



# REVIEW OF AGE-RELATED HEARING LOSS AND EXPLORING CUTTING-EDGE INNOVATIONS IN HEARING LOSS TECHNOLOGY

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**Abstract :** Age-related hearing loss, or presbycusis, poses a significant health challenge globally, particularly among older adults. With approximately one in three individuals over the age of 65 affected, its prevalence underscores the need for effective diagnostic measures and management strategies. Diagnostic tools such as pure tone audiometry, Otoacoustic emissions, and auditory brainstem response testing play crucial roles in identifying and assessing age-related hearing loss. Management strategies have evolved from traditional hearing aids to include innovative approaches like cochlear implants, assistive listening devices, and regenerative medicine.

**Index Terms -** Hearing loss, technology, cochlear implants, regenerative medicine, gene therapy, tele-audiology, assistive listening devices

## INTRODUCTION.

Hearing loss is a prevalent sensory impairment affecting older adults globally, impacting their quality of life and overall well-being. More than 5% of the global population, totaling 430 million individuals (including 34 million children), need rehabilitation for their hearing impairments. Projections suggest that by 2050, this figure will exceed 700 million, affecting 1 in 10 people worldwide. Hearing aids are electrical devices specifically engineered to enhance sound, thereby assisting those with hearing impairments in their ability to communicate and engage in social activities.<sup>1</sup> Evolving technology has transformed them from basic amplifiers to sophisticated devices with digital processing and wireless connectivity, tailored to address diverse aspects of hearing loss.<sup>2</sup> Although traditional hearing aids have historically been the main method for addressing hearing loss, recent technological developments have resulted in the creation of state-of-the-art technologies that provide new opportunities and optimism for those with hearing impairment.<sup>3</sup> This article provides a comprehensive overview of hearing loss in older adults, etiology, clinical manifestations, diagnostic approaches, and management strategies including the latest breakthroughs in hearing loss technology. It aims to enhance understanding among healthcare professionals and facilitate improved care for older adults with hearing loss.<sup>4</sup>

## 1. Age-related hearing loss an overview

Presbycusis, or age-related hearing loss, refers to the steady decrease in auditory ability that occurs in both ears. It is a common problem that frequently appears in older adults, affecting almost one out of every three individuals who are 65 years or older.<sup>4</sup> Due to its gradual onset, individuals may not initially recognize the changes in their hearing abilities. In general, it mostly affects the perception of high-frequency noises, such

as the sound of a ringing phone or the beeping of a microwave, while the capacity to hear low-frequency sounds is mostly unchanged.<sup>5</sup>

## 2. Etiology

Age-related hearing loss can stem from various factors, primarily affecting:

1. The inner ear (most prevalent)
2. The middle ear
3. The nerve pathways to the brain
4. Other factors contribute to age-related hearing loss, including:
  - Prolonged exposure to loud noises, like music or occupational sounds
  - Degeneration of hair cells, which are sensory receptors in the inner ear
  - Genetic predisposition
  - Aging process itself
  - Various health conditions such as heart disease or diabetes
  - Adverse effects of certain medications, such as aspirin and specific antibiotics

## 3. Clinical Manifestations

- Diminished ability to hear noises with a high frequency.
- Difficulty hearing the voices of women or children.
- Struggles with background noises and clear speech comprehension.
- Perception of certain sounds as overly loud.
- Challenges in hearing amidst noisy environments.
- Difficulty distinguishing between sounds like "s" and "th".
- Occurrence of ringing feels in the ears (tinnitus).
- Increasing volume of electronic devices beyond normal levels.
- Frequently asking for repetition during conversations.
- Difficulty understanding phone conversations.<sup>4,5</sup>

## 4. Diagnostic Approaches

**4.1. Pure tone audiometry:** Pure-tone testing evaluates the auditory system by utilizing two pathways. During air conduction (AC) testing, sound waves travel through the external auditory canal, cross the tympanic membrane, ossicular chain, and cochlea, then ultimately reach the cochlear nerve, which is part of cranial nerve VIII. Subsequently, the sound waves traverse the brainstem until they ultimately reach the auditory cortex. During bone conduction (BC) testing, sound waves directly stimulate the cochlea through the vibration of a bone conduction oscillator placed on the mastoid process. Hearing loss can be classified into 3 distinct classifications: conductive, sensorineural, or mixed. Conductive hearing loss is defined by problems in the external ear that impact the ossicular chain. Sensorineural hearing loss affects the cochlea to the auditory cortex. Mixed hearing loss involves both conductive as well as sensorineural components. Both Air Conduction and Bone Conduction testing methods are employed to determine the type of hearing loss.<sup>6</sup>

**4.2 Speech Audiometry:** It assists in identifying the extent and nature of the hearing impairment. Speech audiometry offers insights into word recognition and sensitivity to speech stimuli. Moreover, speech audiometry results are crucial in calibrating the amplification and upper limit of hearing aids for individuals with moderate to severe hearing deficiencies."

**4.3.Tympanometry:** Tympanometry is a diagnostic test used to assess middle ear function, particularly the mobility of the eardrum and the conduction bones. It involves inserting a probe into the ear canal and changing the air pressure to observe the movement of the eardrum.<sup>1</sup> This test helps identify conditions such as fluid in the middle ear, perforations of the eardrum, or issues with the eustachian tube.

**4.4.Otoacoustic Emissions (OAE):** Otoacoustic emissions (OAE) are auditory signals that originate from the cochlea and are transported through the middle ear to the external ear canal, where they can be detected. The presence of OAE serves as an indicator of inner ear well-being and offers a straightforward method for screening hearing impairment. OAE exists in two types: spontaneous OAE (SOAE), which occurs without any external influence, and evoked OAE (EOAE), which requires an acoustic stimulus to be present for measurement.<sup>1</sup> This test assesses the auditory responses of the cochlea, which is the inner ear, to sound stimuli. It aids in identifying any harm to the hair cells in the cochlea, which are vital for hearing.<sup>13</sup>

**4.5.Auditory Brainstem Response (ABR):** The ABR, or Brainstem Auditory Evoked Potentials (BAEP), provides an accurate evaluation of the functionality of the auditory system, which runs from the auditory nerve to the mesencephalon. ABR evaluates synchronized brain activity and can determine hearing sensitivity thresholds in individuals who may have difficulty with conventional behavioral audiometry.<sup>1</sup>

**4.6.Speech-in-Noise Testing:** Speech-in-Noise Testing is a technique employed to evaluate an individual's capacity to comprehend speech in the presence of noise from the environment. During the test, the individual is typically presented with recorded speech stimuli, such as sentences or words, while background noise is simultaneously played at varying levels of intensity.<sup>7</sup> The goal is to determine the signal-to-noise ratio (SNR) at which the person can accurately understand the speech.<sup>8</sup> This test helps assess how well someone can communicate in real-world situations where background noise is common, such as crowded environments or social gatherings. The assessment offers vital insights into an individual's auditory processing ability and can inform treatment recommendations, such as adjusting hearing aid settings or implementing auditory training programs.<sup>9</sup>

**4.7. Bone Conduction Testing:** Bone conduction (BC) is the process where vibrations travel through the skull bones to reach the cochlea and related sensorineural structures, leading to the sensation of sound. This method contrasts with air conduction (AC), where sound travels through the air in the ear canal to reach the middle ear's ossicles (malleus, incus, stapes) through the tympanic membrane, hence, causing the sensorineural organs of the inner ear to be activated.<sup>1</sup>

## 5. Management strategies

**5.1. Hearing Aids:** Age-related hearing loss is commonly addressed using traditional hearing aids, which are widely utilized. They amplify sound and are available in various styles and levels of technology to suit individual needs.<sup>3</sup> There are three primary styles of hearing aids, varying in size, placement, and amplification levels:

**5.1.1. Behind-the-ear (BTE):** These assistive devices are comprised of a shell of plastic that is worn at the back of the ear and attached to an earmold located inside the outer ear. They accommodate mild to profound hearing loss and are also available in open-fit designs.<sup>10</sup>

**5.1.2. In-the-ear (ITE):** Completely fitting inside the outer ear, ITE aids are suitable for mild to severe hearing loss. Some models feature a telecoil for improved telephone communication and are commonly used in settings with induction loop systems.<sup>10</sup>

**5.1.3. Canal aids:** There are two kinds available: in-the-canal (ITC) and completely-in-canal (CIC). These devices are designed to be inserted into the ear canal and are suitable for individuals with mild to moderately serious hearing loss.<sup>1</sup> Nevertheless, their tiny dimensions make them difficult to modify and are generally not advised for young children or those with significant hearing loss.<sup>1</sup> In Age-related hearing loss is commonly addressed using traditional hearing aids, which are widely utilized. They amplify the volume of sound and are available in various styles and levels of technology to suit individual needs.<sup>3</sup>

**5.2. Assistive Listening Devices (ALDs):** ALDs encompass a range of amplification tools aimed at enhancing communication for individuals with hearing impairments, particularly in scenarios where personal hearing aids may not suffice.<sup>14</sup> These devices address challenges related to SNR, such as noise interference, distance, and reverberation.<sup>1</sup> ALDs vary in complexity, from basic wired microphone-amplifier setups to advanced broadcasting systems. Typically, they utilize microphones to capture audio, transmitting it wirelessly via methods like FM modulation, infrared transmission, or induction loops. The seven categories of assistive listening devices (ALDs) encompass hardwired devices, television aids, infrared sound systems, alert/alarm techniques, telephone listening devices, induction loop techniques, and FM sound systems.<sup>8</sup>

**5.3. Communication Strategies:** Education on effective communication techniques, including speaking, facing the individual, and minimizing background noise, can significantly enhance communication for elderly individuals with hearing loss.

**5.4. Auditory Rehabilitation Programs:** Auditory Training (AT) involves a structured series of listening exercises aimed at enhancing an individual's speech perception skills. Rooted in the concept of brain plasticity, AT leverages the central auditory system's ability to adapt its structure and function in response to auditory stimuli.<sup>11</sup> Auditory Training utilizes regular listening exercises that specifically focus on speech sounds to enhance the formation of more effective brain pathways, resulting in enhanced auditory processing and speech discrimination capabilities.<sup>15</sup>

## **5.5. Most Advanced Management Techniques:**

**5.5.1. Cochlear Implants:** Cochlear implants, originally developed for individuals with severe hearing impairment are more prevalent and utilized in older individuals who have serious to profound hearing loss and do not experience any improvement with hearing aids. The cochlear implant (CI) stands out as one of the most successful neuroprosthetic devices, offering speech comprehension to the majority of the millions who are otherwise deaf.<sup>7</sup>

**5.5.2. Bone-Anchored Hearing Aids (BAHA):** Implantable bone conduction devices (IBCDs) have undergone substantial advancements since their inception in the 1970s, serving as a vital tool in the rehabilitation of individuals with conductive/mixed hearing loss (C/MHL). They immediately activate the cochlea, bypassing any problems in the external or middle ear. IBCDs are classified as either passive or active depending on the placement of the bone oscillator or stimulator. Passive equipment, like the Cochlear Baha & Oticon Medical Ponto, create a connection with the bone either through the skin or by directly penetrating it using Osseointegrated implants or screws.<sup>2</sup> BAHA systems use bone conduction to bypass the middle ear, making them suitable for Individuals having C/MHL who are unable to obtain any advantage from traditional hearing aids.<sup>13</sup>

**5.5.3. Tele-audiology and Remote Monitoring:** Tele-audiology is the application of telemedicine in the field of audiology. It facilitates the delivery of remote hearing screenings, evaluation for diagnosis, intervention, and rehabilitation facilities, including the adjustment of hearing aids and the programming of cochlear

implants. Utilizing telecommunication technology, audiologists can improve accessibility to audiological care for elderly individuals.<sup>15</sup>

**5.5.4. Genetic and Precision Medicine Approaches:** Genetic and precision medicine in age-related hearing loss utilize genetic insights and personalized treatments to tackle age-related hearing decline by identifying genetic factors, like mutations, and tailoring interventions to individual genetic profiles. This targeted approach aims to improve management and prevention strategies for age-related hearing loss.

**5.5.5. Auditory Brainstem Implants (ABI):** An ABI is an electronic gadget that activates the cochlear nucleus in order to regain the sense of hearing. Initially designed for NF2 patients with bilateral vestibular schwannomas, candidacy has expanded to non-NF2 cases, comprising congenital inner ear malformations and severe cochlear ossification. Various causes of hearing loss yield distinct results for ABIs, with cochlear implants generally providing better results due to peripheral stimulation over central stimulation by ABIs.<sup>12</sup>

**5.5.6. Regenerative Medicine and Gene Therapy:** Regenerative medicine explores methods to repair or replace damaged tissues, such as inner ear hair cells, to restore hearing function. Gene therapy is the process of inserting genetic material to repair or balance defective genes that are responsible for causing hearing loss.<sup>13</sup> These approaches hold promise for treating both genetic and age-related forms of hearing loss by addressing underlying cellular and genetic factors, potentially leading to improved hearing outcomes.

## 6. Nurses role in management of patients with hearing loss

**6.1. Effective communication strategies** It helps to ensure the patient receive information accurately. This can be implemented through the following.

- Face the patient directly while speaking.
- Use words clearly with moderate pace
- Minimize background noise to enhance understanding

**6.2. Ensure proper lighting:** Sufficient lighting helps the patient to see the speaker's facial expressions and lip movements which contributes improved comprehension of words.

**6.3. Use of visual aids and written information's:** Visual aids like charts, diagrams and other written materials can be used to compliment verbal communication by offering visual references for better understanding.

**6.4. Empowerment and active participation:** Nurses should empower and educate the patient to participate in health care journey by making informed decisions about their treatment.

**6.5. Collaborate with certified interpreters:** Nurses should collaborate with certified interpreters to assure error-free communication regarding medical consultation, discussions, and treatment regimens.

### 6.6. Use of assistive devices

- Educate the patients about the availability and use of hearing aids, cochlear implants and other advanced applications designed to improve auditory experiences.
- Provide maintenance and troubleshooting of these devices is also beneficial.

**6.7. Patient education and emotional support:** Provide emotional support by dealing with concerns, fears, and frustrations which help patient and their families to get deeper insight about the condition and manage its impact on their daily life.<sup>14</sup>

**Conclusion:** The advancements in hearing loss technology present unprecedented opportunities for individuals grappling with hearing impairment. By leveraging innovative solutions such as cochlear implants, regenerative medicine, and tele-audiology services, we can significantly enhance the lives of those affected by hearing loss. Through continued collaboration and exploration of cutting-edge innovations, we can break the silence surrounding hearing loss, enabling individuals to reconnect with the world of sound and enjoy an enhanced quality of life.<sup>15</sup>

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