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Review Article

Hearing Loss as a Risk Factor for Dementia

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Abstract

Age-related hearing loss or presbycusis is the third leading cause of chronic disability in older adults, has been shown to be associated with predisposing cognitive impairment and dementia. Hearing loss is estimated to account for 8 % of dementia cases. Tinnitus is also a chronic auditory disorder demonstrating a growth rate with increasing age. Recent evidence stands for the link between bothersome tinnitus and impairments in various aspects of cognitive function. Both age related hearing loss and age-related tinnitus affect mental health and contribute to developing anxiety, stress, and depression. The present review is a comprehensive multidisciplinary study on diverse interactions among age related hearing loss, tinnitus, and cognitive decline in older adults. This review incorporates the latest evidence in prevalence and risk factors of age-related hearing loss and tinnitus. Using auditory amplification in the alleviation of hearing handicap, depression, and tinnitus demonstrates advantages. The improvement of cognition, social communication, and quality of life is required. Therefore, regular hearing screening programs for identification and management of midlife hearing loss and tinnitus is strongly recommended.

Key Words*: Dementia, Cognitive impairment, Presbycusis, Age related hearing loss, Aural rehabilitation.*

Introduction

Almost twice the amount of people with mild hearing loss develop dementia as compared to those without hearing loss. These risks of developing dementia triples with moderate hearing loss and is nearly five times with severe hearing loss. Low levels of hearing loss is associated with decrease in memory and thinking skills. Among all sensory deficits associated with aging, deterioration in hearing is the most impressive decline in humans (Howarth and Shone, 2006). Population studies estimate the prevalence of significant hearing loss (average of pure-tone thresholds 0.5–4.0 kHz > 25 dB HL) of those aged 60–80 years at 21–27% (Cacciatore et al., 1999; Dalton et al., 2003; Gopinath et al., 2009a; Hogan et al., 2009; Lohler et al., 2019). In the Baltimore study on adults aged 70 years and older, the prevalence of significant age-related hearing loss in the better ear was 63.1% (Lin et al., 2011c). A large body of evidence demonstrates to be detrimental to physical and mental

health, cognition, independence, social interaction, and quality of life in the elderly and that it can precipitate the early landmarks of dementia and Alzheimer's disease (Cherko et al., 2016; Cosetti and Lalwani, 2015; Taljaard et al., 2016). Hearing ability provides communication through speech, informs warning of potentially injurious events occurring outside the visual field, and develops our feelings and realization of music and nature. The stronger impact of hearing loss is manifested by profound consequences on verbal communication, and the social, functional, and psychological well-being of the person (Howarth and Shone, 2006; Lee, 2015; Swords et al., 2018). Even though the complex etiology of the dementia is not fully understood, modifiable risk factors related to lifestyle characteristics, environmental risks, and diseases were shown as the underlying reasons in 35% of cases (Livingston et al., 2017).

Dementia

Dementia is a progressive neurodegenerative disorder associated with cognitive impairment having neuropsychiatric symptoms. This has sensory and physical disabilities, dependency on caregiver, substantial health care expenditures, and premature death (Fiest et al., 2016; Fischer et al., 2016; Luo et al., 2018). Sensorineural systems play a crucial role in the diagnosis, treatment, and management of diverse neurological disorders (McGilton et al., 2016; Panza et al., 2019). Recent evidence indicates that sensory and motor changes may precede the cognitive symptoms of dementia by several years. The function of the ear and eye represents a unique pathway for exploring various conditions in cognitive decline or dementia.

A neuroscientific view in describing the basic and new concepts linked to this subject from diverse but associated fields of studies (e.g., Gerontology, Neurology, Otology, Audiology, and Neuroscience) could synergistically improve the general knowledge in this area and stimulate the emergence of novel ideas for future research.

Hearing Loss and Dementia: How are they Linked?

Low levels of hearing loss have been associated with increased dementia risk and a decrease in memory and thinking skills. Hearing loss has also been shown to be linked to quicker shrinkage of areas of the brain responsible for processing sounds and memories. Hearing aids reduced the rate of cognitive decline in older adults at high risk of dementia by almost 50% over a three-year period. Hearing loss is very treatable in later life, which makes it an important public health target to reduce risk of cognitive decline and dementia. Treating hearing loss may be a safe way to lower the risk of dementia in vulnerable populations. Those who received hearing aids had an almost 50% reduction in the rate of cognitive decline compared with people having age-

related hearing loss without hearing aids. The areas of the brain affected by hearing loss are regions associated with attention and executive function in the frontal cortex, as well as the auditory regions of the temporal lobe. It is known that people who tend to have hearing loss tend to have more dementia.

Hearing loss as a risk factor for dementia

There is strong evidence to show that:

- Hearing is an essential part of brain health.
- Mild hearing loss doubles the risk of developing dementia.
- Moderate hearing loss leads to three times the risk.
- Severe hearing loss increases the risk five times.

Pathophysiology

Age-related hearing loss (presbycusis) refers to bilaterally symmetrical hearing loss resulting from aging process. Presbycusis is characterized by audiometric threshold shift, deterioration in speech-understanding and speech-perception difficulties in noisy environments. Factors contributing to presbycusis include mitochondria DNA mutation, genetic disorders like *Ahl* gene, hypertension, diabetes, metabolic disease and other systemic diseases in the intrinsic aspects. Extrinsic factors include noise, ototoxic medication and diet. Functional decline of the central auditory system, caused by aging, reduces speech-understanding in noisy background and increase temporal processing deficits in gap-detection measures. In the 2003 report by the Center for Disease Control (U.S.), presbycusis was the second most common illness next to arthritis in the aged people.

The areas of the brain affected by hearing loss are regions associated with attention and executive function in the frontal cortex, as well as the auditory regions of the temporal lobe. People with hearing loss exhibit microstructure differences in areas of the frontal cortex linked to executive function and speech and language processing. Age-related hearing loss is highly polygenic, with over 100 genes known to underlie human non-syndromic hearing impairment (Lewis et al., 2018; Van Camp and Smith, 2023), and of these many genes, possibly each makes small contributions to create an estimated heritability of 36–70% (Nagtegaal, 2019). Most cases of genetic deafness imply alterations of the cochlea, the auditory sensory organ; for instance, the OTOF gene encodes the protein otoferlin, which allows synaptic vesicles to fuse to the plasma membrane in the ribbon synapse. Thus, mutations in this gene can lead to a deficiency in exocytosis in the inner hair cells, which interrupts auditory signal transmission and can cause prelingual deafness (Vona et al., 2020). However,

some forms of genetic hearing loss can involve failures in the central auditory system. Genome wide association studies (GWAS) that have focused on the genes associated with age related hearing loss, although showing some overlap, do not show strong agreement with one another (Nagtegaal, 2019; Wells et al., 2019; Liu et al., 2021; Lewis et al., 2022). When considering a genetic relationship between hearing loss and Alzheimer's disease (AD), no GWAS have found a direct causal link between age related hearing loss and Alzheimer's disease (AD).

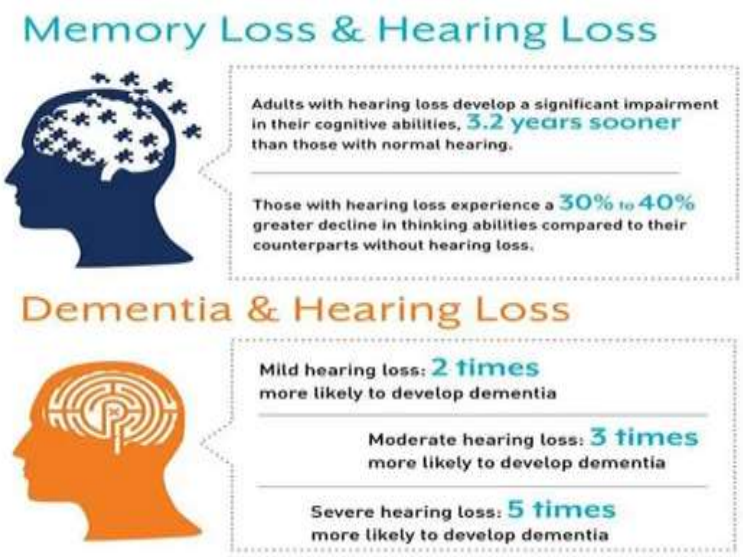

Figure 1

Figure 2

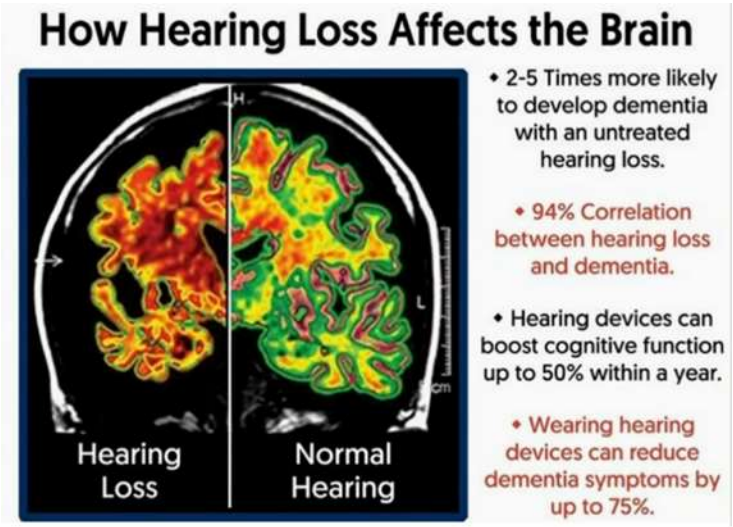

Figure 3

Brain strain and Social Isolation

Hearing loss can make the brain work harder, forcing it to strain to hear and fill in the gaps which comes of the expense of the other thinking and memory systems.

Another possibility: Hearing loss, causes the ageing brain to shrink more quickly.

Third possibility: Hearing loss leads people to be less socially engaged. It is very important to remain intellectually stimulated.

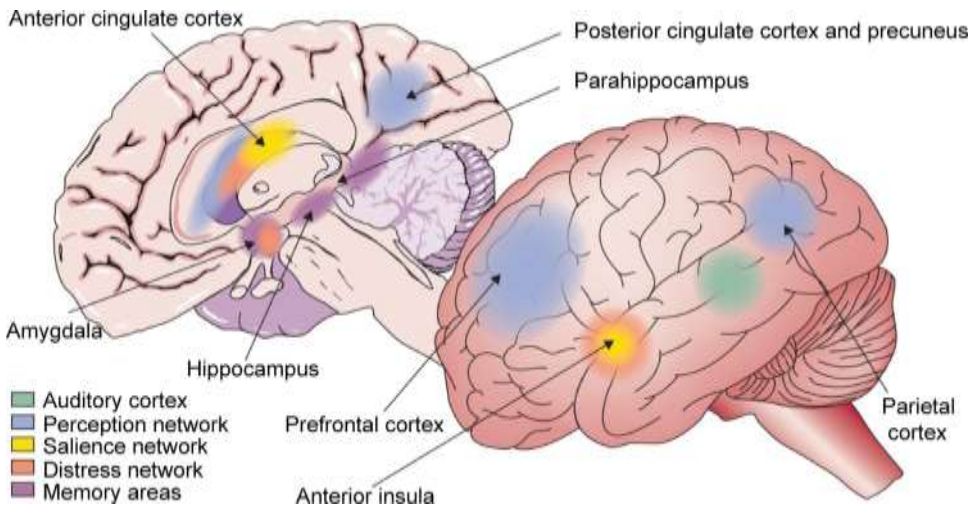

Figure 4

Brain networks involved in tinnitus perception.

Increased activity in the auditory cortex (green) because of auditory deprivation is essential, but not sufficient, for tinnitus perception. Tinnitus reaches to the conscious level if the auditory activity is connected to a larger coactivated awareness network consisting the subgenual and dorsal anterior cingulate cortices, posterior cingulate cortex, precuneus, parietal cortex, and pre-frontal cortex (blue). (Reproduced from Elsevier, The Lancet Neurology, Langguth et al., 2013).

Peripheral and Central Parts of Audiotory System

Basic categories of Presbyacuis:

Cochlear lesion	Pathology	Audiometric configuration
Sensory	Reduction of sensory cells in basal turn of cochea	Abruptly sloping high frequency hearing loss above the speech frequency range
Neural	Loss of cochlear neurons	Progressive loss of speech discrimination in the presence of stable pure-tone thresholds
Strial	Metabolic and vascular changes within cochlea	Slowley progressive hearing loss with flattening of audiogram and good speech discrimination
Conductive	Changes in the conduction or resonance of the cochlear duct	Linear descending pattern on audiogram
Mixed	Combination of above	Mild to moderate high frequency hearing loss
Intermediate	None of the above charactristics, the likelihood of cellular impairment	Flat or abrupt high frequency hearing loss

Figure 5

Progress of Age Related Hearing Loss:

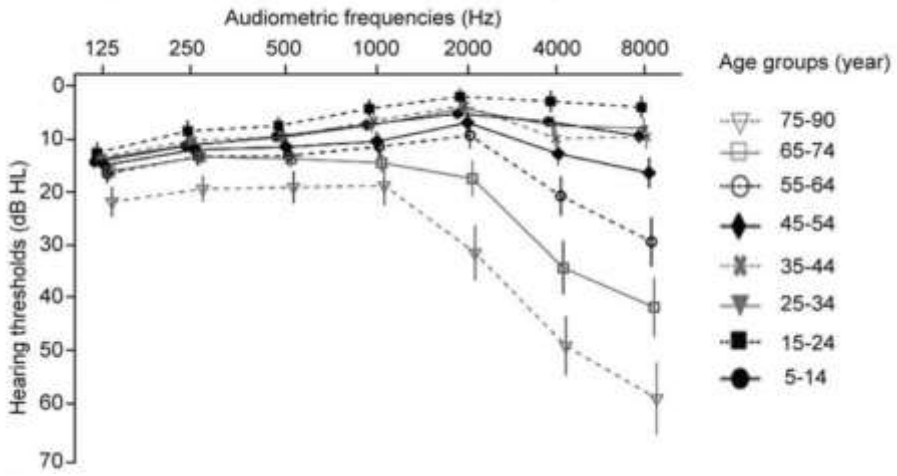

Figure 6

Cellular structures of the Organ of Corti

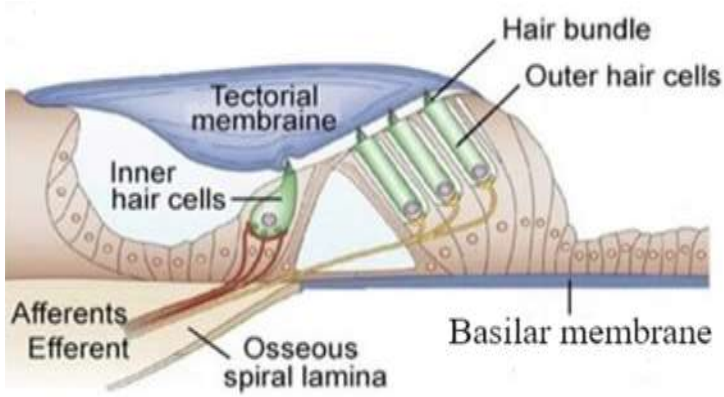

Figure 7

Cross-section of the organ of Corti (~150 μm wide) through a middle turn of the cochlea, commonly three rows of outer hair cells and one row of inner hair cells.

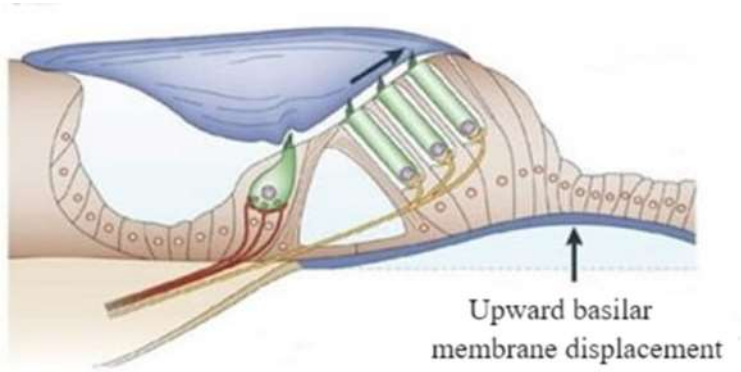

Figure 8

The tectorial membrane is above the cells which can move in response to pressure variations in the fluid-filled tympanic and vestibular canals. Signals from each inner hair cell are relayed to the brain via 10 to 20 afferent fibers of the eighth cranial nerve. Outer hair cells have both sensory and motor capabilities and possess electromotility that underlies the cochlear amplifier.

Pure Tone Audiometry (P.T.A) :

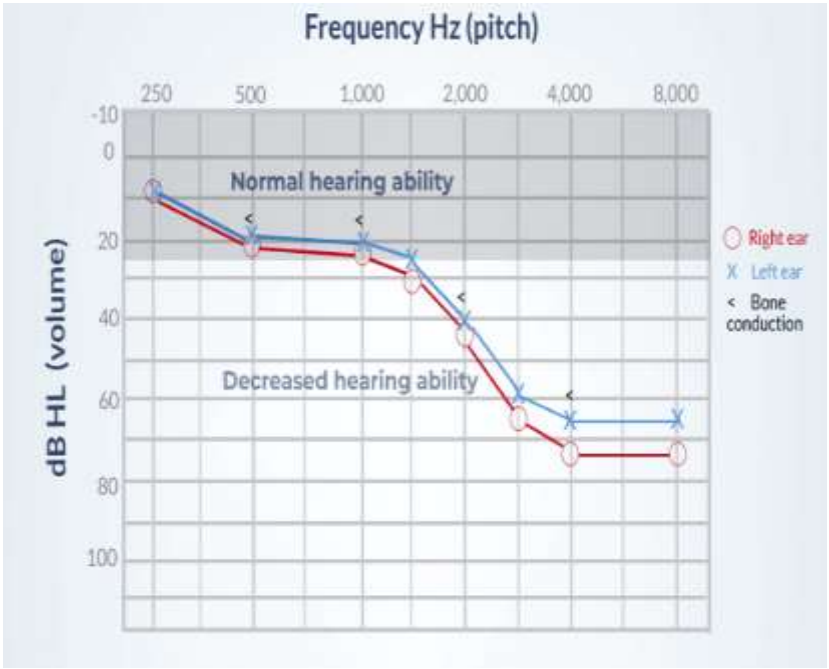

Figure 9: P.T.A. showing high frequency Sensorineural hearing loss in both ears

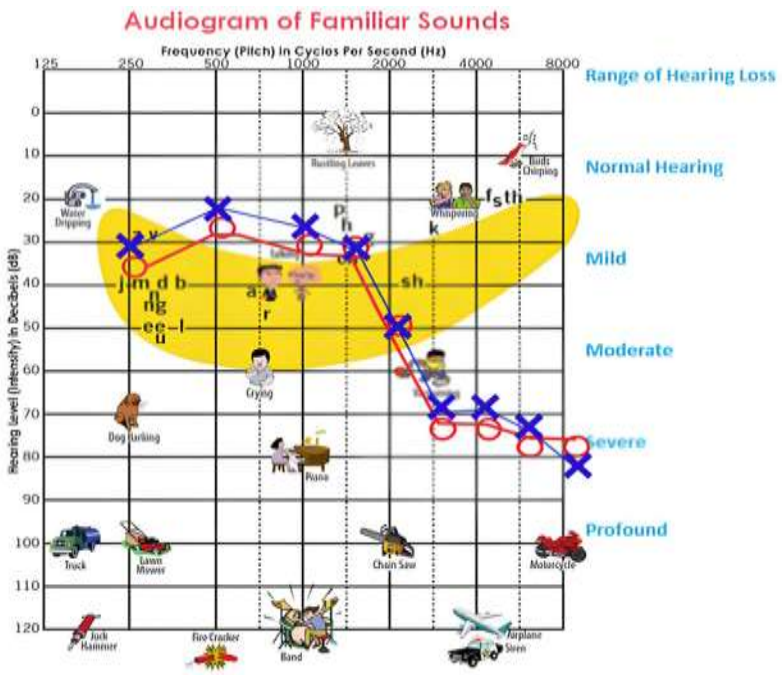

Figure 10: P.T.A. Showing Speech Banana (Horizontal banana shaped area).

The banana shaped range in the speech audiogram that covers the frequencies and intensities (dBHL) that are needed to understand speech.

Pic Courtesy :Whisper Audiology, Ontario, Canada

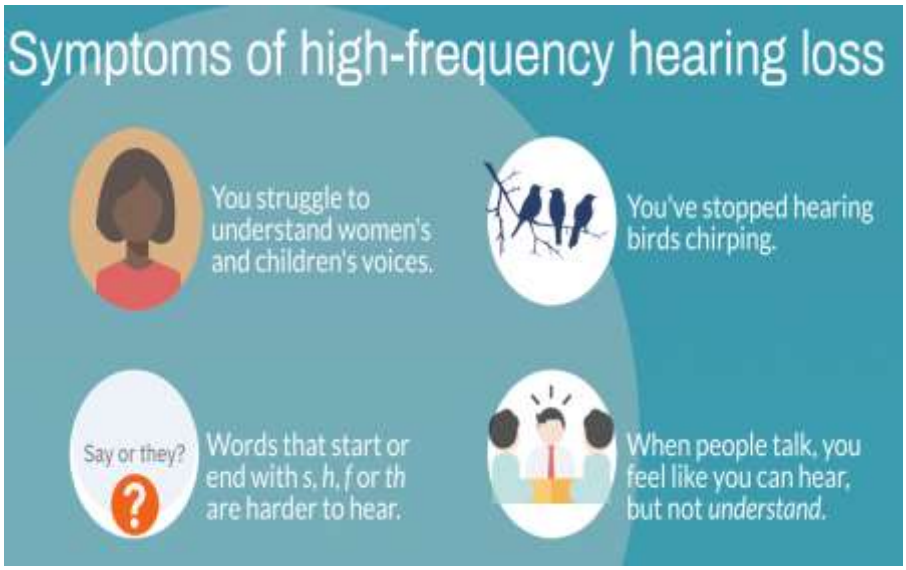

Figure 11

Aural Rehabilitation: Amplification

Dementia is directly related to the nature of prevailing type of hearing loss. So addressing the issue of hearing loss of the individual by means of Hearing Aid fitting would substantially reduce this problem. It has been proved that those who received H.A.'s has an almost 50% reduction in the rate of cognitive decline compared with people in the health-education group. The leading scientists believe that hearing loss may be a cause of dementia. Untreated HL is a public health concern. Vulnerable populations are at an elevated risk for untreated hearing loss. presbycusis—age related hearing loss (primarily affects adults > 50 yrs.). Manifests as a high frequency SNHL……. leads to permanent damage to the cochlear structures. Results from: noise exposure / age related changes in auditory system, i.e., vascular changes. Genetic predisposition.

Hearing Aids (H.A.):

Finding / selecting the right type of H.A. depends on the degree of hearing loss, lifestyle preferences of the individual & cosmetic concerns. Customization is ideal, OTC purchases should be avoided; it should be H.A. trial followed by fitting.

There are two basic types of H.A. that come in different styles :-

1.) In-the ear (ITE)/ In the canal (CIC) H.A.

2.) Behind the-ear (BTE) H.A

Figure 12: **Various hearing aid styles**

Cochlear Implantation:

Figure 13

Cochlear implantation has become known as “the treatment of choice” for adults with severe to profound hearing loss. Wide variability exists, however, in the way hearing loss severity is measured and, in the candidacy, criteria used to recommend cochlear implantation. Cochlear implant candidacy is commonly assessed using aided speech perception scores as a representation of functional hearing difficulties, together with measures of hearing thresholds to confirm the diagnosis of hearing loss. Cognitive functioning improved 12 months after cochlear implantation for older adults with severe hearing loss and poor cognition (Ellen Andries et al, 2023).

Hearing loss is very much treatable in later life, which makes it an important public health target to reduce the risk of cognitive decline and dementia. Hearing aid use, compared with non-use, has been associated with better prevention of cognitive abilities among individuals with hearing loss.

Conclusion

1.The rate of deterioration of auditory acuity or hearing loss tends to increase with age, the timing of onset is variable with the greatest variability in the middle years (40 -62 years).It is seen that once a certain amount of hearing loss has occurred (75-80 dBHL), further progression is very slow particularly in the higher frequencies.

2. Age related hearing loss imparts on psychological well-being as well as physical ability. Decreasing hearing acuity correlates with an increased incidence of falls, depression and dementia in the elderly.

3. The feeling of imprisonment and anxiety that results from social isolation led to reduced higher cognitive functioning which can in turn increase the economic and societal burden of age-related hearing loss. Therefore, an early diagnosis and treatment is warranted in these cases.

4. It is suggested that behavioral mechanism such as societal isolation resulting from chronic hearing loss results in reduced activation of central auditory pathways leading to decreased cognitive performance.

5. Typically, the patient describes a slow and insidious hearing problem. Usually, the first symptoms is difficulty in hearing conversations particularly in the presence of background or competing sounds. This normally, presents as a lack of clarity rather than loss of volume. As the hearing loss worsens, complaint of deafness becomes more apparent as recruitment sets in. Recruitment is defined as the abnormal growth in the perception of loudness by an individual with a hearing loss.

6. About 1–10 % of elderly who present to the audiology department with a significant listening difficulty in the noise or in group conversation have normal pure tone thresholds. In a substantial proportion of these patients, their listening symptoms are attributed to functional deficits in sound processing within the central

auditory nervous system. This clinical presentation is called Auditory Processing Disorder (APD). Auditory processing disorder in the elderly may be diagnosed keeping in mind different compounding factors such as memory, attention and hearing loss. However, there is no international consensus on what constitutes auditory processing disorder as yet.

7. A multidisciplinary team approach is required for Auditory processing disorder rehabilitation taking into account, varied modalities such as auditory training, signal enhancement and compensatory strategies. These will help the patients with hearing loss and dementia in the long run.

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