

BONE-CONDUCTION TESTING

Authored by
mohammad looti

November 7, 2025

RECOMMENDED CITATION

mohammad looti (2025). *BONE-CONDUCTION TESTING*. PSYCHOLOGICAL SCALES.
Retrieved from <https://scales.arabpsychology.com/?p=66141>

BONE-CONDUCTION TESTING

Primary Disciplinary Field(s): Audiology, Otolaryngology, Experimental Psychology

1. Core Definition and Diagnostic Purpose

Bone-conduction testing represents an indispensable diagnostic procedure within the field of clinical audiology, serving as a critical complement to standard air-conduction pure-tone audiometry. This test bypasses the conventional route of sound transmission through the outer and middle ear--the air-conduction pathway--and instead directly stimulates the cochlea, or inner ear, via mechanical vibration transmitted through the skull bones. By measuring the integrity of the inner ear and the neural auditory pathways independently of the sound transmission system, bone-conduction testing allows audiologists to precisely determine the type of hearing loss exhibited by a patient. This differential diagnosis is fundamental, confirming whether previously detected hearing loss results predominantly from sensorineural problems (damage to the cochlea or auditory nerve) or from conductive factors (impairment in the outer or middle ear).

The core objective of this technique is to establish the patient's bone-conduction thresholds--the softest intensity level, measured in decibels hearing level (dB HL), at which a patient can perceive sound presented through the bone vibrator across controlled standard audiometric frequencies (typically 250 Hz to 4000 Hz). When comparing these thresholds to those obtained through air conduction, a powerful diagnostic tool emerges, distinguishing mechanical impedance issues (e.g., fluid in the middle ear, ossicular discontinuity) from sensory organ damage (e.g., presbycusis, noise exposure). This differentiation is paramount for determining appropriate medical or surgical interventions versus the need for hearing amplification devices.

The resulting data is charted on an audiogram, utilizing specific symbols to denote bone-conduction thresholds (often < or > for unmasked thresholds, and for masked thresholds). The relationship between the air-conduction scores and the bone-conduction scores is quantitatively expressed through the calculation of the Air-Bone Gap (ABG), a fundamental indicator of the degree of conductive involvement. A small or nonexistent ABG indicates a purely sensorineural loss, where sound transfer is unimpaired but the sensory organ is damaged, whereas a significant ABG points directly to a conductive element causing the sound attenuation.

2. Physiological Mechanism of Bone Conduction

The transmission of sound energy through bone conduction relies on complex biophysical processes that utilize the mechanical coupling between the vibrator and the skull, which subsequently causes vibrations within the cochlear fluids. Unlike air conduction, which relies on the eardrum and ossicles, bone conduction stimulates the inner ear directly through three primary, interacting mechanisms, all contributing to the final perceived sound. Understanding these

mechanisms is essential for interpreting bone-conduction thresholds accurately, especially when dealing with anomalies such as the occlusion effect.

The first mechanism is known as **Distortional Bone Conduction**. This occurs when the skull vibrates as a unit, causing the bony walls of the cochlea to distort or compress. These distortions create pressure waves within the perilymph and endolymph fluids housed inside the cochlea, directly stimulating the hair cells of the Organ of Corti. This method of stimulation bypasses the external auditory canal and middle ear entirely, making it the purest measure of sensorineural function. Distortional bone conduction is particularly relevant at higher frequencies, where the skull vibrations are more efficiently transmitted directly to the inner ear structures.

The second mechanism is **Inertial Bone Conduction**, which primarily impacts lower frequencies (below 1000 Hz). The skull vibrates, but the ossicular chain (malleus, incus, stapes) lags slightly due to its inertia. This differential movement between the surrounding temporal bone and the ossicles causes the stapes footplate to move in and out of the oval window, mimicking the piston-like action seen in air conduction, thereby creating fluid displacement within the cochlea. A third mechanism, known as **Osseotympanic Bone Conduction**, involves the vibration of the temporal bone causing sound energy to radiate into the external ear canal. If the canal is open, this sound dissipates; however, if the canal is occluded (e.g., by a headphone or an earplug), the sound is reflected back toward the tympanic membrane, resulting in a low-frequency enhancement of bone-conduction sensitivity known as the occlusion effect.

3. Instrumentation and Methodology

Bone-conduction testing is performed using specialized equipment integrated into a clinical audiometer. The key instrument is the bone-conduction vibrator or oscillator, a small transducer that converts electrical signals from the audiometer into mechanical vibrations. This vibrator is typically held firmly against the patient's head using a specialized metal headband to ensure adequate pressure and reliable acoustic contact with the bone. The standard placement locations for the oscillator are either the mastoid process, the bony prominence immediately behind the auricle (pinna), or, less commonly, the center of the forehead.

The mastoid placement is the standard method because it generally yields the most sensitive thresholds, placing the oscillator closer to the cochlea. However, the forehead placement offers advantages in terms of test-retest reliability and less variance due to soft tissue interference, although it typically requires slightly higher output levels. Regardless of placement, the audiologist must ensure the vibrator is centered and maintained with consistent pressure throughout the test sequence to avoid artifactual variability in the measurements. Furthermore, unlike air-conduction testing where high output levels are achievable, bone-conduction testing is limited by the maximum output capability of the transducer, often resulting in lower maximum intensity levels, particularly at

high frequencies, due to the need to prevent signal distortion or discomfort.

The procedural methodology follows the standardized pure-tone audiometric technique, usually employing a bracketing procedure (e.g., Hughson-Westlake procedure) to determine the patient's threshold for each tested frequency. Sound is presented in controlled increments, and the patient responds when the tone is heard. Crucially, the process of bone-conduction testing often necessitates the use of masking--introducing controlled noise to the non-test ear--to prevent the signal delivered to the bone vibrator from crossing over and being perceived by the better ear. Because bone conduction effectively stimulates both cochleae simultaneously due to the skull's excellent conductivity, masking is required whenever there is a possibility that the non-test ear might respond, a necessary step to ensure the measured threshold truly represents the sensitivity of the ear under examination.

4. The Role of the Air-Bone Gap (ABG)

The clinical interpretation of the relationship between air-conduction (AC) thresholds and bone-conduction (BC) thresholds is centered entirely on the magnitude and configuration of the Air-Bone Gap (ABG). The ABG is defined simply as the difference (in dB) between the AC threshold and the corresponding BC threshold at a given frequency. This gap is the cornerstone of differential diagnosis in audiometry.

If the ABG is negligible (typically defined as 10 dB or less across all frequencies), the audiologist concludes that the hearing loss is **sensorineural**. In this scenario, the air-conduction pathway and the bone-conduction pathway yield similar results because the sound transmission system (outer/middle ear) is intact, and the hearing loss originates exclusively within the cochlea or the auditory nerve. Examples include noise-induced hearing loss or hereditary hearing loss. Treatment focuses on amplification or addressing the underlying neural condition, as mechanical repair is not applicable.

Conversely, a significant ABG (greater than 10 dB) indicates the presence of a **conductive component**. When a gap exists, it means the bone-conduction scores are significantly better (lower dB HL) than the air-conduction scores. The inner ear (measured via BC) is relatively functional, but the outer or middle ear transmission system (measured via AC) is impaired. The size of the ABG directly correlates with the severity of the conductive pathology, which could range from simple cerumen impaction or middle ear fluid (otitis media) to complex issues like otosclerosis or tympanic membrane perforation. In these cases, the conductive element is often medically or surgically treatable, potentially restoring hearing to the level indicated by the bone-conduction threshold.

5. Clinical Applications and Classification of Hearing Loss

Bone-conduction testing is vital not only for identifying the locus of the hearing impairment but also for guiding rehabilitation and medical management. The resulting pure-tone audiogram, utilizing both AC and BC data, permits the classification of hearing loss into three primary types: conductive, sensorineural, or mixed. This classification dictates the subsequent clinical pathway, whether it involves pharmacological intervention, surgical repair, or fitting of hearing aids. For instance, a patient with a large ABG due to chronic middle ear fluid will likely be referred to an otolaryngologist, while a patient with a purely sensorineural loss is typically referred for audiological rehabilitation.

A **Mixed Hearing Loss** diagnosis arises when both the air-conduction and bone-conduction thresholds are poorer than normal, and a significant ABG is also present. This indicates simultaneous damage to both the conductive mechanism and the sensorineural mechanism. In this scenario, the BC threshold reveals the extent of the permanent inner ear damage, while the ABG reveals the degree of potentially reversible conductive pathology. This delineation is crucial for prognosis, allowing clinicians to predict the maximum level of hearing improvement possible after addressing the conductive element.

Beyond traditional pure-tone testing, bone conduction principles are applied in other specialized audiological tests, such as the Weber Test and the Rinne Test, though these are typically qualitative tuning fork tests rather than quantitative audiometric measures. Modern applications also extend to bone-anchored hearing systems (BAHS), where the technology utilizes sophisticated bone conduction to transmit sound directly to the cochlea, bypassing untreatable conductive pathologies. Bone-conduction transducers are also utilized in electrophysiological tests, such as Auditory Brainstem Response (ABR) testing, particularly when assessing hearing sensitivity in infants or difficult-to-test populations where standard air-conduction methods may be unreliable or impossible.

6. Historical Evolution of Bone-Conduction Testing

The recognition that sound could be perceived through mechanical vibration of the skull predates modern electronic audiometry by centuries. Early understanding of bone conduction is often attributed to figures like Ludwig van Beethoven, who reportedly used a wooden rod connected to his piano to perceive music through the bone as his hearing deteriorated. The scientific exploration, however, formalized the phenomenon through the work of 19th-century physicians who developed the foundational tuning fork tests.

The most enduring of these early methods are the Rinne and Weber tests, both of which rely on bone conduction to differentiate hearing loss types. The Rinne test compares a patient's hearing by air conduction versus bone conduction using a vibrating tuning fork placed on the mastoid process.

A positive Rinne suggests a normal or sensorineural system, while a negative Rinne suggests a conductive loss. The Weber test, which places the fork on the forehead or vertex, determines whether the sound is centralized (normal) or lateralized to one ear, an outcome crucial for diagnosing the side of the conductive or sensorineural pathology. While these tests are qualitative, they established the critical principle: if the sound bypasses the outer and middle ear, the remaining hearing function belongs to the inner ear.

The advent of standardized electronic audiometers in the mid-20th century allowed for the transition from qualitative tuning fork observations to the precise, quantitative measurement of bone-conduction thresholds across specific frequencies. This technological leap standardized the placement of the oscillator and provided calibrated output, making the comparison between air and bone thresholds (the ABG) a reliable and repeatable diagnostic metric. Modern audiology owes its precise diagnostic capabilities largely to this standardization, enabling accurate medical referrals and rehabilitation planning based on the objective measurement of the bone-conduction pathway.

7. Limitations and Technical Challenges

Despite its diagnostic power, bone-conduction testing is subject to several important limitations and technical challenges that require careful clinical management. One primary constraint is the physical output limitation of the bone vibrator. Unlike air-conduction earphones, which can typically deliver stimuli up to 110 or 120 dB HL, bone vibrators are limited to lower output levels, particularly at high frequencies, due to the rapid onset of distortion and the discomfort caused by intense mechanical vibration. This means that individuals with severe or profound sensorineural hearing loss may not have their true bone-conduction thresholds measured, as the sound required to reach their threshold exceeds the transducer's physical limits--a condition known as "out of range."

A critical technical challenge is the mandatory use of masking. Since the skull is highly conductive, any sound presented to one side via the bone vibrator is immediately audible to the other cochlea at similar intensity levels. Therefore, whenever the bone-conduction threshold of the test ear is significantly poorer than the air-conduction threshold of the non-test ear, masking noise must be introduced to the non-test ear to keep it busy. Improper or insufficient masking can lead to "shadow audiograms," where the better ear responds for the poorer ear, artificially improving the perceived bone-conduction thresholds and potentially misdiagnosing a conductive loss as a mixed loss, or vice versa.

Finally, bone-conduction results can sometimes be complicated by **tactile responses**, particularly at very low frequencies (250 Hz and 500 Hz) and high stimulus intensities. If the stimulus intensity is high enough, the patient may not be hearing the sound but rather perceiving the mechanical vibration as a tactile sensation on the skin, thus giving a false threshold response. The audiologist must be trained to recognize and differentiate true auditory thresholds from these tactile artifacts,

usually by careful instruction to the patient and observation of the frequency-specific threshold pattern. These constraints underscore the need for rigorous clinical calibration and meticulous procedural execution during all bone-conduction testing.

Further Reading

[Audiogram](#)

[Air-conduction testing](#)

[Air-Bone Gap \(ABG\)](#)

[Bone Conduction](#)

[Sensorineural Hearing Loss](#)

[Masking in Audiology](#)

ARABPSYCHOLOGY.COM