Overview

Pure-tone audiometry is a behavioral test used to measure hearing sensitivity. This measure involves the peripheral and central auditory systems. Pure-tone thresholds (PTTs) indicate the softest sound audible to an individual at least 50% of the time. Hearing sensitivity is plotted on an audiogram, which is a graph displaying intensity as a function of frequency.

Degrees of hearing loss

- Normal hearing (0-25 dB): At this level, hearing is within normal limits.
- Mild hearing loss (26-40 dB): Mild hearing loss may cause inattention, difficulty suppressing background noise, and increased listening efforts. Patients with this degree of loss may not hear soft speech. Children may be fatigued after listening for long periods.
- Moderate hearing loss (41-55 dB): Moderate hearing loss may affect language development, syntax and articulation, interaction with peers, and self-esteem. Patients with this degree of loss have trouble hearing some conversational speech.
- Moderate-severe hearing loss (56-70 dB): Moderate-severe hearing loss may cause difficulty with speech and decreased speech intelligibility. Patients with this degree of loss do not hear most conversational-level speech.
- Severe hearing loss (71-90 dB): Severe hearing loss may affect voice quality.
- Profound hearing loss (>90 dB): With profound hearing loss (deafness), speech and language deteriorate.

Types of hearing loss

- Conductive
  - Conductive hearing loss has normal bone-conduction thresholds, but air-conduction thresholds are poorer than normal by at least 10 dB.
  - Conductive hearing loss is secondary to an outer ear or middle ear abnormality, which can include abnormalities of the tympanic membrane. The abnormality reduces the effective intensity of the air-conducted signal reaching the cochlea, but it does not affect the bone-conducted signal that does not pass through the outer or middle ear.
  - Examples of abnormalities include occlusion of the external auditory canal by cerumen or a mass, middle ear infection and/or fluid, perforation of the tympanic membrane, or ossicular abnormalities. Pure-tone air-conduction thresholds are poorer than bone-conduction thresholds by more than 10 dB (see image below).

Audiogram depicting a mild rising conductive hearing loss in the left ear. Note the significant air-bone gaps.
• **Sensorineural**
  ◦ Sensorineural hearing loss has bone- and air-conduction thresholds within 10 dB of each other, and thresholds are higher than 25 dB HL. See image below.

![Audiogram depicting a high-frequency sloping sensorineural hearing loss in the left ear.](image)

  ◦ Sensorineural hearing loss is secondary to cochlear abnormalities and/or an abnormality of the auditory nerve or central auditory pathways. Because, in this type of hearing loss, the outer ear and middle ear do not reduce the signal intensity of the air-conducted signal, both air- and bone-conducted signals are effective in stimulating the cochlea. Pure-tone air- and bone-conduction thresholds are within 10 dB.
  ◦ Examples included presbycusis, noise-induced hearing loss, Ménière disease, and retrocochlear lesions such as vestibular schwannoma.

• **Mixed**
  ◦ Mixed hearing loss has conductive and sensorineural components.
  ◦ This type of hearing loss has sensorineural and conductive components. Pure-tone air-conduction thresholds are poorer than bone-conduction thresholds by more than 10 dB, and bone-conduction thresholds are less than 25 dB (see image below).

![Audiogram depicting a mixed sloping hearing loss in the left ear.](image)

**Terminology**

• **Audiogram**
  ◦ The audiogram is a chart of hearing sensitivity with frequency charted on the abscissa and intensity on the ordinate (see images shown above). Intensity is the level of sound power measured in decibels; loudness is the perceptual correlate of intensity.
  ◦ For threshold testing intensity, decibels are measured in hearing level (HL), which is based on the standardized average of individuals with normal hearing sensitivity. HL is not equivalent to sound pressure level (SPL), but the American National Standards Institute (ANSI) has defined a relationship between SPL and HL for each audiometric frequency from 250-8000 Hz.

• **Frequency**
  ◦ Frequency is cycles per unit of time. Pitch is the perceptual correlate of frequency. Frequency is measured in hertz, which are cycles per second.
  ◦ Usually frequencies of 250-8000 Hz are used in testing because this range represents most of the speech spectrum, although the human ear can detect frequencies from 20-20,000 Hz. Some children can detect even higher frequencies.

• **Pure-tone average**
Pure-tone average (PTA) is the average of hearing sensitivity at 500, 1000, and 2000. This average should approximate the speech reception threshold (SRT), within 5 dB, and the speech detection threshold (SDT), within 6-8 dB.

If the SRT is significantly better than the PTA, the possibility of pseudohypoacusis should be considered. If the PTA is significantly better than the SRT, the possibility of central involvement should be considered.

- **Speech reception threshold**
  - The SRT is the softest intensity spondee words that an individual can repeat at least 50% of the time.
  - Spondees are bisyllabic words equally emphasizing both syllables. In some cases (eg, patients with poor word recognition), a limited set of words may be used.

- **Speech detection threshold**
  - The speech detection threshold (SDT), also termed the speech awareness threshold (SAT), is the lowest intensity speech stimulus that an individual can detect at least 50% of the time.

- **Word recognition**
  - Word recognition (formerly called speech discrimination) is the ability to repeat correctly an open set of monosyllabic words at suprathreshold intensity. Word lists are phonetically balanced (PB), meaning that the speech sounds used occur with the same frequency as in the whole language.
  - The score represents the percent of words correct for most word recognition tests.

### Common audiogram/audiologic assessment abbreviations

- CNT - Could not test
- DNT - Did not test
- HA - Hearing aid
- HAE - Hearing aid evaluation
- NR - No response
- SNHL - Sensorineural hearing loss
- WNL - Within normal limits
- AU - Both sides (ears)
- AS - Left
- AD - Right
- VT - Vibrotactile response
- RTC - Return to clinic
- PRN - As needed
- BC - Bone conduction
- AC - Air conduction
- PTA - Pure-tone average
- UCL - Uncomfortable loudness level
- MCL - Most comfortable loudness level
- HFA - High frequency average
- HL - Hearing level
- SPL - Sound pressure level
- SRT - Speech reception threshold
- SAT - Speech awareness threshold

### Indications

- The usual primary purpose of pure-tone tests is to determine the type, degree, and configuration of hearing loss.

### Contraindications

- Patients unable to cooperate because of young age or other conditions cannot undergo pure tone audiometry. They may need to have the auditory system tested by other methods.

### Anesthesia

- The patient cannot be sedated or under anesthesia for pure tone audiometry.

Equipment

- The necessary equipment depends on the testing method used and may include the following:
  - Headphones
  - Insert earphones
  - Speakers
  - Bone-conduction oscillator

Positioning

- Patients are usually seated in a comfortable position.

Technique

Air conduction

- This test assesses sensitivity when the signal is transmitted through the outer, middle, and inner ear and then through the brain to the cortex. Testing may be performed using headphones, insert earphones, or sound fields.
- Headphones are placed over the outer ear. Circumaural headphones have a large cushion and fit around the ear, contacting the head. These generally are used to reduce ambient noise. Supra-aural headphones are more common and rest on the ear or pinna, but they typically provide no ambient noise reduction and may collapse the ear canals.
- Insert earphones are transducers housed in a small box approximately 2" by 3" by 0.5". The signal is transmitted down a tube to foam tips, which fit in the ear canal. Insert earphones help reduce collapsing ear canals, and they reduce ambient noise and crossover of auditory stimuli to the nontest ear via skull transmission.
- Sound-field (free-field) testing signals are presented via speakers, usually at a 45° azimuth to the patient's face. This form of testing is used with infants, toddlers, and other individuals with special needs for whom earphone use may be problematic. During sound-field testing, an individual sits in the center of the room, facing forward, halfway between each speaker. Typically, visual-reinforcement audiometry (toys light and animate when the child responds to sound); conditioned-orientation response audiometry (toys on both sides test localization); or play audiometry (various games, eg, dropping a block in response to sound) are used. These conditioned responses to auditory stimulus provide reinforcement that allows for measurable responses and longer interest in the test situation.
- In a sound field, the auditory signals are warble tones or bursts of narrow-band noise. Pure tones cannot be used because they can create standing waves in a sound field, which can alter signal intensity.
- Sound-field testing may also assess hearing aid benefit. Placing the person in the center of the room (facing the speakers) yields aided thresholds. The difference between aided and unaided thresholds is termed functional gain.

Bone conduction

- This technique assesses sensitivity when the signal is transmitted through the bones of the skull to the cochlea and then through the auditory pathways of the brain. This type of testing bypasses the outer and middle ear.
- A small oscillator is placed on the forehead or more commonly, the mastoid bone. The device stimulates the bones of the skull, which in turn stimulates both cochleae. The oscillator may produce a vibration that is perceived by the patient, thus eliciting a vibrotactile response instead of a response to the auditory stimulus.

Crossover

- Crossover occurs when sound presented to the test ear travels across the head to the nontest ear. This occurs at approximately 40 dB for circumaural earphones across all frequencies. When hearing sensitivity is much poorer in the test ear than the nontest ear, the signal may cross over and be perceived in the ear with better hearing, thus yielding a false impression of the intended test ear's sensitivity.
- Insert earphones reduce the crossover by reducing surface contact area.
Masking

- Masking presents a constant noise to the non-test ear to prevent crossover from the test ear. The purpose of masking is to prevent the non-test ear from detecting the signal (line busy), so only the test ear can respond.
- When a signal is presented to the test ear, the signal may also travel through the head and reach the cochlea on the other side. However, the intensity of the signal from the test to the non-test ear can be reduced by the mass of the head. This signal reduction is called interaural attenuation. For bone conduction, the interaural attenuation may be as low as 0 dB because the bones of the skull are very efficient at transmitting sound. Thus, any suspected difference in bone conduction between the test and non-test ears requires masking. Interaural attenuation for air conduction can range between 40 and 80 dB. Masking should be used if the difference in air conduction in one ear and bone conduction in the other ear is 40 dB or greater.
- Thresholds obtained with masking in the contralateral ear are called masked thresholds and should represent the true threshold of the test ear. A masking dilemma occurs when masking from the non-test ear crosses over to the test ear and affects threshold testing for the test ear. In this case, a reliable masked threshold cannot be obtained, and it is referred to as the masking dilemma. This phenomenon generally occurs only in the presence of a substantial conductive component to the hearing loss and is less problematic with the more common use of insert earphones.

Pure-Tone Audiograms Typical of Common Auditory Disorders

Presbycusis (age-related hearing loss)

Presbycusis usually manifests as a bilateral and symmetric sensorineural hearing loss. Usually, the higher frequencies are most severely affected. Word recognition may be poorer than predicted from the audiogram. A person with presbycusis may have more difficulty with hearing aids than a younger patient with equivalent hearing loss.

Onset of presbycusis typically occurs in middle-aged or older patients. Hearing loss is secondary to degeneration of the cochlea, cranial nerve VIII, and/or the central auditory system. The condition is usually slowly progressive.

Otitis media

This condition is marked by fluid in the middle ear space, which may be caused by inflammation of the middle ear lining or inadequate aeration of the middle ear space. Otitis media frequently results in flat or up-sloping conductive hearing loss. Word recognition usually is excellent. With acute otitis media, otalgia or fever may accompany the condition.

Onset can occur at any age, but otitis media is most common in young children. Without intervention, the fluid can become more viscous, and greater hearing loss develops as the middle ear mechanism stiffens. In some cases, otitis media can progress to mastoiditis, and/or cholesteatoma.

Noise-induced hearing loss

Exposure to high-intensity noise may cause temporary or permanent hearing loss. Repeated exposure to noise trauma may change a temporary threshold shift (TTS) to a permanent threshold shift (PTS). However, PTS can occur secondary to a single noise exposure in some cases. Degree and configuration of hearing loss depends on time exposure, sound intensity, and sound frequency characteristics. Noise-induced hearing loss is typically greatest in the 4000- to 6000-Hz region.

With more intense sound, the exposure time before hearing loss may be shorter (Occupational Safety and Health Administration [OSHA] standard 29 CFR 1910.95 addresses exposure limits). Noise-induced hearing loss is sensorineural except in certain blast injuries with possible tympanic membrane and middle ear damage.

Onset may occur at any age, and intersubject variability is high even for the same exposure. Hearing loss may be unilateral or bilateral but is usually bilateral. Asymmetric noise exposure (e.g., from firearms) may yield asymmetric hearing loss. Degree of hearing loss can vary. Complaints of muffled hearing or tinnitus are common. Hearing loss is secondary to cochlear damage (see image below).
Audiogram depicting a high-frequency sensorineural hearing loss in the right ear. The pattern exhibits the greatest hearing loss in the 4000- to 6000-Hz region (with some recovery at 8000 Hz) and is typical of noise-induced hearing loss.

**Otosclerosis**

Otosclerosis causes a slowly progressive conductive or mixed hearing loss. Word recognition is usually excellent when speech is sufficiently loud. The condition is caused by stapedial fixation in the oval window, stiffening the middle ear system.

Onset usually occurs when patients are aged 15-45 years, and otosclerosis is more common in women than in men. One half of patients report a family history of otosclerosis (see image below).

Audiogram depicting a moderate-severe conductive hearing loss consistent with otosclerosis.

Otosclerosis surgery is shown in the images below.

Video of laser stapedotomy with SMart piston prosthesis.

Video of bucket handle prosthesis positioning.

**Ménière disease**

Ménière disease affects the cochlear and vestibular systems. Attacks lasting from 20 minutes to several hours generally include some combination of vertigo, hearing loss, sensation of aural fullness, and tinnitus. Tinnitus and hearing loss may persist between attacks. Hearing loss is usually unilateral, at least in the early stages, and fluctuant, but it typically develops into a permanent sensorineural hearing loss. Many patients report increased sensitivity to loud noises (recruitment) in addition to the listed symptoms. Word recognition is frequently poorer than predicted from pure-tone audiogram.

Onset for approximately one half of patients occurs when aged 40-60 years. The disease is rare in children (see image below).
Audiogram depicting a mild rising sensorineural hearing loss in the right ear typical of Ménière disease.

Contributor Information and Disclosures

Author
Joe Walter Kutz Jr, MD  Assistant Professor, Department of Otolaryngology-Head and Neck Surgery, University of Texas Southwestern Medical Center

Joe Walter Kutz Jr, MD is a member of the following medical societies: Alpha Omega Alpha, American Academy of Otolaryngology-Head and Neck Surgery, American Neurotology Society, and Texas Medical Association

Disclosure: Nothing to disclose.

Coauthor(s)
Ginger Mullin, AuD  Newborn Infant Hearing Screening Program, Division of Specialized Care for Children, State of Illinois

Disclosure: Nothing to disclose.

Kathleen C M Campbell, PhD  Professor, Director of Audiology Research, Department of Surgery, Division of Otolaryngology, Southern Illinois University School of Medicine

Kathleen C M Campbell, PhD is a member of the following medical societies: American Academy of Otolaryngology-Head and Neck Surgery, American Auditory Society, American Tinnitus Association, Association for Research in Otolaryngology, and New York Academy of Sciences

Disclosure: Nothing to disclose.

Specialty Editor Board
Carol A Bauer, MD, FACS  Associate Professor of Surgery, Division of Otolaryngology-Head and Neck Surgery, Southern Illinois University School of Medicine

Carol A Bauer, MD, FACS is a member of the following medical societies: American Academy of Otolaryngology-Head and Neck Surgery, American Neurological Association, and Society of University Otolaryngologists-Head and Neck Surgeons

Disclosure: Nothing to disclose.

Francisco Talavera, PharmD, PhD  Adjunct Assistant Professor, University of Nebraska Medical Center College of Pharmacy; Editor-in-Chief, Medscape Drug Reference

Disclosure: Medscape Salary Employment

Gerard J Gianoli, MD  Clinical Associate Professor, Department of Otolaryngology-Head and Neck Surgery, Tulane University School of Medicine; Vice President, The Ear and Balance Institute; Chief Executive Officer, Ponchartrain Surgery Center

Gerard J Gianoli, MD is a member of the following medical societies: American Academy of Otolaryngology-Head and Neck Surgery, American College of Surgeons, American Neurotology Society, American Otological Society, Society of University Otolaryngologists-Head and Neck Surgeons, and Triological Society

Disclosure: Vesticon, Inc. None Board membership

Christopher L Slack, MD  Otolaryngology-Facial Plastic Surgery, Private Practice, Associated Coastal ENT; Medical Director, Treasure Coast Sleep Disorders

Christopher L Slack, MD is a member of the following medical societies: Alpha Omega Alpha, American Academy of Facial Plastic and Reconstructive Surgery, American Academy of Otolaryngology-Head and Neck Surgery, and American Medical Association

http://emeds.png
Disclosure: Nothing to disclose.

Chief Editor

Arlen D Meyers, MD, MBA  Professor, Department of Otolaryngology-Head and Neck Surgery, University of Colorado School of Medicine

Arlen D Meyers, MD, MBA is a member of the following medical societies: American Academy of Facial Plastic and Reconstructive Surgery, American Academy of Otolaryngology-Head and Neck Surgery, and American Head and Neck Society

Disclosure: Covidien Corp Consulting fee Consulting; US Tobacco Corporation Unrestricted gift Unknown; Axis Three Corporation Ownership interest Consulting; Omni Biosciences Ownership interest Consulting; Sentegra Ownership interest Board membership; Syndicom Ownership interest Consulting; Oxlo Consulting; Medvoy Ownership interest Management position; Cerescan Imaging Honoraria Consulting; GYRUS ACMI Honoraria Consulting

References


Medscape Reference © 2011 WebMD, LLC