

# A Systematic Review of Auditory Loss and its Management

## Abstract:

Auditory loss is a highly under recognised undermined issue which needs to be studied in extensive detail, as according to World Health Organisation, more than 45% of the global population has loss of auditory. The high percentage can be lowered if auditory enhancement techniques such as auditory aids or implants of cochlea were not underused. In order to increase the usage of these devices we must first understand the inner workings of the ear and the pathologies that may cause it to malfunction and then move on to proper management. Auditory loss as defined by WHO as the inability to hear as well as someone with normal auditory, these are persons having auditory thresholds of 20 dB or better than 20 dB in both ears. Auditory loss is often classified into two types, conductive auditory loss and sensorineural auditory loss which is a broad classification into which we can separate the various pathologies which bring about same outcomes. In conductive auditory loss, there is often involvement of external or middle ear where there is obstruction in relay of sound waves, hence, quite literally a problem with the conduction. Conductive auditory loss can be both congenital or acquired but most often can be resolved in a manner which will result in recovery of auditory. Sensorineural auditory loss occurs when there is dysfunction in the inner ear which often leads to progressive and permanent auditory loss. Though it can be congenital, it is most often acquired, especially when it is age related more commonly known as presbycusis which affects a large amount of the aging population. The management can be done through various processes including oral medications, surgical interventions and other manual procedures. Various assistive technologies like auditory aids and cochlear implants are also vital in preservation of auditory.

**Keywords:** Hearing Loss, Conductive hearing loss, Sensorineural hearing loss, Auditory loss, Presbycusis.

## Introduction:

According to WHO, auditory loss is defined as the inability to hear as well as someone with normal auditory, these are persons having auditory thresholds of 20 dB or more than 20 dB in both the ears. 'Hard of auditory' is a term used when individuals have auditory loss that ranges from mild to severe; these individuals can often communicate through spoken language and can also avail of assistive technologies and services like captioning from which they can benefit. Meanwhile, 'deaf' people are those with complete auditory loss which results in little to no auditory. These individuals often use sign language as a mode of communication (1). The most common types of peripheral auditory loss are conductive auditory loss, caused by dysfunction in the outer or middle ear and sensorineural auditory loss which is induced by an issue with the inner ear typically a condition in the cochlea or spiral ganglion. Mixed auditory loss is a type of auditory loss that includes both sensorineural and conductive components (2). Sensorineural auditory loss which is age related, better known as presbycusis, is a phenomenon that occurs in the elderly which is particularly difficult to manage in social settings. Auditory loss can be improved through various assistive technologies such as cochlear implants and auditory aids while current research also delves into gene therapy, pharmacotherapy and stem cells through which we have made giant strides for bettering auditory loss (3). The ear is a highly intricate organ which is susceptible to various traumas and diseases of which auditory loss is a monumental change which can take

place in any individual's life regardless of age, thus leading to decrease in quality of life. Therefore, this article aims to compile and review all relevant information related to auditory loss and its management which can give us a glimpse into the many facets of this disease.

### **Anatomy of Ear**

The ear is separated into 3 components namely, the external ear, middle ear and inner ear. The external ear is an essential shell-like structure which exists bilaterally on lateral aspect of head. It is mostly cartilaginous in nature and has a variety of anatomical landmarks such as antihelix, tragus and antitragus which prove to be useful for identification and precision along with a central depression known as external acoustic meatus. The acoustic meatus leads into acoustic canal which ends with the tympanic membrane on other side, leading into middle ear. The canal itself is divided, two thirds is cartilaginous containing cerumen glands which perform several important functions in ear and the inner one third is bony attaching to tympanic membrane. The middle part of the ear ranges from inner portion of tympanic membrane and is a space filled with air. It contains the ossicular chain, comprised of malleus, incus and stapes and is heavily related to various anatomical landmarks which are of utmost surgical importance such as jugular vein, facial nerve, carotid artery, mastoid and eustachian tube. The ossicular chain, however, are the most crucial structures as these ligament-suspended bones help in transmission of sound vibrations to middle ear. The inner part of the ear is composed of two parts, bony labyrinth and membranous labyrinth which co-exist with each other, one in the other. The bony labyrinth has a cavity known as vestibule which contains the three semi-circular canals including the vestibular part of the eighth cranial nerve. Cochlea which is the organ of auditory is also present and gives rise to cochlear part of 8th nerve and joining with vestibular part to form vestibulocochlear nerve (4). The inner ear also contains sensory hair cells which can be destroyed due to various stressors, unfortunately the mammalian cochlea cannot regenerate these hair cells and this often leads to auditory loss (2).

### **Physiology of Hearing**

The ear is made up of two components, a sound conducting mechanism wholly made up of external ear containing of pinna and ear canal and a sound transducing mechanism existing in middle made up of tympanic membrane. The eustachian tube links the middle ear air space to the nose and the mastoid air space also connected to middle ear space. The mastoid air space contains the ossicular chain which is made up of a trio of miniscule bones namely the malleus, incus and stapes. A vibration is passed into perilymph which is then transduced by the inner ear or cochlea and is then converted into a neurological impulse, this impulse goes to the brain where it is interpreted and then professed as sound. The inner hair cells are responsible for the conversion of vibration into neuronal impulse which occurs when basilar membrane starts movement due to onset of new vibration leading to the bending of cilia present on inner hair cells in relation to hair cell causing opening and closing of several ion passages and ultimately resulting in the stimulation of the afferent nerve located in the base of the hair cell (5).

Audible sound is in the approximate range of ten octaves, ranging from 16 to 32 Hz cycles/sec to 16,000 to 20,000 Hz cycles/sec. The sensitivity is less at the extremes, though it increases dramatically over 128 Hz until around 4,000 Hz, when it swiftly decreases. Due to age, the full range of sensitiveness and audibility continuously decreases (5).

The head is an extremely necessary organ for the conduction of sound by being an important structure to maintain sound localization, which is a phenomenon based on differing intensities and frequencies of sound. For this function, high frequency audio is more important than low frequency audio, which elucidates as to why sound localisation develops increasingly tough with a high frequency auditory loss. The ear canal functions as a resonant duct, amplifying noises as well as increasing the ear's sensitivity as well as predisposition to harm at higher frequencies. The ear is extremely delicate and can identify very low-intensity noises, which is due to pressure equalization on either side of tympanic membrane which is a function carried out by the eustachian membrane. The sound signal is amplified by the external and middle ears. Because the pinna has a huge superficial area and channels the waves of sound to the small tympanic membrane, which is considerably larger than the surface of the stapes foot plate, where finally amplification of the hydraulic type occurs. Thus, a tiny crusade over a vast area is turned to a larger crusade over an area that is smaller. Furthermore, the three bones present in middle ear acts as a series of levers that amplify sound (5).

## Classification

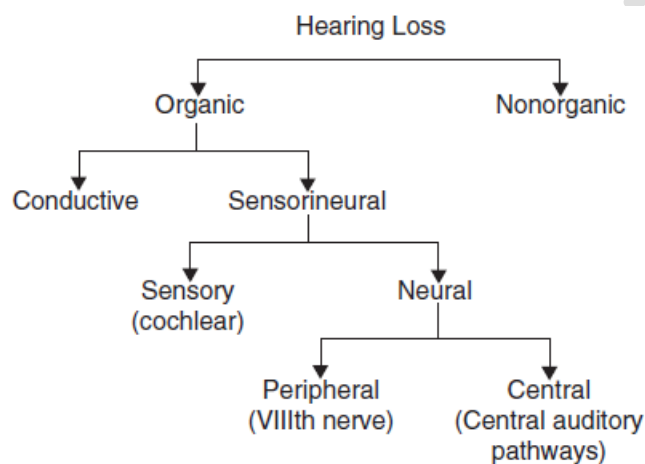


Fig. 1. Hearing loss

### 1) Auditory Loss of Conductive Type:

It is instigated by any disease process which prevents sound from reaching the cochlea. The affected structures are external ear, tympanic membrane, middle ear, and/or ossicles up to the level of stapediovestibular joint of which any or all may have lesions. The characteristic features are all based on screening tests which makes it easier to differentiate between the types. Conductive auditory loss is defined by a Rinne test which is negative. That is where bone conduction is more than air conduction, this is supported on performing audiometry which also confirms that bone conduction is more improved than air conduction with an air bone gap. The larger the air bone gap, the greater the conductive loss, however the loss does not exceed 60 dB. Weber test is performed and lateralization to poorer ear is observed. Though lower frequencies are affected negatively, speech discrimination is good. Schwabach test is also performed revealing normal absolute bone conduction.

### 2) Auditory Loss of Sensorineural Type:

Cochlear injury ,and lesions to VIIIth cranial nerve, or central auditory pathways cause auditory loss of sensorineural type. The characteristics of auditory loss of sensorineural type, like conductive auditory loss are also based on various screening tests, but unlike conductive auditory loss often have the opposite results. SNHL is defined by a Rinne’s test that is positive indicating that air conduction is better than bone conduction and is again supported by performing audiometry which shows no gap between air and bone conduction. The auditory loss can exceed 60 dB in these cases. On performing Weber test, the lateralization is to the better ear. Higher frequencies are affected negatively, thus, speech discrimination is substandard and there is adversity in auditory if there is large amount of noise in immediate surroundings. The bone conduction is seen to be reduced on performing Schwabach test as well as other absolute bone conduction tests.

### Aetiology

Table 1. Conductive Auditory Loss

Congenital	Acquired
<ul style="list-style-type: none"> <li>● Meatal Atresia</li> </ul>	<ul style="list-style-type: none"> <li>● Any obstruction present in external ear</li> </ul>
<ul style="list-style-type: none"> <li>● Fixation of stapes footplate</li> </ul>	<ul style="list-style-type: none"> <li>● Perforation of tympanic membrane</li> </ul>
<ul style="list-style-type: none"> <li>● Fixation of malleus head</li> </ul>	<ul style="list-style-type: none"> <li>● Mass or fluid in middle ear</li> </ul>
<ul style="list-style-type: none"> <li>● Ossicular discontinuity</li> </ul>	<ul style="list-style-type: none"> <li>● Disruption or fixation of ossicles</li> </ul>
<ul style="list-style-type: none"> <li>● Congenital cholesteatoma</li> </ul>	<ul style="list-style-type: none"> <li>● Eustachian tube blockage</li> </ul>

Table 2. Sensorineural Auditory Loss

Congenital	Acquired
<ul style="list-style-type: none"> <li>● Anomalies of inner ear</li> </ul>	<ul style="list-style-type: none"> <li>● Infections of labyrinth</li> </ul>
<ul style="list-style-type: none"> <li>● Damage to auditory apparatus during prenatal or perinatal circumstances</li> </ul>	<ul style="list-style-type: none"> <li>● Trauma to labyrinth or VIIIth CN</li> </ul>
	<ul style="list-style-type: none"> <li>● Noise linked auditory loss</li> </ul>
	<ul style="list-style-type: none"> <li>● Presbycusis</li> </ul>
	<ul style="list-style-type: none"> <li>● Meniere’s Disease</li> </ul>
	<ul style="list-style-type: none"> <li>● Acoustic Neuroma</li> </ul>
	<ul style="list-style-type: none"> <li>● Ototoxic medications</li> </ul>

(6)

### Screening Tests

Various screening tests are useful for detecting and measuring auditory loss. They can be administered by self or through in-clinic auditory tests, out of which in-clinic tests are the best and most accurate method of screening. Self-tests can be administered by questionnaires while in the clinic we can administer tests such as whispered voice test, finger rub test and audiometry are easy to use and precise. The various tests are:

1) Clinical Examination including:

- Finger Rub test

The clinician rubs their fingers on each other softly at a distance of six inches from the ear of the patient. At least six attempts are made out of which if in three, there is inability to identify the rub it is seen as a positive result.

Clinician rubs fingers together softly at a distance of six inches from the ear of the patient; incapability to identify the rub in at least three of 6 efforts indicates a positive result.

- Whispered voice test

One ear of the patient is closed and clinician stands behind the patient at a length of a single arm. The clinician then whispers six number or letter combinations, which the patient is asked to repeat. The positive result is indicated when patient is unable to repeat at least three of the six letter or number combinations.

2) Direct Question

The patient is asked directly by clinician if they are experiencing auditory loss on a yes or no basis.

3) Audiometry

- Handheld Audiometry

The clinician places the device in ear of the patient and the patient is requested to acknowledge and differentiate between each tone that is played. The test result is measured positive if the patient cannot identify the frequencies of 1000 or 2000Hz in both ears or either the 1000 Hz or 2000 Hz frequency in single ear.

- Tabletop

A range of audiometers which are compact and portable and even audiometric programmes running on electronic devices are available for use.

4) Tuning Fork tests

All these tests are done with tuning fork of frequency 512 Hz.

- Rinne's test

The clinician strikes the tuning fork and rests it on the mastoid bone posterior to the ear and asks the patient to indicate when no more audio is present. The tuning fork which is still vibrating is then taken close to the ear and the patient is then asked to indicate when they can no longer hear any audio. This test follows the basic principle that air conduction is better than bone conduction, however, if there is inability to identify the sound after lifting it to the ear it may imply that there is conductive auditory loss.

- Weber's test

The clinician strikes the tuning fork and puts it at any central marker of the body such as the forehead or chin, where the normal result is that the vibration is lateralized to both sides equally indicating a negative test. However, a positive result is when vibration is lateralized to single ear more than the other. In sensorineural auditory loss, lateralization occurs in better ear while in conductive auditory loss the vibrations are lateralized to poorer ear (7).

## **Clinical Aspects**

For patients with auditory loss, it's important to decipher immediately such as if the loss is bilateral or unilateral, progression of loss and if there is presence of any associated factors such as vertigo or tinnitus. A detailed history of chronic otalgic infections, previous otalgic surgery or exposure to extremely high levels of noise. Use of any ototoxic medications must be noted like aminoglycosides, diabetes, loop diuretics and cisplatin chemotherapeutic agents should be noted. Any history of systemic diseases like atherosclerosis, diabetes and renal disease should also be recorded (8).

## **Primary Care Management and Treatment**

Auditory loss is managed differently depending on the source and kind of loss. Medical treatment, surgery, and amplification are all choices. Medical therapy in the form of antibiotics or steroids may be used to treat auditory loss caused by infections or systemic aetiologies. Surgery can be used to treat a variety of problems (8). Several conditions can be taken care of under primary care while other cases must be referred to otolaryngologists. For conductive auditory loss, in cerumen impaction or other cases where there is mechanical obstruction, physician can employ use of techniques such as syringing, use of curette and even use of hydrogen peroxide may be used to remove or loosen obstruction. In other cases, like CSOM, the physician can prescribe antibiotics and analgesics as well as other remedial therapies. Though otitis media with effusion often resolves itself, however, if infection lasts for three months or more then surgery is considered. Insertion of grommets is often seen to be beneficial, especially if auditory loss exceeds 25 to 30 dB. In preparation for grommet insertion, a myringotomy is performed on patient so as to drain and clear all middle ear fluid. An adenoidectomy may also be performed if the auditory loss is associated with the secretions. Then, a grommet is inserted into the anteroinferior quadrant of tympanic membrane which allows for ventilation. Grommets may be prone to complications such as infections or tympanosclerosis, but are still preferred over T-tubes. Cholesteatomas must be surgically removed completely. A mastoidectomy can be performed in one of two ways which are canal wall down surgery, which requires an endaural or postaural incision, or canal wall up surgery, which requires a postauricular incision. Ossiculoplasty may be required if a trauma causes ossicle discontinuity. Conservative treatment options for otosclerosis include observant waiting, auditory aids, and supplementation of fluoride. When the air-bone gap exceeds 20 decibels, surgery may be required, which may include total/partial stapedectomy or stapedotomy. Auditory aids can be used in the remedy of conductive auditory loss that is not responsive to medical or surgical treatment (9). However, in cases of sensorineural auditory loss as aetiology though known is still a relatively uncertain area we can prescribe glucocorticoids and further recommendation to specialist, however, the doctor must make diligent note of any ototoxic medication taken as by discontinuing use we can provide relief to patient (10). There are often associated features with sensorineural auditory loss such as tinnitus which is often remedied by fitting the patient with auditory aids. Fitting the affected ear is sufficient in people with one-sided sensorineural auditory loss and tinnitus. Bilateral adjustment is required for people who have symptoms on both sides. Speech discrimination scores before fitting determined the effectiveness of fitting in the group of patients that are affected (11-18).

## **Conclusion:**

There is no complete and effective way for the treatment of auditory loss of sensorineural type, however, the usage of auditory aids and implants of cochlea is recommended as the treatment of choice in this dysfunction.

### References:

1. Deafness and auditory loss [Internet]. [cited 2021 Nov 16]. Available from: <https://www.who.int/news-room/fact-sheets/detail/deafness-and-auditory-loss>
2. Cunningham LL, Tucci DL. Auditory Loss in Adults. *N Engl J Med*. 2017 Dec 21;377(25):2465–73.
3. Patel R, McKinnon BJ. Auditory Loss in the Elderly. *Clin Geriatr Med*. 2018 May;34(2):163–74.
4. Sánchez López de Nava A, Lasrado S. Physiology, Ear. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 [cited 2021 Nov 17]. Available from: <http://www.ncbi.nlm.nih.gov/books/NBK540992/>
5. Alberti PW. THE ANATOMY AND PHYSIOLOGY OF THE EAR AND AUDITORY. :11.
6. Causes of Auditory Loss in Adults [Internet]. American Speech-Language-Auditory Association. American Speech-Language-Auditory Association; [cited 2021 Nov 16]. Available from: <https://www.asha.org/public/auditory/causes-of-auditory-loss-in-adults/>
7. Michels TC, Duffy MT, Rogers DJ. Auditory Loss in Adults: Differential Diagnosis and Treatment. *Am Fam Physician*. 2019 Jul 15;100(2):98–108.
8. Phan NT, McKenzie J-L, Huang L, Whitfield B, Chang A. Diagnosis and management of auditory loss in elderly patients. *Aust Fam Physician*. 2016 Jun;45(6):366–9.
9. Sooriyaamoorthy T, De Jesus O. Conductive Auditory Loss. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 [cited 2021 Nov 17]. Available from: <http://www.ncbi.nlm.nih.gov/books/NBK563267/>
10. Yueh B, Shapiro N, MacLean CH, Shekelle PG. Screening and Management of Adult Auditory Loss in Primary CareScientific Review. *JAMA*. 2003 Apr 16;289(15):1976–85.
11. Zagólski O. Management of tinnitus in patients with presbycusis. *Int Tinnitus J*. 2006;12(2):175–8.
12. Guru, Bhushita Nilesh, and Bhushan Narayan Lakhkar. “Osteoma of Internal Auditory Canal - A Rare Pathology.” *JOURNAL OF EVOLUTION OF MEDICAL AND DENTAL SCIENCES-JEMDS* 9, no. 38 (September 21, 2020): 2863–64. <https://doi.org/10.14260/jemds/2020/625>.
13. Mahalle, Shrikant. “Osteoma of External Auditory Canal Associated with External Auditory Canal Cholesteatoma and Exuberant Granulation Tissue in Mastoid Air Cell System: A Rare Association.” *INDIAN JOURNAL OF OTOLARYNGOLOGY AND HEAD & NECK SURGERY* 71, no. SUPPL 2, 2, SI (November 2019): 1505–7. <https://doi.org/10.1007/s12070-019-01643-9>.

14. Kalambe, Sanika, Shraddha Jain, Ashish Disawal, Deepshikha Chandravanshi, and Sagar Gaurkar. "Supra-Threshold Hearing Sensitivity Disorders and Mild Permanent Hearing Loss: Neglected Cause of Hidden Hearing Loss and Speech Defects." *INDIAN JOURNAL OF OTOLARYNGOLOGY AND HEAD & NECK SURGERY*, n.d. <https://doi.org/10.1007/s12070-020-01816-x>.
15. Haile LM, Kamenov K, Briant PS, Orji AU, Steinmetz JD, Abdoli A, et al. Hearing loss prevalence and years lived with disability, 1990-2019: findings from the Global Burden of Disease Study 2019. *LANCET*. 2021 Mar 13;397(10278):996–1009.
16. Abbafati, Cristiana, Kaja M. Abbas, Mohammad Abbasi, Mitra Abbasifard, Mohsen Abbasi-Kangevari, Hedayat Abbastabar, Foad Abd-Allah, et al. "Five Insights from the Global Burden of Disease Study 2019." *LANCET* 396, no. 10258 (October 17, 2020): 1135–59.
17. Abbafati, Cristiana, Kaja M. Abbas, Mohammad Abbasi, Mitra Abbasifard, Mohsen Abbasi-Kangevari, Hedayat Abbastabar, Foad Abd-Allah, et al. "Global Burden of 369 Diseases and Injuries in 204 Countries and Territories, 1990-2019: A Systematic Analysis for the Global Burden of Disease Study 2019." *LANCET* 396, no. 10258 (October 17, 2020): 1204–22.
18. Franklin, Richard Charles, Amy E. Peden, Erin B. Hamilton, Catherine Bisignano, Chris D. Castle, Zachary Dingels V, Simon Hay I, et al. "The Burden of Unintentional Drowning: Global, Regional and National Estimates of Mortality from the Global Burden of Disease 2017 Study." *INJURY PREVENTION* 26, no. SUPP\_1, 1 (October 2020): 83–95. <https://doi.org/10.1136/injuryprev-2019-043484>.