score
- **Judged Sound Quality**
  - JSQ ratings for speech and music stimuli
Summary

- Verification measurements are not just about gain and output. Many advanced signal processing features can also be verified and used in counseling.
- Validation measures are important for end users to recognize benefit, and can also be helpful for fine tuning and counseling.
- Both verification and validation are important for documentation and professionalism.
Top 10 Ways To Create Consumer Delight with Hearing Aids

- Hearing Aids that Actually Work
- Motivation
- Professionalism
- Evaluation
- Counseling
- Strong Recommendation
- Experimentation
- Verification & Validation
- Continued Connection
- You, the hearing care professional

Taylor & Rogin, Hearing Review, July 2011
Questions?

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