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(Research Article)

# A study on incidence of vestibular deficits in children with sensory neural hearing loss by using cervical Vestibular Evoked Myogenic Potentials (cVEMP)

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## Abstract

This study was conducted from an Audiology & rehabilitation clinic in Kerala- India from January 2022 to August 2022.In both evolutionary and embryonic perspective, the organs responsible for hearing and balance (auditory & vestibular system) have a common origin and developmental pattern. Sensory neural hearing loss (SNHL) is a common congenital sensory deficit occurring in large number of children and it is extensively investigated and has well defined management protocols such as hearing aids or cochlear implants and speech-language rehabilitation. But in comparison with the case of SNHL, very little effort has been done to investigate and treat the vestibular deficits which can co-occur along with SNHL. This study is an attempt to throw some light about the incidence of vestibular deficits in hearing impaired children. It was found that abnormal/absent VEMP responses were found in 57% of children with SNHL. VEMP responses were completely absent in 65% of ears with severe to profound hearing loss. Vestibular dysfunction was also present in 19% of children with moderate to moderately severe hearing loss. Incidence of vestibular deficits increases in higher degree of hearing loss such as severe to profound category. Motor delay was also reported in 10 out of 26 participants in this study which could be attributed to lack of visual motor development in children with vestibular deficits. However a large number of vestibular deficits in children with SNHL still remain under reported and uninvestigated which points to the need for conducting vestibular assessment in children diagnosed with SNHL.

**Keywords:** cVEMP (Cervical Vestibular Evoked Myogenic Potentials); SNHL (Sensory Neural Hearing Loss); P13 (Positive peak at around 13 milliseconds in VEMP responses); N23 (Negative peak at around 23 milliseconds in VEMP responses)

## 1. Introduction

It is well known that during the stages of embryonic development, both the auditory and vestibular system develops from a structure called Oticplacode (1). During development the oticplacode develops as a simple sheet of epidermal cells and then transforms into a complicated system of ducts, recesses, hair cells, and sensory neurons of the vestibular and cochlear apparatus. The evolution of the vertebrate ear into a complex three-dimensional system requires coordinated development of morphology (2).Non sensory structures such as cupula and tectorial membranes; and sensory structures, including neurons connect the ear to the brain (3,4)

Since birth onwards, both auditory stimuli and visual orientation are closely related. A child's early responses to auditory stimuli are basically visual motor responses such as eye blinking, head turn or moving eye towards source of sound (5). So some researchers believed that auditory deprivation will lead to delay in motor skills during the early stages of development [1]. The Cochlea and vestibule are the peripheral sensory organs of the auditory and vestibular system respectively. They are anatomically, phylogenetically, and functionally related. Cochlea and the vestibular

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apparatus are inter related in terms of innervations and vascular supply and lies in close proximity (6).Deficits in cochlear function resulting in sensory neural hearing loss (SNHL) could in turn cause vestibular impairment because the cochlea and vestibule has the common membranous labyrinth of the inner ear. Thus any high risk factors causing cochlear impairment could cause deficit in the vestibule also [3,5]. Prevalence of SNHL among pediatric population is estimated to be around 0.2% at birth and 0.35% during adolescence. Since it is very hard to notice symptoms of vestibular dysfunction in children, there could be a large number of hearing impaired children with vestibular dysfunction, requiring identification, education, and therapy. Many studies reported semicircular canal function was abnormal in response to a caloric stimulus in around 50% of children with severe to profound SNHL [8,3,9,10].

The vestibular-evoked myogenic potential (VEMP) amplitudes were found lower in children with SNHL when comparing with normal hearing children [7]. Previous studies [8] among 40 children with SNHL and reported that in 40% VEMP was absent either in one ear or in both ears thus confirming saccular dysfunction. The prognosis in sensory neural hearing loss (SNHL) could be worse if vestibular system is also involved because it could affect the motor development also. But vestibular function in children with SNHL is very less investigated and reported. The aim of this study was to determine the incidence of vestibular dysfunction in children with various degree of SNHL.

### *Aim of this study*

- To study the incidence of vestibular dysfunction in children with different degree of hearing loss.
- To identify the presence of motor delay in children with SNHL and Vestibular dysfunction.

## 2. Participants

### 2.1. Control group

Twenty children (12 boys and 8 girls) with normal hearing, middle ear function,speech, language and motor development were included in the control group.

### 2.2. Study group

Twenty six children (10 girls and 16 boys) with SNHL of more than 45 dB were selected in the study group. 10 children had bilateral profound hearing loss, 4 children had profound hearing loss in right ear and moderately severe SNHL in left ear, 2 children had profound hearing loss in left ear with moderate and moderately severe hearing loss in right ear, 4 children had bilateral moderate SNHL, 2 children had bilateral severe SNHL and remaining 4 children had moderate SNHL in one ear and severe SNHL in the other ear. All children who participated in this study used hearing aids in both ears. 6/10 children with profound hearing loss discontinued using hearing aids due to lack of benefit and they we having very poor speech development and intelligibility. All children were between 5 and 15 years of age with normal/ average academic performances. This study was conducted from an Audiology & Rehabilitation clinic at Kerala- India from January 2022 – August 2022. Informed consent was obtained from parents of all children who participated in this study.

### 2.3. Exclusion criteria

Children with other disabilities such as neuromotor deficits, orthopedic dysfunctions, hyperactivity, socio-behavioral problems and those under neuro medication were excluded.

## 3. Methods

Each children was subjected to the following

- A detailed case history and all available medical records were examined. Since it was very difficult to identify vestibular symptoms such as vertigo, nausea, disorientation etc in children, case history mainly focused on the motor milestones and development of the child. Motor delay was seen in 10 out of 26 participants in the study group.
- Audiological evaluation; Detailed audiological investigations such as pure tone audiometry, immittance audiometry and speech audiometry was done in all subjects to identify and diagnose the type and degree of hearing loss. ABR was done in few cases in which subjective responses were not reliable. The examination was carried out in a standard soundproof room with ANSI standards. SNHL was classified according to the degree of hearing loss based on Goodman classification [11].

- VEMP test; For successful measurement of the VEMP, the sternocleidomastoid muscle (SCM) must be maintained in tonic contraction. VEMP is not produced by the contraction of a muscle butVEMP arises from modulation of background EMG activity and differs from other neural potentials because it requires tonic contraction of the muscle (12,13). Stimuli for evoking VEMP are abrupt and very high intensity sounds, either clicks or tone bursts.Published evidence consistently confirms that tone bursts are more effective for elicitation of VEMP than click stimuli, and low frequency tone bursts (500 Hz) are more effective stimuli than higher frequency tone bursts(10,14).

Numerous studies are done in adults but a significantly less number of studies are available to reflect saccular function in paediatric population. The recording site for VEMP was sternocleidomastoid (SCM) muscle. The VEMP test was performed with children in sitting position. To activate the SCM muscle, the children were asked to turn their head towards the opposite side of the ear being tested. The active electrodes were attached on the mid half of the SCM muscles on both sides symmetrically and reference electrode was placed on the sternoclavicular joint. 90dB stimulus was presented monaurally through insert ear phones with rate 4/s. Analysis time was set to 80ms and band pass filter was 50-500Hz. Recordings from 200 stimuli were averaged and amplified and also replicability was checked to confirm the presence or absence of p13 and n23. Thus the latencies and amplitudes of the peak p13, peak n23 were measured.Subjects were given 30 seconds to relax between each recording [15].

### 3.1. Equipment's

- Maico MI 24 Digital diagnostic audiometer.
- Maico MI 44 immittance audiometer.
- Pilot Blankenfelde Corona - Auditory Evoked Potential instrument.

## 4. Results and discussion

All the 20 normal hearing children in the control group showed normal VEMP responses. P 13 latencies was within (11 – 18) ms with average p13 latency 14.85ms. The N23 latencies was within (21- 28) ms and average latency was 25.43ms. Deficits in saccular function observed as abnormalities of VEMP response, was found in 57% (15/26) of HI children. VEMP responses was completely absent in 65% of ears with severe to profound hearing loss. However in lesser degree of hearing loss such as moderate and moderately severe hearing loss VEMP responses were absent in only 15% of ears and VEMP responses were abnormal/delayed in another 4%

The results of this study showed that abnormal VEMP responses were seen in children with sensory neural hearing loss and its incidence increased in higher degree of hearing impairment such as severe to profound degree of hearing loss. Even if VEMP responses were present if some children with SNHL, the responses showed increased latency and reduced amplitude compared to the control group. So this study also agrees with the common assumption that both auditory and saccular functions are inter related. So it can be concluded that those factors which can cause damage to the cochlear haircells of auditory system are capable of causing damage to the vestibular system also, particularly the saccule.

But none of the 26 hearing impaired children nor their parents did not report any vestibular symptoms. We assume that the possible reasons could be:

- Young children are not able to report symptoms of dizziness or vertigo to parents or physicians
- Saccular impairment alone does not cause significant vestibular impairments
- Peripheral vestibular deficit may generate some kind of central compensation
- It is hard for the parents or care givers to notice vestibular symptoms in a child so less attention is given.

## 5. Conclusion

Vestibular deficits co-occur along with sensory neural hearing loss. Incidence of vestibular deficits increases in children with high degree of hearing loss such as severe to profound category. But vestibular symptoms in children may often go unnoticed. Vestibular deficits in very young children may case delay in visual motor skills and development. Thus proper assessment and management of vestibular disorders in children with SNHL is very important factor determining the prognosis of the whole re/habilitation process.

### *Recommendations*

This study underlines the need for proper vestibular assessment in children diagnosed with SNHL. However a detailed study with a large sample size is required to get a more clear idea about the incidence, assessment, management and the benefits of treatment for vestibular defects in hearing impaired children.

## Compliance with ethical standards

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### *Disclosure of conflict of interest*

There is no conflict of interest in this study

### *Statement of ethical approval*

Ethical committee approval was received from Naadam Speech and Hearing Clinic & Rehabilitation Center-Calicut, Kerala to use the clinical data for this study.

### *Statement of informed consent*

Informed consent was obtained from all individual participants included in the study

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