Comparison of vestibular evoked myogenic potentials between low and high tone idiopathic sudden sensorineural hearing loss

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Objectives: Vestibular evoked myogenic potentials (VEMP) have been reported to be useful in evaluating not only vestibular function but also the prognosis of idiopathic sudden sensorineural hearing loss (ISSNHL) patients. Even though low frequency, high frequency, and all frequency-involved ISSNHL groups tend to show varied clinical characteristics, there is a lack of data using VEMP results to analyze these subgroups. We investigated if the VEMP test is a valuable tool to predict recovery from hearing loss in association with different frequencies.

Methods: A total of 26 ISSNHL patients were divided into three different groups impaired with low tone (ascending type), high tone (descending type), and all tones (flat type) based on the initial audiograms. Each group included five, 10, and 11 patients, respectively, and their VEMP results were compared between the three subgroups.

Results: Abnormal VEMP results were found in five of the total 26 ISSNHL patients (19.2%). Two (40.0%), one (10.0%), and two (18.1%) patients of low tone, high tone, and all tone hearing loss groups, respectively, showed abnormal VEMP results. However, there was no statistically significant difference between the three groups.

Conclusions: Even though VEMP is known as a valuable tool for predicting the prognosis of ISSNHL patients, it does not seem to reflect frequency-sensitive aspects of ISSNHL.

Keywords: Sudden hearing loss; Sensorineural hearing loss; Vestibular evoked myogenic potentials

INTRODUCTION

Idiopathic sudden sensorineural hearing loss (ISSNHL) is defined as unexplained and rapid hearing loss of 30 dB or more over at least three consecutive frequencies within 72 hours [1]. It has been reported that the estimated incidence of ISSNHL is 2.4 to 27 per 100,000 population, but the exact underlying mechanisms regarding its pathogenesis are still unclear [2,3]. A variety of factors including viral infection, vascular disease, and metabolic imbalance seem to trigger hearing loss [3,4]. Since ISSNHL is a type of medical emergency requiring immediate diagnosis and treatment and it widely affects the quality of life of the patients, a number of laboratory tests have been developed not only for the diagnosis but also for the prediction of the prognosis. Many studies have proved that vestibular function tests can be useful to assess the damaged vestibular systems of ISSNHL pa-
tients as they impair not only the hearing function but also the vestibular function [5,6].

The prognosis of ISSNHL can be affected by several features such as the patient’s age, the severity of hearing loss, and the time between hearing loss and treatment initiation, and the type of hearing loss is one of the major factors for prediction of hearing recovery [7]. To be more specific, the low tone ISSNHL patients have more favorable hearing recovery than high tone ISSNHL patients [8]. On the other hand, the recurrence rate is higher in the patients with low tone ISSNHL than high tone while residual symptoms such as tinnitus are more common in the high tone ISSNHL group [8]. Since the clinical characteristics tend to vary depending on the damaged hearing frequency, vestibular function based on vestibular evoked myogenic potentials (VEMP) results of low, high, and all tone ISSNHL patients will be compared in this study.

METHODS

Ethics Statement
This study adhered to the ethical guidelines of the World medical Association’s Declaration of Helsinki and the study protocol was approved by the Institutional Review Boards of Gyeongsang National University Hospital (No. 2024-02-017). Informed consent was obtained from all subjects at the time of enrollment.

Study Population and Data Collection
Among the patients with sudden hearing loss who visited Gyeongsang National University Hospital between November 2011 to July 2023, 770 patients were finally diagnosed with ISSNHL. A total of 26 ISSNHL patients who performed VEMP test within 7 days after the initial diagnosis were included, and their complete clinical data were retrospectively evaluated. All study participants with sudden sensorineural hearing loss affected by Menière’s disease, herpes zoster oticus, noise-induced hearing loss, and other known causes of inner ear disease were excluded. The patients had undergone oral corticosteroid treatment by taking a full dose (1 mg/kg/day, maximum 60 mg/day) of prednisolone for 10 days and tapering dose for 5 days.

Pure Tone Audiometry and Speech Audiometry
The participants underwent pure tone audiometry (PTA) and speech audiometry for hearing assessment. The frequencies of 0.25, 0.5, 1, 2, 3, 4, and 8 kHz were assessed by PTA, and sensorineural hearing loss was diagnosed with hearing impairment greater than 30 dB at least three contiguous frequencies. The patients with sensorineural hearing loss were divided into three different groups based on the shape of the audiogram: low tone (ascending type), high tone (descending type), and flat type (flat type). Low tone hearing loss (ascending type) was termed for those with hearing loss of >30 dB at 0.25/0.5 kHz than at 4/8 kHz while high tone hearing loss (descending type) showed hearing loss of >30 dB at 4/8 kHz than at 0.25/0.5 kHz. Flat type showed a difference of <20 dB between the best and worst thresholds in the range of 0.25 to 8 kHz [8].

Cervical Vestibular Evoked Myogenic Potentials
Eclipse hardware platform with VEMP-module (Interacoustics A/S) was used to perform cervical VEMP (cVEMP). The response of the sternocleidomastoid muscle was recorded while the participants were in the supine position, and they were asked to raise their head off the bed to activate the neck flexor muscles. The VEMP response was detected using 500-Hz tone burst stimuli. Uncorrected interaural amplitude difference was calculated as follows: (amplitude of the unaffected ear−amplitude of the affected ear)/(amplitude of the unaffected ear+amplitude of the affected ear)×100, and values above 35% were considered abnormal.

Statistical Analysis
One-way analysis of variance was used to evaluate the associations between a type of hearing loss and cVEMP results and correlations of clinical characteristics between different hearing loss groups (p<0.05).

RESULTS
The age of patients with ISSNHL included in this study ranged between 32 and 79 years, and 16 patients were male while 10 patients were female. Among the 26 patients, 16 patients had ISSNHL in the right year, while
10 patients had ISSNHL in the left ear. For vestibular function evaluation, cVEMP was performed in all participants, and the cVEMP results were within the normal range in 21 patients, and five patients showed abnormal results (Table 1).

Among the 26 participants, five subjects had low tone hearing loss (ascending type), 10 subjects had high tone hearing loss (descending type), and 11 subjects had all tone hearing loss (flat type). In vestibular function examination, altered cVEMP results were shown in two (40.0%), one (10.0%), and two (18.1%) patients of low tone, high tone, and all tone hearing loss groups, respectively. Statistical analysis showed that there was no significant difference in cVEMP results between the three different hearing loss groups ($p=0.67$).

As reported in Table 2, the three different hearing loss groups did not differ in terms of age, severity of hearing loss evaluated by initial PTA of the affected and unaffected year, and cVEMP latency and amplitude ($p>0.05$).

**DISCUSSION**

ISSNHL is a type of sensorineural deafness without identifiable causes despite adequate investigation [1]. While various clinical factors such as the patient's age and the severity of initial hearing loss are known to affect the prognosis of ISSNHL, the type of hearing loss is also one of the most important prognostic values [7]. Several studies have reported that low tone hearing loss showing the ascending type of audiogram shape has more favorable hearing recovery than high tone ISSNHL patients [8]. For example, Psillas et al. [8] revealed that hearing loss was completely recovered in 77.7% of the patients in the low tone hearing loss group while only 15% of the patients in the high tone hearing loss group were totally recovered. Also, Watanabe and Suzuki [9] reported that the ascending type hearing loss group had the best prognosis (60%–88%).

Another important clinical factor affecting the recovery of hearing loss is the presence of accompanying

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<th>Table 1. The characteristics of each group</th>
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<td>Characteristic</td>
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<td>No. of patients</td>
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<td>Age (yr)</td>
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<tr>
<td>Sex</td>
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<td>Male</td>
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<td>cVEMP</td>
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$cVEMP$, cervical vestibular evoked myogenic potentials.

<table>
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<th>Table 2. Correlation of age and clinical characteristics between three groups</th>
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<td>Variable</td>
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<tr>
<td>Age (yr)</td>
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<tr>
<td>Initial PTA of the affected ear</td>
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<td>Initial PTA of the unaffected ear</td>
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<td>cVEMP P1 latency (ms)</td>
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<td>cVEMP N1 latency (ms)</td>
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<td>cVEMP N1-P1 amplitude</td>
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Values are presented as mean±standard deviation.

PTA, pure tone audiometry; cVEMP, cervical vestibular evoked myogenic potentials.
symptoms including dizziness, and many studies have focused on evaluating vestibular function of ISSNHL patients. Byl [10] reported the relationship between the presence of vertigo, consequently involving the posterior labyrinth, and the disease course of ISSNHL in his paper. The vestibular function has been studied by various methods such as head impulse test, caloric test, and VEMP, and cVEMP has been adopted in this study since the correlation between VEMP and hearing loss is still controversial [5,11]. Some papers have reported a significant correlation between VEMP results and hearing loss, while others have shown no consistent correlation [11,12]. For example, Quaranta et al. [12] reported that VEMP results in 60% of the subjects affected by ISSNHL were abnormal and the recovery rate was significantly higher in the group without vestibular involvement. Also, Wang et al. [13] insisted that the VEMP test could be an effective way of evaluating the vestibular nerve function of ISSNHL patients as abnormal VEMP results were found in 25.7% of the patients. On the other hand, this study shows that the cVEMP result does not vary depending on the damaged hearing frequencies, and this result seems consistent with the idea of Korres et al. [7] suggesting that anatomical proximity to the cochlear cannot completely explain the involvement of vestibular apparatus and cochlear damage in ISSNHL patients. Otherwise, this can be due to the small number of subjects included in this study so a larger number of ISSNHL patients including different hearing loss groups and their VEMP results are required to be further analyzed.

To our knowledge, this is the first report focused on the varied vestibular function test of different hearing loss groups including low tone, high tone, and all tone ISSNHL patients. Abnormal cVEMP results were shown in 40.0%, 10.0%, and 18.1% of patients of low tone, high tone, and all tone hearing loss groups, respectively, and there was no significant difference in cVEMP results between the three groups. The limitations of the study are that the small number of ISSNHL subjects were included and only cVEMP was used to compare vestibular functions of the three different hearing loss groups. Also, uncorrected values from cVEMP rather than corrected values were used in this study. Future prospective studies including larger populations and a variety of vestibular function tests are warranted for a comprehensive understanding of the pathogenesis and better predicting the prognosis of ISSNHL.

ARTICLE INFORMATION

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Conflicts of Interest
No potential conflict of interest relevant to this article was reported.

Availability of Data and Materials
All data generated or analyzed during this study are included in this published article. For other data, these may be requested through the corresponding author.

Authors’ Contributions
Ceptualization, Project administration: SKA, SR, SWP; Data curation, Resources, Software: SR; Formal analysis, Validation: JWL; Investigation, Visualization: CDY; Methodology: DGH; Supervision: SKA, DGH; Writing—original draft: SR, SWP, SKA; Writing—review & editing: all authors.

All authors read and approved the final manuscript.

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