

Verification of Hearing Aids

A Practical Guide

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Introduction

The purpose of this volume is to provide clinicians, educators, and students with a comprehensive, evidence-based guide to hearing aid verification practices, with a particular emphasis on real ear measurements and complementary test box procedures. As hearing aid technology continues to evolve and incorporate advanced signal processing features, adaptive algorithms, and connectivity options, the need for precise, patient-centered verification has never been greater.

This book aims to bridge the gap between theory and clinical application. It offers structured protocols, practical decision-making frameworks, and detailed explanations of verification methods to ensure that devices perform as intended in real world conditions. By integrating standardized procedures with individualized care strategies, the text supports clinicians in achieving optimal auditory outcomes while maintaining efficiency in busy clinical environments.

Beyond technical guidance, the volume underscores the importance of transparency and patient engagement in the fitting process. Accurate verification not only enhances device performance but also fosters trust, satisfaction, and long-term adherence to hearing aid use. Whether addressing pediatric fittings, complex feature validation, or bimodal configurations, the chapters in this book provide actionable insights grounded in current best practices and research.

HOW TO USE THESE CHAPTERS

For Professors (Instructors, Course Directors)

- Curriculum design: Integrate chapters as required readings for courses in amplification, hearing aid fitting, or clinical audiology. Assign

specific chapters for foundational knowledge (e.g., verification methods, protocols, advanced features).

- Case-based learning: Use the provided case study format to create exam questions, Objective Structured Clinical Examinations, or in-class discussions. Encourage students to answer clinical reasoning and troubleshooting questions using evidence from the chapters.
- Assessment: Use the example answers as grading rubrics or model responses. Assign students to write their own case studies or modify existing ones for peer review.
- Protocol development: Guide students in developing or critiquing clinical protocols using the step-by-step frameworks and checklists in the chapters.
- Faculty training: Use the chapters as a reference for onboarding new clinical instructors or standardizing teaching across multiple faculty.

For Students and Other Practitioners (Graduate Doctor of Audiology, Hearing Instrument Dispensers, Audiology Assistants, Graduate Speech-Language Pathologist, Deaf Educators)

- Study guide: Read chapters before labs or clinical rotations to understand the rationale behind verification, protocols, and feature testing.
- Exam preparation: Practice answering the case study questions as if in an oral or written exam. Use the example answers to self-assess and identify knowledge gaps.
- Clinical simulation: Role-play as the clinician in the case studies by making decisions and justifying them with chapter references.
- Protocol mastery: Memorize the checklists and step-by-step procedures for real ear measurement (REM), test box verification, and troubleshooting. Apply these in simulated or real patient encounters.

- **Research projects:** Use the literature and case examples as a foundation for capstone projects, presentations, or journal club discussions.

For Clinicians (e.g., Audiologists, Hearing Instrument Specialists)

- **Clinical reference:** Keep chapters accessible in the clinic for a quick reference on verification procedures, troubleshooting, and advanced feature testing.
- **Protocol implementation:** Adopt or adapt the sample protocols and checklists to standardize care in your clinic. Use the “Monday Morning Checklist” to ensure readiness for patient appointments.
- **Continuing education:** Use the chapters for self-study or as part of in-service training. Review case studies to stay current with best practices and evidence-based care.
- **Patient counseling:** Use the counseling tips and visual explanations from the chapters to educate patients about the importance of verification and realistic expectations.
- **Quality assurance:** Audit your own practice using the documentation and protocol standards described in the chapters.

For Practice Owners (e.g., Clinic Directors, Managers, Patient Care Coordinators)

- **Quality improvement:** Use the chapters to benchmark your clinic’s protocols against best practices. Implement standardized protocols to reduce variability and improve patient outcomes.

- **Staff training:** Incorporate chapters into onboarding materials for new clinicians and support staff. Use the training plans and checklists to ensure consistency across providers.
- **Accreditation readiness:** Prepare for accreditation site visits by aligning your documentation, protocols, and quality assurance processes with the standards outlined in the chapters.
- **Equipment justification:** Use the cost-benefit analyses and sample justification letters to advocate for investment in verification equipment.
- **Patient satisfaction:** Monitor return visits, patient complaints, and satisfaction scores before and after implementing standardized protocols, as described in the case studies.

GENERAL TIPS FOR ALL USERS

- **Cross-reference:** Use the chapters together—for example, combine foundational knowledge (Chapters 1–2), protocols (Chapter 10), and advanced features (Chapters 6–8) for a holistic understanding.
- **Customization:** Adapt the protocols and checklists to fit your specific clinical environment, patient population, and available equipment.
- **Documentation:** Use the provided templates for electronic medical record documentation, checklists, and patient counseling to improve consistency and audit readiness.
- **Feedback loop:** Encourage feedback from students, clinicians, and patients to refine protocols and teaching materials over time.



Foundations of Hearing Aid Verification

INTRODUCTION TO HEARING AID VERIFICATION

Hearing aid verification is a cornerstone of best practices in audiology. It represents a suite of objective measures used to confirm that a hearing aid is providing amplification consistent with prescriptive targets derived from the patient's audiogram. The purpose of verification is to ensure that hearing aid fittings result in audibility of speech cues, comfort for the user, and maximization of speech intelligibility, particularly in complex listening environments.

Verification differs fundamentally from validation. While verification is an objective process relying on measurements taken in real ear or test box environments, validation is subjective and patient-centered. It seeks to confirm that the user derives perceived benefit from the hearing aid and that the hearing goals identified during the assessment phase are being met. Verification answers the question: "Is the hearing aid performing as intended?" Validation asks: "Is the patient satisfied and experiencing improved function in daily life?" Both are essential, but only verification provides the scientific data to inform immediate adjustments during fitting (Kossek & Flores, 2017).

The importance of verification in the overall hearing aid fitting process cannot be overstated (Jorgensen, 2016). Following the initial comprehensive audiological assessment, which includes pure-tone and speech audiometry, immittance testing, and sometimes otoacoustic emissions or auditory brainstem response testing, clinicians select an appropriate hearing aid. This selection is guided by the audiogram, by the patient's listening needs and preferences, and often by the results of speech-in-noise tests or other functional assessments. Once a device is selected and programmed according to a prescriptive fitting algorithm (e.g., National Acoustics Laboratory-[NAL]-NL2 or Desired Sensation Level [DSL] v5.0), verification is used to ensure that the device's output matches the prescribed target for that individual's hearing loss. Only after successful verification is completed does validation—through questionnaires, interviews, and self-report instruments—become meaningful.

Without verification, clinicians are relying on subjective impressions and default manufacturer settings that may not account for individual differences in ear canal acoustics or auditory processing. A well-verified fitting forms the basis of trust between the clinician and patient and is central to modern, evidence-based audiology practice.

HISTORICAL EVOLUTION

The evolution of hearing aid verification mirrors the broader development of audiology as a profession (Jerger, 2019). In the early 20th century, hearing aids were rudimentary devices with limited amplification capabilities and with no means for precise fitting. Early fittings were often based on patient feedback alone. Clinicians would ask patients how they felt about the sound and make manual adjustments, often with screwdrivers or dials on analog hearing aids. There was little to no objective measurement involved.

The limitations of these early methods were evident. Patients frequently returned with complaints about discomfort, lack of clarity, or insufficient amplification. The inability to measure actual sound pressure levels in the ear canal meant that fittings were imprecise and highly variable. This trial-and-error approach also resulted in inconsistent outcomes, with many users abandoning their hearing aids out of frustration.

In the 1970s and 1980s, a paradigm shift began with the development of real ear measurement (REM) systems. These systems used a thin probe microphone inserted into the ear canal to measure the sound pressure level at or near the eardrum. This allowed clinicians to determine exactly what the hearing aid was delivering in the patient's ear, not just what it was programmed to deliver in a test chamber. This innovation revolutionized hearing aid fitting and provided the means to match amplification precisely to the individual's prescriptive targets (Valentinuzzi, 2020).

Simultaneously, test box measures were evolving. Initially designed for quality control in manufacturing, test boxes allowed for standardized measurement of hearing aid characteristics in a controlled environment using a 2-cubic centimeter (cc) coupler. These procedures were adapted for clinical use, offering another avenue for objective assessment of hearing aid function. While test boxes do not account for individual ear canal acoustics, they are invaluable for verifying features and ensuring device functionality.

Key milestones include the introduction of digital hearing aids in the 1990s, which enabled more precise programming and better compatibility with verification systems. The development of speech mapping, a form of REM that uses live or recorded speech signals to visualize amplification, offered an intuitive and engaging way to demonstrate hearing aid performance to patients and families.

The 2000s saw the publication of several influential guidelines promoting verification as a best practice. Professional bodies such as the American Academy of Audiology (AAA) and the American Speech-Language-Hearing Association (ASHA) began emphasizing the role of verification in clinical protocols. Research during this time consistently demonstrated the positive impact of verified fittings on speech intelligibility, patient satisfaction, and hearing aid use (e.g. Narayanan & Manjula, 2021; Sanjay et al., 2025; Valente et al., 2018).

Technological advancements have continued into the 21st century and include wireless probe microphone systems, automated REM protocols, and integration of verification into hearing aid fitting software. The ongoing evolution of artificial intelligence and teleaudiology is poised to further transform verification practices and enable remote measurements and adaptive fitting algorithms that adjust in real time.

Today, verification is a standard component of high-quality hearing health care. It represents the culmination of decades of innovation, clinical research, and professional advocacy.

WHY VERIFICATION MATTERS

The clinical importance of hearing aid verification is rooted in the fundamental goals of audiological care: ensuring audibility, optimizing speech understanding, and enhancing quality of life for individuals with hearing loss. Without verification, even the most sophisticated hearing aid technologies may fail to deliver these outcomes. This section explores the multifaceted rationale behind

verification from clinical, ethical, and practical standpoints.

Clinical Rationale

Verification allows audiologists to objectively determine whether a hearing aid is delivering sound at appropriate levels for soft, moderate, and loud inputs. Through REM (e.g., Real Ear Aided Response [REAR], Real Ear Insertion Gain [REIG]) and test box outputs, clinicians can evaluate if the amplified speech signal meets prescribed targets. Prescriptive fitting methods such as NAL-NL2 and DSL are designed to balance audibility and comfort and provide appropriate gain at various frequencies (Portelli et al., 2024). Verification confirms that the gain prescribed is, in fact, being delivered.

One of the core clinical goals of hearing aid fitting is to restore access to the speech spectrum, particularly in the 1000 to 4000 Hz range where much of speech intelligibility resides (Picou et al., 2022). Without verification, a hearing aid may under-amplify key frequency regions, rendering speech muffled or unclear. Alternatively, overamplification may cause discomfort, particularly for loud sounds, increasing the risk of hearing aid rejection. Verification ensures that soft sounds are audible, moderate sounds are comfortable, and loud sounds are not uncomfortably loud.

Further, verification facilitates the fine-tuning of specific features such as directional microphones, feedback suppression, and noise reduction. Each of these features influences signal processing and real-world performance (Palmer & Zitelli, 2024a, 2024b). By confirming that these features function as intended, clinicians can optimize the hearing aid's performance for a variety of listening environments.

Ethical and Professional Responsibilities

Verification is not only clinically beneficial; it is an ethical imperative (Palmer, 2009). Audiologists are bound by professional codes of conduct

that emphasize competence, transparency, and patient-centered care.

Verification Exemplifies This Principle in Action

Providing a hearing aid without verifying its output falls short of the ethical standard of care (Palmer, 2009). Imagine a physician prescribing a medication but never checking whether it is reaching therapeutic blood levels. In audiology, a failure to verify means that clinicians are potentially delivering suboptimal or even harmful amplification. This is particularly concerning for vulnerable populations, such as children, individuals with cognitive impairments, or those with limited communication abilities—all of whom may not be able to report fitting issues.

Verification also serves a legal function. In the event of a complaint or malpractice claim, documentation of verification provides objective evidence that the clinician followed professional guidelines and applied due diligence. It protects both the patient and the practitioner.

Impact on Patient Outcomes and Satisfaction

Several studies have demonstrated that verified fittings result in significantly better outcomes than fittings based solely on manufacturer defaults or patient feedback (e.g., Narayanan & Manjula, 2021; Sanjay et al., 2025; Valente et al., 2018). Patients whose fittings have been verified show greater improvement in speech understanding, especially in noise, and report higher overall satisfaction with their hearing aids (Almufarrij et al., 2021; Leavitt & Flexer, 2012; Valente et al., 2018). This is particularly true when REMs are used to fit to a prescribed target.

For example, research comparing two groups—one fit using REM and another using first-fit settings—found that the REM group had significantly higher speech recognition scores, were more likely to continue using their devices after six months, and had more provider loyalty (Amlani

Case Study: A Tale of Two Fittings

Consider a 72-year-old patient, Mr. R, presenting with a moderate high-frequency sensorineural hearing loss. He was previously fit at another clinic and reported dissatisfaction with his hearing aids. He noted that voices sounded “boomy” and that background noise was overwhelming. His previous audiologist had relied solely on manufacturer default settings and made several subjective adjustments based on Mr. R’s feedback. As a new user with a long-standing hearing loss, he did report that it was too loud but also recognized that there were going to be changes. He was dissatisfied with his ability to hear in conversations and complained that he often heard those around him better than the person with whom he was trying to converse. He went back several times and received adjustments, but he was never satisfied. He decided to put the aids in the drawer and not wear them. After his grandson graduated from college and he struggled to hear at the graduation party, he decided to get a second opinion prior to his granddaughter’s wedding.

Upon conducting verification at the second clinic, it was determined that the hearing aids were under-amplifying speech at 2000 to 4000 Hz by 10 to 15 decibels (dB) and overamplifying low frequencies. These deviations explained Mr. R’s complaints of poor clarity and difficulty in noise. After adjusting the devices to match prescriptive targets using real ear speech mapping and verifying the directional microphone performance, Mr. R reported immediate improvement: Voices became clearer, and background noise was less distracting.

A follow-up validation using a Client-Oriented Scale of Improvement showed substantial gains in key listening situations. Mr. R expressed gratitude for the “night-and-day difference” and became a regular advocate for real ear verification, often mentioning it to friends and family who were considering hearing aids.

This case highlights how verification can improve a marginal fitting into a highly successful one—and illustrates the value of combining objective science with personalized care.

et al., 2017). Such findings underscore the real-world consequences of omitting verification. The authors further reported that even experienced users benefit from verification. When long-term hearing aid users were refit with verification-based adjustments, they reported improved listening comfort and clarity, suggesting that even small deviations from target can have meaningful perceptual effects.

Overview of Verification Methods

Verification of hearing aids relies on a set of techniques designed to assess the performance of amplification systems objectively. These methods range from in situ, patient-specific measures to standardized laboratory procedures, each serving unique clinical purposes. In this section, we will introduce the primary verification strategies used in audiology practice and focus on their applications, strengths, and limitations.

REAL EAR MEASURES (REM)

REMs are considered the gold standard for verifying hearing aid output in individual users on their ears (APSO, n.d.a). By placing a thin probe microphone into the patient’s ear canal alongside the hearing aid, clinicians can directly measure the sound pressure level delivered to the eardrum.

Key Types of REM

Real Ear Unaided Response (REUR): Measures the natural resonance of the ear canal without a hearing aid. It provides a baseline for comparison with aided responses.

Real Ear Aided Response (REAR): Measures the sound level in the ear canal with the hearing aid in place and turned on. This is compared

against prescriptive targets to assess how well the aid is performing.

Real Ear Insertion Gain (REIG): Calculates the difference between the REAR and REUR, quantifying the amount of gain provided by the hearing aid across frequencies.

Modern REM systems often include speech mapping, which uses live or recorded speech stimuli to assess the hearing aid's performance in a more realistic listening context. Speech mapping offers a visually intuitive display for patients and clinicians alike and often uses dynamic range indicators (e.g., speech banana overlays) to show how amplified speech falls within the listener's residual dynamic range.

Real-Ear-to-Coupler Difference (RECD)

RECD, when conducted on the ear, is not directly a measure of a hearing aid (Jorgensen et al., 2022). It is critical to verification, especially in pediatric audiology and other cases where in-ear measurements are not feasible (Moodie et al., 2016). It quantifies the difference in sound pressure level between a 2-cubic centimeter (2cc) coupler (used in test box measures) and the individual's real ear. This difference accounts for the unique acoustic properties of the ear canal, which can vary significantly between individuals. The goal is to accurately convert the dB Hearing Level of the audiogram to the dB Sound Pressure Level (SPL) of the hearing aid. This generates an accurate dB SPL audiogram by which the output of the hearing aid may be compared and by which the prescriptive targets are generated. Additionally, it can be used to simulate REMs in the test box. By incorporating RECD into the verification process, clinicians can ensure accurate, individualized fittings even when direct REMs are not an option.

Clinical Utility of REAR (aka Speech Mapping)

REAR, aka speech mapping, has become increasingly popular for both its diagnostic power and its

educational value. By presenting speech signals and displaying how they are amplified across frequencies and intensity levels, clinicians can:

- demonstrate the impact of the hearing aid in real time
- identify gaps in audibility
- adjust gain to ensure speech peaks fall within the user's residual dynamic range
- validate advanced processing features (e.g., compression, adaptive directionality)

For patients and family members, this visual feedback enhances understanding and engagement, often reducing skepticism and improving adherence to hearing aid use.

OTHER MEASUREMENTS

Test Box Measures

Test box verification involves placing a hearing aid in a standardized acoustic coupler within a sound-isolating chamber. A calibrated speaker delivers test signals, and microphones measure the output. While this method lacks the patient-specific accuracy of REM, particularly with venting, it offers several important applications:

- quality control and functionality checks
- baseline measurements for comparison over time
- assessment of specific features, such as maximum output (Output SPL at 90 dB SPL), harmonic distortion, and battery drain

Test box verification is also useful in pediatric fittings or when REM is not feasible, such as in cases involving very small ear canals or limited patient cooperation. The American National Standards Institute (ANSI), International Organization for Standards (ISO), and International Electrotechnical Commission (IEC) standards govern the stimuli, couplers, and procedures used in test box verification to ensure consistency across devices and settings.