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# Audiological and Vestibular Findings in an Adult with Tinnitus and Dizziness: A Case Report

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## ABSTRACT

**Background:** Tinnitus is a phantom auditory perception that can significantly affect cognitive, emotional, and psychosocial well-being. It is often associated with dizziness and vestibular dysfunction, contributing to a reduced quality of life. Despite extensive research, the exact pathophysiology remains unclear, making diagnosis and management challenging.
**Materials and methods:** A 49 years old male locomotive pilot reported of occupational noise exposure with right-sided tinnitus, dizziness and imbalance. Comprehensive audiological and vestibular assessment included pure tone audiometry, speech audiometry (SRT and WRS) and immittance audiometry followed by vestibular subjective tests (Romberg and Fukuda Step Test) and objective assessment (VNG, cVEMP and oVEMP).
**Results and discussion:** Audiological findings revealed moderately severe sensorineural hearing loss in the right ear with reduced speech discrimination scores and no acoustic reflexes. Vestibular subjective examination showed unilateral vestibular weakness of the right side. Videonystagmography demonstrated left beating nystagmus after shaking of the head that implied of vestibuloparesis of the right side. Cervical and ocular Vestibular Evoked Myogenic Potentials (cVEMP and oVEMP) were absent on the right indicating an associated existence of vestibular dysfunction in sacculo-colic and utriculo-ocular pathways. Self-report questionnaires (THI and DHI) showed mild handicap (tinnitus and dizziness) with modest quality of life impact.
**Conclusion:** A holistic and integrated audiological and vestibular evaluation is of paramount importance for diagnosing adults with auditory and vestibular co-morbidity. Early intervention and prevention measures, such as noise protection and balance rehabilitation, are crucial for prevention of the long-term consequences.

***Keywords:*** Tinnitus, vestibular dysfunction, VEMP, noise-induced hearing loss.

## INTRODUCTION

Tinnitus denotes hearing an imaginary sound with no external presence, which is an intricate sensory experience that is usually characterized by its spatial distribution, duration, pitch, and quality (Norena et al., 2021). This hearing phenomenon without sound has been attributed to changes in the auditory system or in more general neural networks, influenced by several factors including physiologic and psychologic aspects (Hu et al., 2021). Tinnitus can have a range of negative impact, such as reduced attention and concentration, higher risk of

falls, inability to sleep properly, and even reduced ability to do the daily chores, which all together affect the quality of life (Swain et al., 2021). As estimated by World Health Organization (2003), worldwide, about 278 million people suffer from tinnitus, constituting about 15% of the population. This percentage increases greatly in older populations, more than 60% of people over the ages of 60 report having tinnitus. These statistics are essential as they indicate that the problem of tinnitus is significant in the public health sector, especially among the elderly individuals (WHO, 2021).

Tinnitus can be subjective, when the experience is of the individual alone, or, less commonly, objective, when an observer can hear the tinnitus. The description of the sensation is generally perceived as of hissing, sizzling, and ringing although some has described it as more complex sounds such as voices or music. Tinnitus can sometimes be a rhythmical or pulsatile sound (Stouffer & Tyler, 1990). Pulsatile tinnitus can be synchronous with the heartbeat, in which case a vascular origin is likely, or asynchronous, in which case myoclonus of middle-ear or palatal muscles is probable (Baguley et al., 2012). Tinnitus can be constant or intermittent, and many patients experience more than one sound. The causes of tinnitus are particularly numerous and often relate to issues such as middle ear disorders, neurodegenerative issues, heart and vascular diseases, metabolic disorders, mental illnesses, and various forms of hearing loss (Langguth et al., 2024). In addition, tinnitus is often found together with other conditions such as problems with balance, hearing, and mental functioning (Peter et al., 2019). This becomes even more complex considering the closely related features of auditory and vestibular functions that is, movement and maintenance of appropriate posture which are spatial positions, that affects one system or both.

The frequent occurrence of tinnitus and its effect on mental, emotional health as well as auditory and vestibular system makes it important to know the relationship between tinnitus and functions of the vestibular system and further leading to early identification of vestibular dysfunction. Tinnitus is a public health concern that is significant among many conditions thus creating an urgent need for appropriate assessment and treatments to reduce negative effect on daily life and associated impairments of psychological and functional state.

## MATERIALS AND METHODS

A 49-year-old male, locomotive pilot with noise exposure for over a decade (approximately 8 hours per day) was referred to the department of audiology with a complaint of reduced hearing sensitivity in right ear and giddiness for 4 months. The patient also reported of continuous tinnitus in the right ear, dizziness lasting for nearly 2 minutes and imbalance while walking. Previous records, including a pure tone audiometry (PTA) report, indicated a moderately severe to severe sensorineural hearing loss in the right ear and mild to moderate sensorineural hearing loss in the left ear following which medication was recommended for a period of 15 days.

Detailed case history was followed by comprehensive audiological and vestibular assessment. Pure Tone audiometry was carried out at frequencies ranging from 250 Hz to 8 kHz using a two-channel audiometer (Interacoustics AA-222) to assess the degree, type and configuration of hearing loss. Speech audiometry was conducted to assess speech discrimination ability and included speech recognition threshold (SRT) and word recognition score (WRS) measures. Immittance audiometry was performed (Interacoustics AT-235) for both ears using a probe tone of frequency 226 Hz and acoustic reflex thresholds were obtained at 0.5, 1, 2, and 4 kHz on ipsilateral and contralateral stimulation.

Vestibular assessment was conducted to evaluate functioning of the balance system. Firstly, a detailed case history regarding vestibular symptoms was taken followed by administration of subjective tests, which

included Romberg and Fukuda step test. In the Romberg test, the patient was asked to stand with feet together and eyes closed, to identify any balance issues. In Fukuda step test, the patient was instructed to march in place with eyes closed, which helped to detect any asymmetry in vestibular function. A two-channel videonystagmography system (NeuroEquilibrium) was used to assess eye movement in response to various visual and positional stimuli. VNG included spontaneous nystagmus and head shaking nystagmus testing, positional tests (dix-hallpike test, supine roll test, supine test) to evaluate vestibulo-ocular reflex (VOR) function and detect any nystagmus which is indicative of vestibular dysfunction. Vestibular Evoked Myogenic Potentials (VEMPs) were recorded to assess otolithic (gravity-sensitive) function, as abnormalities would indicate issues with the saccule and utricle. Two types of VEMPs were performed that consisted of Cervical Vestibular Evoked Myogenic Potential (cVEMP) test which measured saccular function and Ocular Vestibular Evoked Myogenic Potential (oVEMP) that measured utricular function.

The cVEMP was recorded from the sternocleidomastoid (SCM) muscle in response to sound stimulation. The patient was seated and instructed to turn their head away from the side being tested to activate the SCM. The active electrode was placed on the midpoint of the SCM muscle belly, whereas the reference electrode was positioned on the sternoclavicular junction, and the ground electrode was placed on the forehead. This configuration ensured optimal response amplitude and latency. The oVEMP recorded eye muscle responses to sound stimuli. Electrodes were placed below the eyes; with the active electrode positioned approximately 1 cm below the centre of the lower eyelid and the reference electrode placed 2 cm below the active electrode whereas the ground electrode was placed on the forehead. During the test, the patient was asked to gaze upward to elicit response.

Self-report questionnaires were administered to quantify the impact of dizziness and tinnitus on the patient's quality of life. Dizziness Handicap Inventory (DHI) developed by Jacobson & Newman (1990) was used to assess the perceived impact of dizziness on physical, emotional, and functional aspects of daily life. The inventory consisted of 25 items with a scoring system that helps to categorize dizziness impact as mild, moderate, or severe. Tinnitus Handicap Inventory (THI) given by Newman et al., (1996) was used to evaluate the perceived severity of tinnitus-related handicap. This 25-item questionnaire assessed the impact of tinnitus on functional, emotional, and catastrophic domains. The results from THI provided a quantifiable measure of the patient's subjective tinnitus distress. The battery of tests contributed to a holistic profile of the patient's auditory and vestibular status, allowing for a thorough understanding of the severity and interplay of hearing loss, tinnitus, and vestibular dysfunction.

## RESULTS

The results of the audiological evaluation showed that the subject had moderately severe, high frequencies sloping sensorineural hearing loss in the right ear, however had hearing sensitivity within normal limits in the left ear. The pure tone average of right and left ear was 56.25 dB HL and 13.75 dB HL respectively. The speech reception threshold (SRT) was 65dB HL in the right ear and 25 dB HL in the left whereas the speech discrimination scores were 80% in the right ear and 100% in the left ear. He had bilateral "A" type tympanogram with absent ipsilateral and contralateral reflexes in the right ear and present reflexes in the left ear.

The subjective vestibular assessments included Fukuda step test and Romberg test. The results of Fukuda step test showed a deviation to the right side where as findings of Romberg test implied a positive result. The VNG Head-Shaking Nystagmus test results presented with a left-beating nystagmus after horizontal head shaking. The findings were suggestive of nystagmus

of pathological nature, which indicated asymmetry in the vestibulo-ocular circuits and a vestibular functioning deficit. Head-Shaking Nystagmus test waveforms are shown in Figure 1.

| | Right Eye SPV(°/sec) | Right Eye Beats | Left Eye SPV(°/sec) | Left Eye Beats |
|---|---|---|---|---|
| Horizontal Left Beating | 5 | 39 | 7 | 35 |
| Horizontal Right Beating | 0 | 0 | 0 | 0 |
| Vertical Up Beating | 0 | 0 | 0 | 0 |
| Vertical Down Beating | 0 | 0 | 0 | 0 |

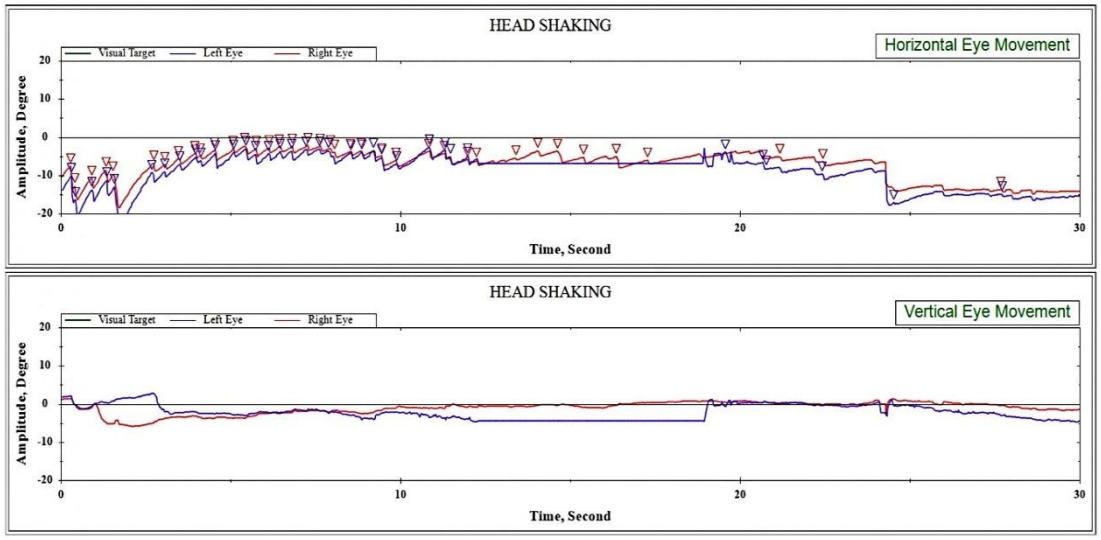


**Figure 1. Result of Head Shaking Nystagmus (HSN) test. Illustrates eye movement recordings post-head shaking, with horizontal eye position displayed on the y-axis and time on the x-axis.**

The cVEMP and oVEMP results showed absent response in the right ear and responses were present in the left ear. This suggested a dysfunction in the sacculocollic pathway and utriculo-ocular pathway of the right ear whereas intact function of the pathways was indicated for the left ear. The cVEMP and oVEMP waveforms are shown in Figure 2 and Figure 3, respectively.

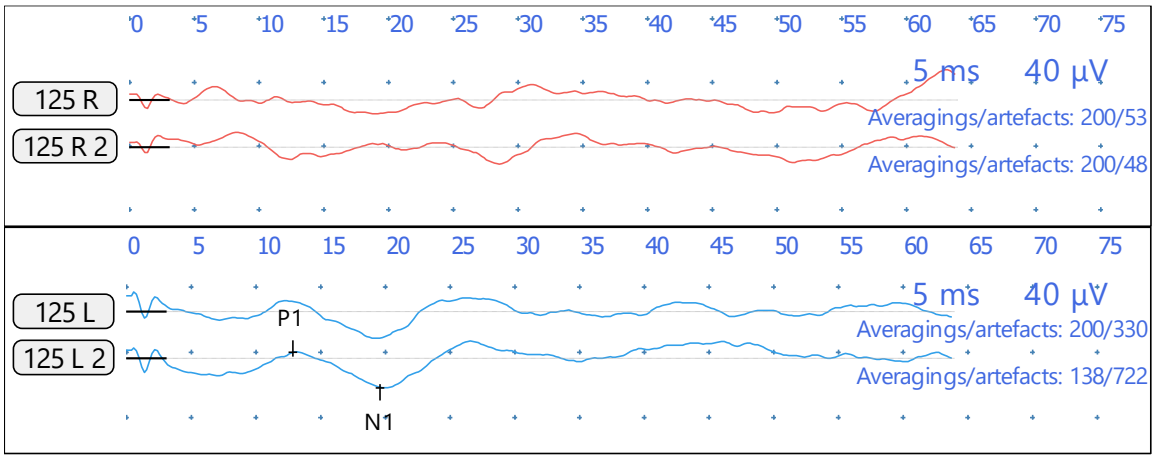


**Figure 2. Cervical Vestibular Evoked Myogenic Potential (cVEMP) for the right and left ear. The absent cVEMP of right ear indicates dysfunction of the sacculo-collic pathway.**

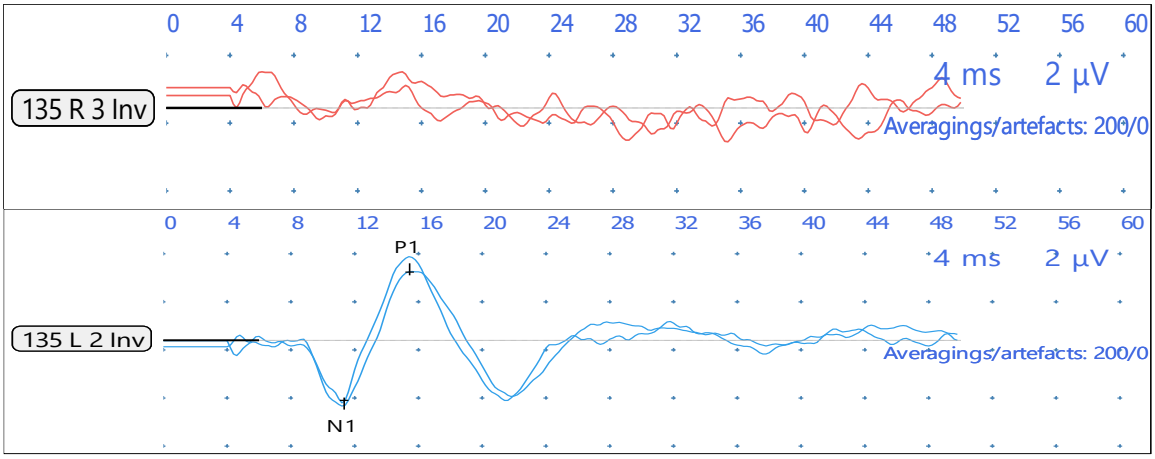


**Figure 3. Ocular Vestibular Evoked Myogenic Potential (oVEMP) for the right and left ear. The absent oVEMP indicates dysfunction of the utriculo-ocular pathway**

In positional tests, Dixhallpike test showed no significant nystagmus bilaterally, suggestive of no indication of posterior or anterior semicircular canal BPPV. Supine roll test showed absent nystagmus, suggestive of negative supine roll test. This result indicated of no signs of horizontal canal BPPV.

The patient scored 36 and 18 in Tinnitus Handicap Inventory (THI) and Dizziness Handicap Inventory (DHI) respectively. This suggested of a mild degree of handicap. These scores reflect the impact of tinnitus and dizziness on daily functioning and indicate that, while not debilitating, the symptoms may affect quality of life.

## DISCUSSION

The results of the study showed that the patient had continuous tinnitus and moderately severe sensorineural hearing loss in the right ear, sloping at higher frequencies. The left ear, however, maintained hearing sensitivity within normal limits, demonstrating a significant contrast between ears. Additionally, the right ear's poor SRT and WDS indicate a considerable decline in speech recognition and discrimination, likely due to cochlear distortion impacting the clarity of sound transmission and interpretation. This suggests of cochlear involvement possibly due to damage within the basal turn of the cochlea where high-frequency sounds are processed. This high-frequency sloping loss may correlate with cellular damage in the cochlear outer hair cells, which is often accompanied by tinnitus and diminished speech perception, both of which are noted in the patient's profile. Further confirmation of auditory asymmetry and dysfunction was provided by immittance audiometry. The study findings of bilateral "A" type tympanogram ruled out no middle ear pathology, confirming that the dysfunction is likely sensory rather than conductive. The absence of both ipsilateral and contralateral reflexes in the right ear, with normal reflexes in the left, suggested of a potential neural lesion or reduced compliance in the affected ear, further substantiating the likelihood of sensorineural damage. This pattern of absent reflexes on the right side aligns with findings of neural pathway involvement, supporting a peripheral auditory dysfunction consistent with vestibulocochlear nerve compromise. Fabijanska et al. (2012) studied that high-frequency hearing loss correlates with cochlear damage, especially in the basal turn, and is commonly accompanied by tinnitus. Additionally, OHC dysfunction has been linked to difficulties in speech recognition, particularly in noisy environments, highlighting the role of OHCs in speech perception (Hoben et al., 2017).

The vestibular assessments also reinforced a diagnosis of unilateral vestibular weakness on the right side. The Fukuda step test and Romberg test findings suggested of an imbalance in the patient's vestibular

function, commonly seen in unilateral vestibulopathies where patients tend to veer toward the side with impaired vestibular input. The VNG Head-Shaking Nystagmus test corroborated these findings, presenting a left-beating horizontal nystagmus after rightward head shaking, a classic sign of vestibuloparesis. This response indicated that the left vestibular system functioning is relatively intact, while the right side exhibits impaired vestibular functions. The presence of left-beating horizontal nystagmus following rightward head shaking during the Head-Shaking Nystagmus (HSN) test is a well-established clinical indicator of right-sided unilateral vestibular hypofunction (Boniver, 2008). This phenomenon occurs because the fast phase of nystagmus typically beats toward the functionally intact or "stronger" ear, reflecting asymmetry in vestibular input (Striteska etal., 2022). These findings collectively reinforce the assessment of unilateral vestibular weakness on the right side in the present study.

Advanced vestibular testing with cervical and ocular vestibular-evoked myogenic potentials (cVEMP and oVEMP) highlighted further abnormalities. Abnormal cVEMP and oVEMP responses in the right ear suggested of compromised sacculo-colic and utriculo-ocular pathways, which are involved in reflexive head and eye movements respectively. The results indicated that the patient's vestibular deficit likely extends beyond the cochlear area, involving both otolithic organs (saccule and utricle) critical for detecting linear acceleration and head tilts. Specifically, the utricle is responsible for detecting horizontal linear accelerations and head tilts, while the saccule detects vertical linear accelerations and head tilts (Wong, 2015). Lempert et al., (1997) demonstrated that dysfunction in otolithic organs can lead to impaired visual acuity during linear head motion, highlighting their essential role in stabilizing vision during such movements. Kadan (2021) highlighted positive correlations between tinnitus characteristics and vestibular dysfunction, even in individuals with normal hearing, underscoring the interdependence between auditory and vestibular systems.

The results of the present study revealed that symptom of tinnitus can be correlated to affected cochlear and vestibular nuclei, leading to abnormal audio-vestibular results. A detailed audio-vestibular evaluation can identify the possible site of the lesion and the pathophysiology of the audio-vestibular symptoms. Cetinbag-Kuzu (2023) emphasized the importance of comprehensive auditory-vestibular evaluations in individuals exposed to noise, given the shared pathways and susceptibility of both systems to damage from common etiologies like noise exposure and ototoxicity. A comprehensive audio-vestibular evaluation is essential for identifying the potential site of the lesion and understanding the pathophysiology underlying the audio-vestibular symptoms. In summary, the findings of this case study are consistent with right-sided vestibulopathy accompanied by sensorineural hearing loss and tinnitus. These results highlight the importance of integrated vestibular and auditory assessments in diagnosing and managing complex cases where symptoms overlap across both systems.

## CONCLUSION

The present case study provides insight into the complex interplay between auditory and vestibular dysfunction, highlighting the potential for reversible cochlear abnormalities as well as the persistence of deficits in vestibular and auditory functions in the right ear. The findings underscore the importance of timely and thorough audiological and vestibular evaluations, not only to diagnose current issues but also to establish a basis for early intervention and preventive measures, ultimately aiming to preserve and optimize hearing health.

***Declaration by Authors***

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