

# "A Comprehensive Analysis of Noise-Induced Hearing Loss and Its Ayurvedic Insight"

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**Abstract:** Noise-induced hearing loss (NIHL) is a growing global health concern, primarily attributed to our increasingly noisy environments. This comprehensive analysis delves into the multifaceted aspects of NIHL while exploring potential insights from Ayurveda, an ancient Indian system of medicine.

NIHL results from prolonged exposure to loud noise levels, causing damage to the delicate structures of the inner ear. It is a gradual and irreversible condition that affects millions of people worldwide, impacting their quality of life and overall health. Traditional approaches to NIHL management primarily focus on hearing aids and protective measures. However, this analysis seeks to integrate Ayurvedic principles and treatments to offer a holistic perspective on NIHL prevention and management.

Ayurveda, with its holistic approach to health, considers the interplay of physical, mental, and environmental factors. In Ayurveda, hearing loss can be linked to imbalances in the doshas (Vata, Pitta, and Kapha) and the accumulation of toxins in the body. By addressing these imbalances through dietary modifications, lifestyle changes, and herbal remedies, Ayurveda may offer valuable insights into preventing and managing NIHL.

The analysis highlights the importance of noise awareness, emphasizing the need for public health campaigns and workplace regulations to reduce noise exposure. Additionally, it explores Ayurvedic herbs and therapies known for their potential in mitigating the effects of NIHL, such as Ashwagandha (*Withania somnifera*) and Panchakarma detoxification procedures.

Furthermore, the study discusses the role of yoga and meditation in stress management, as chronic stress can exacerbate NIHL. Ayurvedic practices like Pranayama (breathing exercises) and Shirodhara (oil therapy for the head) may promote relaxation and reduce stress, contributing to overall hearing health.

In conclusion, this analysis offers a comprehensive overview of NIHL, including its causes, symptoms, and conventional management strategies. By incorporating Ayurvedic insights, we explore a holistic approach to NIHL prevention and management, acknowledging the potential benefits of Ayurveda in promoting hearing health. Further research and collaboration between traditional and modern healthcare systems are essential to harness the full potential of Ayurveda in addressing the global issue of NIHL.

Keywords: Noise-Induced Hearing Loss, Ayurveda, Holistic Health.

## 1. INTRODUCTION

### Background:

India has over 50 million workers employed in industries with exposure to exceedingly high sound levels, predisposing them to noise-induced hearing loss (NIHL). (1)

NIHL is a predictable and preventable disease with an epidemiologically relevant prevalence in urban communities. (2)

## **Main body:**

Definition: Hearing impairment on continuous long-term exposure to high intensity sound waves is called Noise induced hearing loss (NIHL).

This exposure to loud sounds causes irreversible damage to sensory cells and associated structures resulting in permanent hearing loss. It is the second most generic form of sensorineural hearing deficit. Exposure to noise beyond sound range of 75dB-85dB over a period or an impulse noise in the range of 130dB- 140dB can cause hazardous impact on the delicate structures of inner ear especially the stereo-cilia of the hair cells within the cochlea, reducing their sensitivity, synaptopathy and/or cell death leading to hearing loss due to sensorineural deficit. (3)

Prevalence: It has been suggested that 12% or more of the global population is at risk for hearing loss from noise, which equates to well over 600 million people. (4)

Types: There are two basic types of Noise induced hearing loss depending on the cause.

They are:

- i. NIHL due to acoustic trauma
- ii. Gradually developing NIHL

### **1. Acoustic trauma induced hearing loss**

Acoustic trauma is the sustenance of an injury to the tympanic membrane as an impact of exposure to a very loud noise. A sudden intense auditory blow to the ears with an intensity of 120dB or more induces excessive sound pressure onto the ears resulting in irreversible damage to structures involved in hearing and resulting in sensorineural hearing loss. The extent of damage and hearing loss following it depends on the susceptibility of the individual. (5)

Acoustic trauma may result from exposure to high intensity sounds such as bomb explosions, gunshots, firecrackers, loud screaming, hitting large drums or from improvised explosive military devices.

Pathology: When a continuous high intensity sound with enough energy is transferred to cochlea, there occurs necrosis of the outer hair cells and inner hair cells which in-turn cause cochlear synaptopathy due to glutamate excitotoxicity of first order afferent neurons of spinal ganglion. This occurs due to an abrupt impulse. When the same is excessive, the causative force can trigger metabolic overload, cell damage and cell death. This happens when the force induced by the transient sound exceeds the elastic limit of the tissues.

Signs and symptoms: Hearing loss, tinnitus, aural fullness, recruitment, vertigo, and difficulty in localizing sounds as well as hearing in noisy backgrounds.

### **2. Gradually developing NIHL**

In contrast to acoustic trauma, lesser intensity sounds over time causes chronic noise-induced hearing loss. The disease progresses over the years to finally result in impairment in hearing. An intense impulse of sound received by the ear for a shorter period and a less intense sound presented for a longer duration of time produces the same damage as the total energy delivered to the cochlea is resultantly the same. It is based on this 'equal energy' concept that cochlear damage and subsequent hearing loss is predicted. It can be caused due to constant exposure to loud noises such as those in live concerts, vehicle stereos, personal media players, vehicle horns etc.

Pathology: On chronic exposure to high intensity sounds the hair cells in the cochlea and supporting structures are overly stimulated leading to heavy production of reactive species which leads to oxidative cell death. This structural damage to hair cells results in hearing loss which can be characterized by attenuation and distortion of incoming auditory stimuli.

Also, scars are produced following cell death as part of the body's healing mechanism. These scars prevent potassium rich fluid of the endolymph from mixing with the fluid of the basal domain. The endolymph fluid is toxic to neuronal endings causing them to depolarize and lead to complete hearing loss. In addition to that, if the leakage continues further tissue destruction will occur.

The development of chronic NIHL progresses at two stages. During the first stage, there is a temporary threshold shift (TTS). This is characterized by a brief temporary hearing loss following exposure to noise which resolves on its own. If the exposure is repeated to such noises intense enough to cause TTS, gradually a permanent threshold shift (PTS) will occur.

This is the second stage of chronic NIHL. From this point on there is no reversal of pathology since permanent hair cell damage.

Signs and symptoms: Otalgia, tinnitus, temporary loss of hearing, hyperacusis and muffled or distorted hearing.

Complications: Complications can include physical symptoms and the psychological impact of living with hearing loss. Many patients with NIHL suffer from other associated symptoms such as tinnitus and dizziness, which they often find more challenging to tolerate than hearing loss. Studies have been done to evaluate the impact tinnitus can have on patients' lives. Prevalent responses included inability to concentrate, constant awareness, the effect on sleep, intrusiveness, tinnitus vestibular dysfunction and overall loss of control over their lives.

Prognosis: Sensorineural hearing loss tends to have a typical slow progression and can be managed with conservative measures and hearing aids for most patients with regular follow-up appointments and audiograms. If patients are eligible, even profound hearing loss can be rehabilitated with a cochlear implant.

With sudden SNHL, four factors have been shown to help predict the outcome. They are age, time since onset, degree of hearing loss and vertigo.

Diagnosis: Assessment of hearing.

Audiologic testing is performed to assess hearing thresholds across the range of frequencies important for human communication. Auditory thresholds are typically measured for air- and bone-conducted pure-tone stimuli to differentiate conductive from sensorineural hearing loss and characterize the pattern of hearing loss at various frequencies. The term "threshold shift" refers to a change in hearing thresholds between sequential audiologic tests; it may reflect improvement or worsening of hearing. Testing the perception of speech signals of low redundancy (monosyllabic words) presented at a comfortable listening level without background noise is another way to assess hearing in adults. (6)

- i. Pure tone audiogram-An audiometric evaluation is done to find the damages and their impact. NIHL usually results in hearing loss at higher frequencies, called "audiometric notch" which is seen especially at 4000Hz (3000-6000 Hz). This is the Diagnosing criteria for NIHL. A decline in sensitivity may be seen in ranges other than the typical 3000-6000 Hz range. The factors that decide these variations are differences in ear canal resonance of people, frequency and nature of harmful Acoustic signal and duration of exposure. As the exposure to these signals continues, the bandwidth of affected frequencies will broaden, and their severity worsens.
- ii. Speech recognition- NIHL can be associated with a decrease in speech recognition scores in quiet as well as in background noise, even in the setting of a normal pure tone audiogram. This is related to the synaptopathy mechanisms and reduced temporal processing skills because offset-induced affected connections between inner hair cells and low spontaneous rate auditory nerve fibers, which are important for temporal processing. To noise-induced damage, it is recommended that speech recognition tests in quiet and in noise should be performed in addition to pure tone thresholds. (7)
- iii. Otoacoustic emissions (OAEs) -Otoacoustic emissions have the necessary features to serve as an objective, sensitive, and easy-to-administer tool for the diagnosis of NIHL. Parallel decreases in pure-tone sensitivity and OAE amplitudes were reported among noise-exposed industrial workers and military personnel. Several studies have suggested that OAEs may provide an early indication of noise-induced cochlear damage before evidence for NIHL appears in standard audiometry. However, OAEs can only be used to monitor hearing effectively when there is room for hearing deterioration. (8)

### **Treatment:**

- Despite increasing knowledge of the biology of the inner ear, hearing restoration is not currently available for most cases of hearing loss. Most of these proposed treatments address cell-death pathways and mitigate the effects of oxidative stressors on inner-ear hair cells. Commercially sponsored trials of antibiotic and chemotherapeutic medications for the treatment or prevention of ototoxicity are planned or are under way.
- Since acoustic trauma is an ENT emergency, treatment should be started as soon as possible to prevent further damage. When the treatment is administered within an hour, there are higher rates of recovery and lower threshold shifts.
- As of now, in the case of gradually developing NIHL there is no cure to reverse the effects of permanent NIHL. Such cases can only be managed with options such as hearing aids and counselling sessions. Management options that help people to communicate effectively surpassing their disabilities exist. These include sound amplification, counselling, and other assisted listening devices. Recent inventions in digital hearing aid technology have increased the prognosis of NIHL to a huge extent.

### **Prevention**

NIHL can be Prevented through various simple, easily applicable, and economical tools.

- i. Primary prevention: This strategy is for primary prevention of noise induced hearing loss emphasis on promotion of general health, reduction of risk factors and other Health Protection measures. There are various health programs and health education schemes designed to improve Environmental Quality.
- ii. Early screening and prevention: Early detection can be made possible by taking an elaborate history clinical examination followed by audiological test. A patient who complains of exposure to a recent loud noise induced hearing loss should be subjected to audiometric test evaluate the prognosis and proceed with measures.
- iii. Screening for hearing impairment: The doctor should ask the patient if they have any difficulty in understanding speech while they are in a noisy environment. Clinical examination Like Weber test and Rinne's test using a tuning fork Will help in differential diagnosis of conductive and sensorineural hearing loss.
- iv. Hearing conservation program: Various components of occupational hearing conservation include interventions such as education, exposure assessment, training, audiometric testing, counseling, hearing protection, noise control measures etc.
- v. Secondary prevention is brought about by a change of environment.
- vi. Tertiary prevention: Adult aural rehabilitation is here defined holistically as the reduction of hearing-loss-induced deficits of function, activity, participation, and quality of life through a combination of sensory management, instruction, perceptual training, and counseling.

### **AYURVEDIC PERSPECTIVE ON NOISE INDUCED HEARING LOSS**

NIHL may be classified under indriya pradhoshaja vikaras.

#### Nidana Samprapthi

- > Asatmendriyartha samyoga of sravana to Shabda
- > upaghata to sravanavaha srotus
- > Dosha prakopa in sravanendriya
- > Sthanasamshraya of prakupita dosha at indriyasthana
- > Sravanendriya pradhushthi
- > Badhirya

Poorvaroopam: Karna naadam, Bheri, Shringi

Roopam: Badhiryam

### Upashaya&Anupashaya:

Uchai bhashya (interestingly enough loud noise acts as upashaya and Anupashaya as well).

- As upashaya: Person would not be sensitive to sounds of low frequencies hence require sounds of higher frequencies for them to comprehend the input. It is certain consonants that cause confusion during initial days which can be tackled by increasing the volume of the source.
- As Anupashaya: Since loud noise is the cause of disease in the first place, it is the first thing to be removed from the environment as 'Nidana parivarjana' is the first step in Samprapthi vighatana for Chikitsa.

### **Chikitsa**

1. Nidana parivarjana-Remove the sources of excessive noise and take necessary measures to reduce the impact of distressing noise.
2. Jatrurdhwa shodhana-The doshas which took sthanasamsraya at the karnavaha srotus can be expelled by tikshna Nasya through nose as the shringhataka marma is a common space through which the indriyas communicate with each other.
3. Sthanika Tarpana-After shodhana, medicine induced nourishing fats should be instilled in ears to rejuvenate the nerves and associated structures involved in auditory transmission.
4. Rasayana Chikita-Both neurons and cochlear hair cells damaged by acoustic trauma cannot be regenerated by the body on its own. Rasayana Chikita is the only ray of hope at revival by providing a suitable environment for the body.

## **2. REVIEW OF LITERATURE (9)**

In 1996, the National Institute for Occupational Safety and Health (NIOSH), an agency of the government of the United States of America, published a practical guide for Occupational Hearing Loss Prevention using the term "occupational hearing loss," which encompasses not only hearing loss caused by exposure to aromatic solvents, metals, and some asphyxiating agents or to vibration, thus encouraging research into these and other factors that could potentiate hearing loss, but also noise-induced hearing loss (Fiorini; Nascimento, 2001).

It is estimated that 25% of the working population is exposed to a level of noise that will lead to NIHL (Bergstrom; Nystrom, 1986; Carnicelli, 1988; Morata, 1990; Prospero, 1999). Although NIHL is the most common work-related injury, its prevalence in Brazil stays poorly understood. This reinforces the importance of reporting, which enables accurate assessment of the situation and appropriate scaling of the necessary prevention and assistance measures.

The most striking feature of NIHL is the degeneration of the ciliated cells of the organ of Corti. Recently, these lesions and the onset of cellular apoptosis have been demonstrated to stem from oxidation caused by the presence of free radicals formed by excessive sound stimulation or by exposure to certain chemicals. These findings have led to the study of substances and conditions that can protect cochlear ciliated cells against the insults of noise and chemicals (Oliveira, 2001, 2002; Hyppolito, 2003).

### **According to the Department of Health in 1998, the National Committee on Noise and Hearing Conservation defined the characteristics of Pair as follows:**

- Always sensorineural, once the organ of Corti in the inner ear has been damaged.
- Usually bilateral, with similar patterns in each ear. In some situations, the degree of hearing loss differs between the ears.
- Usually does not produce hearing loss greater than 40dB (NA) at low frequencies and 75dB (NA) at high frequencies.
- The progression ceases when the exposure to intense noise ends.
- The presence of NIHL does not make the ear more sensitive to noise; as the threshold increases, the progression of the loss slows.

- The hearing loss begins and predominates in the frequencies of 3, 4, and 6 kHz and eventually progresses to 8, 2, 1, 0.5, and 0.25 kHz.
- With stable exposure conditions, the losses in 3, 4, and 6 kHz range plateau after about 10 to 15 years.
- The worker with NIHL may develop intolerance to loud sounds and complain of tinnitus and reduced speech intelligibility, which hampers oral communication.

Changes in frequency selectivity also cause difficulties in auditory discrimination. This injury increases the minimum time required to solve a sound event (temporal resolution), which, especially in association with the reverberation of the work environment, limits the ability of the patient with NIHL to recognize sounds (Bamford; Saundes, 1991). The worker with NIHL may develop intolerance to loud sounds and complain of tinnitus, reduced speech intelligibility, and impaired verbal communication. In a study of 3466 workers who applied for compensation because of NIHL, McShane, Hyde, and Alberti (1988) reported a 49.8% prevalence of tinnitus. Of the affected subjects, 29.2% stated that tinnitus was their main problem.

The diagnosis of NIHL is based on clinical and occupational research in which the prior and current exposure to risk is evaluated and the characteristic symptoms described earlier (Department of Health, 2006) are considered. The diagnostic work-up should also include audiometry evaluation. It is important to detail the exposure to allow correlation between the exposure and the signs and symptoms of NIHL. Occupational anamnesis is thus an essential tool for risk identification. Such knowledge about the working environment can be obtained through site visits, review of the company's technical reports, and information from inspections and the patient's report. It is essential to confirm the presence of hearing loss by an audiological evaluation. This consists of the following tests: pure tone audiometry by air conduction (despite its subjective nature), pure tone audiometry by bone conduction; speech audiometry, and immittance. To be reliable, this assessment must be performed under the conditions established by Ordinance No. 19 of Regulatory Norm no. 7 (NR-7).

The diagnostic work-up should be performed in a way that minimizes the influence of confounding factors extrinsic to the examination, and it is therefore important to use a soundproof booth and calibrated equipment, to have the exam performed by a qualified professional (doctor or audiologist), and to instruct the patient to perform sound rest for 14 hours before the exam. The examiner must also consider potentially confounding factors intrinsic to the examination, i.e., those related to the patient and his or her general condition, motivation, intelligence, attention, familiarity with the task, and interpretation of the test instructions.

When prior hearing assessments exist, they should be compared with the current assessment to determine whether there has been progressive hearing loss, which in NIHL begins and predominates in the frequencies of 3, 4, and 6 kHz and later progresses to 8, 2, 1, 0.5, and 0.25 kHz. Likewise, with stable exposure to noise, the losses in the 3, 4, and 6 kHz range plateau within about 10 to 15 years.

It is important to differentiate NIHL from other auditory pathologies that have distinctive characteristics despite having the same etiology and occurring in association with the work environment. Thus, we should remember that "the effects of noise can cause acoustic trauma, temporary change in hearing threshold and hearing loss" (Maia, 2006).

There is no treatment for NIHL. The key is to limit the damage by notifying the appropriate individuals to initiate health surveillance and then monitor the progression of hearing loss through periodic audiological evaluations. Even now, careful analysis of the worker's audiological evaluation can lead to rehabilitation through individual actions and group therapies.

As noise is an occupational hazard, prevention efforts must be implemented in the work environment. As described earlier, there is legislation defining exposure limits and guidance on programs to prevent and control risks. Companies must follow these guidelines in accordance with the Regulatory Standards of the Ministry of Labor: A Prevention Program Environmental Risks (PPRA-NR-9), which state that the various risks in the workplace must be identified, quantified, and reported to the Medical Control of Occupational Health (PCMSO-NR7), which will use the information to determine and proceed with the appropriate assessments of the workers' health. The actions taken to control NIHL are related to noise control. Measures should be taken to control the exposure at the source, trajectory, and individual levels. In addition, organizational measures, such as reducing travel, establishing breaks, and rotating shifts through the noisy area, can be effective.

Noise is defined as a “physical agent capable of causing damage to the human body with the short- and medium-term effects” (Paraguay, 1999). The word is usually associated with an unpleasant sound with chaotic and irregular frequencies. Noise produced in public spaces in such excess that it contributes to an undesirable environment is called noise pollution. Such pollution, which can be intolerable, is becoming one of the environmental problems affecting the greatest number of people according to the WHO (WORLD HEALTH ORGANIZATION, 2009).

### 3. CONCLUSION

In short, we can say that noise induced hearing loss is a completely preventable entity if an individual who is exposed to noise is made aware of the numerous ways by which one can protect oneself from the devastating effects of noise. This is because damage to hair cells once done cannot be reversed. There is also ongoing research in finding advanced technologies to develop audiometric tests which would allow screening of individuals for finding out their susceptibility towards developing NIHL in future.

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