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Evaluation of semicircular canals in patients with vestibular migraine with suppression head impulse paradigm test and video head impulse test

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Abstract

Background & Objective: Vestibular migraine (VM) is a prevalent disorder characterized by recurrent episodes of spontaneous vertigo, which may occur with or without headaches. This study aimed to evaluate the vestibular system in individuals with VM using the video head impulse test (vHIT) and suppression head impulse paradigm (SHIMP). *Methods:* In this study, 20 individuals diagnosed with VM according to the Bárány Society criteria were included in the VM group, and 20 individuals without vertigo symptoms were included as controls. All participants underwent both vHIT and SHIMP tests. The Beck Depression Inventory (BDI) and Dizziness Handicap Inventory (DHI) were also administered to assess depression and dizziness. *Results:* No significant differences in vestibular-ocular reflex (VOR) gains were observed between the VM and control groups across all semicircular canal (SCC) planes. Overt saccades were noted in 12 VM patients in the right lateral SCC, and in 9 patients in the left lateral SCC. Covert saccades were observed in 1 patient in each of the right and left lateral SCCs. No saccades occurred in the anterior or posterior SCCs. The SHIMP test revealed no significant differences in gain or anti-compensatory saccades between the groups. However, significant differences were observed in the BDI and DHI scores ($p = 0.000$).
Conclusion: vHIT and SHIMP testing do not effectively identify vestibular dysfunction during the inter-attack period in VM patients. However, overt saccades may serve as potential indicators of dysfunction. Both otoneurological evaluation and psychological assessment are crucial in the comprehensive evaluation of VM patients.

Keywords: Vestibular migraine, overt saccade, depression, vHIT, SHIMP

INTRODUCTION

Vestibular migraine (VM) is a disorder that causes episodic vertigo, frequently accompanied by headache. It is often underdiagnosed but is becoming more widely recognized. Comprising 11% of cases in dizziness clinics, 13% of cases in headache clinics, and 1-2.7% of the general population, it is currently believed to be the most common cause of spontaneous (non-positional) episodic vertigo.[1] The trigeminovascular system/nociceptive brainstem centers, vestibular system dysfunction, abnormal sensory modulation or integration within the thalamo-cortical network and hereditary factors are among the potential mechanisms of VM. Nonetheless, the specific pathophysiology of VM is largely unknown, and current understanding of probable VM processes is mostly in the hypothesis stage.[2]

VM has been associated with various abnormalities in vestibular tests, including caloric test results[3-5] and cervical and ocular vestibular evoked myogenic potentials (VEMPs).[6,7] While central features such as vertical nystagmus, central positional nystagmus, and abnormal smooth pursuit are frequently observed in VM patients, recent studies have highlighted the vestibulo-ocular reflex (VOR) as a key area of

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interest, particularly its evaluation using the HIMP paradigm, which has yielded inconsistent findings.[8-11] Another vHIT-based approach, the suppression head impulse paradigm (SHIMP), may provide valuable insights into the physiological mechanisms underlying VOR suppression in VM patients. In fact, some studies have suggested that SHIMP may offer advantages over HIMP.[12] However, the existing literature reveals that only two studies have compared VOR gain measured by HIMP with VOR suppression gain obtained through SHIMP in VM patients.[9,13] Given the limited information on the correlation between HIMP and SHIMP findings in this population, this study aims to address this gap by thoroughly evaluating these paradigms in patients with vestibular migraine.

METHODS

Patients

This study included 20 individuals (17 female, 3 male; mean age 39.50 ± 11.57 years) who met the definitive vestibular migraine diagnostic criteria according to the Barany Society[14] (Appendix 1) and 20 healthy individuals (14 female, 6 male; mean age 33.45 ± 9.23 years). Patients with a history of otologic surgery, trauma, visual and neck problems were excluded. The study was approved by the Ethics Committee of the Faculty of Medicine on April 10, 2023 (Decision No: 2023/010). All participants gave written informed consent and did not receive any remuneration.

Auditory and vestibular evaluation

Hearing function was assessed using pure tone and speech audiometry. Individuals with a pure tone average (calculated as the sum of hearing levels at 0.5, 1, 2 and 4 kHz divided by 4) better than 20 dB were included.

All subjects first underwent the vHIT and then the SHIMP tests. The test was started after proper eye and head calibration. The vHIT and SHIMP tests were performed as previously described in our earlier studies.[15,16] Patients underwent a sudden, brief and unpredictable head rotation test to measure VOR gain in each semicircular canal (SCC) plane by an audiologist using a video-oculography device (Interacoustics, Denmark). The vHIT was performed in the lateral semicircular canal, right anterior left posterior (RALP) and left anterior right posterior (LARP) planes, respectively. The SHIMP test was then performed in the lateral SCC plane. In the SHIMP test, unlike the vHIT test, the individual was asked to look not at a fixed point but at a point moving with the head in the same direction and at the same speed as the head movement.[17] In the vHIT test, the VOR gain of each SCC plane and catch-up saccades were evaluated, while in the SHIMP test, the VOR gain of the right and left lateral SCC planes and anti-compensatory saccades were evaluated.

Questionnaires

The Dizziness Handicap Inventory (DHI- Turkish version) was administered to subjectively describe the imbalance and dizziness problems experienced by the individuals in the VM group. The questions in the inventory assess functional, physical and emotional effects on disability. Responses are calculated as no: 0, sometimes: 2 and yes: 4 points.[18,19]

The Beck Depression Inventory (BDI-Turkish version) is a 21-item self-assessment tool that quantitatively assesses patients' depressive perspectives. According to the total score, 0-9 points are graded as minimal depression, 10-16 points as mild depression, 17-29 points as moderate depression and 30-63 points as severe depression.[20,21]

Statistical analysis

Data were analyzed with SPSS 22 software (SPSS Inc., Chicago, IL, USA). Mean, standard deviation (SD), median and minimum-maximum values were given for descriptive statistics. Mann-Whitney U test was used to compare VM and control groups in terms of Beck Depression questionnaire, Dizziness Disability Inventory BDI-Emotional, BDI-Functional, BDI-Physical and BDI-Total scores. Independent samples test was used in the comparison of VM and control groups in terms of right lateral SCC gains, left lateral SCC gains, right posterior SCC gains, left posterior SCC gains, right anterior SCC gains, and left anterior SCC gains if they fit the normal distribution, and Mann Whitney U test was used if they did not fit the normal distribution. Independent samples test was used to compare right lateral SCC SHIMP gains and left lateral SCC SHIMP gains between VM and control groups. $p<0.05$ was considered statistically significant.

RESULTS

In this study, we prospectively investigated vHIT and SHIMP responses for all semicircular canals

in patients with VM and compared the findings with healthy individuals. The average age of the control group was 33.45 ± 9.23 years (ranging from 22 to 50 years), while the average age of the VM group was found to be 39.50 ± 11.57 years (ranging from 24 to 61 years). No significant age difference was observed between the two groups ($p> 0.05$).

Statistically significant differences were found between the VM and control groups in the Beck Depression Inventory, DHI-Emotional, DHI-Functional, DHI-Physical, and DHI-Total scores ($p< 0.001$) (Table 1).

No statistically significant differences were observed between the VM and control groups in the gains of right lateral SCC, left lateral SCC, right posterior SCC, left posterior SCC, right anterior SCC, and left anterior SCC ($p> 0.05$) (Table 2). No statistically significant differences were found between the VM and control groups in the right lateral SHIMP gains and left lateral SHIMP gains ($p> 0.05$) (Table 3).

In the SHIMP test, both the VM and control groups exhibited anticipatory saccades in both right lateral and left lateral SCC planes. The number of overt saccades, covert saccades, and overt-covert saccades for right lateral, right anterior, right posterior SCC, left lateral, left anterior, and left posterior SCC in both VM and control groups is presented (Table 4).

DISCUSSION

In our study evaluating VOR gain in individuals with a definite diagnosis of VM, no statistically significant differences were observed in gain between the control group and both the vHIT and SHIMP tests.

Salmito *et al*. reported that in their study on individuals with VM, VOR gains in all SCC planes were within normal limits, but the gains in the vertical SCCs were found to be higher compared to the control group.[22] They attributed the normal lateral SCC VOR gains to the generally normal findings in vestibular test results during the interictal period in individuals with VM. In contrast to the study by Salmito *et al*., our study found that both lateral and vertical SCC VOR gains were within normal limits. We believe that this difference may be related to various factors such as the duration of the disease and the number of episodes experienced. Yoo *et al*. performed caloric and vHIT tests on 36 individuals with VM during the interictal period and found abnormalities in only 3 of the patients. They

Table 1: Comparison of BDI score, DHI Emotional, Functional and Physical and Total scores of VM and Control group

	VM group	Control group	p value
BDI			
Average±SD	13.60±8.09	3.95±3.64	
Median	12.00	2.50	**<0.001***
Minimum-maximum	5.00-31.00	0-12.00	
DHI-**Emotional**			
Average±SD	11.70±6.56	0.80±2.28	
Median	11.00	0	**<0.001***
Minimum-maximum	2.00-28.00	0-10.00	
DHI-**Functional**			
Average±SD	21.70±9.20	1.00±2.55	
Median	18.00	0	**<0.001***
Minimum-maximum	12.00-40.00	0-8.00	
DHI-**Physical**			
Average±SD	15.70±4.95	0.40±1.39	
Median	16.00	0	**<0.001***
Minimum-maximum	4.00-24.00	0-6.00	
DHI-**Total**			
Average±SD	49.10±16.70	2.10±5.44	
Median	43.00	0	**<0.001***
Minimum-maximum	26.00-76.00	0-22.00	

VM: Vestibular Migraine, SD: Standard Deviation, BDI: Beck Depression Inventory, DHI: Dizziness Handicap Inventory, *Mann-Whitney U test, $p<0.05$

Table 2: Gain Comparison in SCCs between VM and Control Groups

	VM group	Control group	p value
Right lateral SCC gain			
Average±SD	1.05±0.09	1.02±0.09	
Median	1.08	1.04	**0.337****
Minimum-maximum	0.80-1.21	0.77-1.20	
Left lateral SCC gain			
Average±SD	1.06±0.07	1.03±0.10	
Median	1.08	1.07	**0.495***
Minimum-maximum	0.88-1.16	0.70-1.19	
Right posterior SCC gain			
Average±SD	1.05±0.09	1.05±0.11	
Median	1.07	1.07	**0.823****
Minimum-maximum	0.82-1.20	0.85-1.21	
Left posterior SCC gain			
Average±SD	0.98±0.11	0.99±0.11	
Median	0.99	1.00	**0.756****
Minimum-maximum	0.79-1.19	0.83-1.20	
Right anterior SCC gain			
Average±SD	1.02±0.11	1.01±0.10	
Median	0.99	0.98	**0.594****
Minimum-maximum	0.84-1.20	0.86-1.20	
Left anterior SCC gain			
Average±SD	1.04±0.08	1.03±0.12	
Median	1.05	1.03	**0.726****
Minimum-maximum	0.89-1.18	0.80-1.22	

VM: Vestibular Migraine, SD: Standard Deviation, SCC: Semicircular Canal, *Mann-Whitney U test, **Independent samples test, $p<0.05$

particularly noted that abnormal vHIT gains are rare in individuals with VM during the interictal period.[23] In our study, normal vHIT gains were observed in all patients. It can be considered that normal vestibular functions are present in the SCCs during the interictal period in individuals with VM.

Another important finding we obtained in individuals with VM is the observation of overt saccades in approximately half of the patients in both the right and left lateral SCCs during vHIT testing. Covert saccades were only observed in 2 patients. In the control group, no catch-up saccades were seen. Although VOR gains are normal in individuals with VM, the presence of catch-up saccades can be considered an indicator of vestibular dysfunction.[24] Koç and Akkılıç assessed 84 individuals with VM using vHIT during dizziness attacks and found that VOR gains in all SCCs were lower in individuals with VM

Table 3: Comparison of right and left lateral SSCs SHIMP gains between the VM and control groups

	VM group	Control group	p value
Right lateral SCC SHIMP gain			
Average±SD	1.04±0.07	1.00±0.09	
Median	1.03	1.00	**0.173***
Minimum-maximum	0.89-1.15	0.82-1.16	
Left lateral SCC SHIMP gain			
Average±SD	1.04±0.09	1.01±0.09	
Median	1.08	1.02	**0.317***
Minimum-maximum	0.83-1.19	0.82-1.20	

VM: Vestibular Migraine, SD: Standard Deviation, SSC: Semicircular Canal, SHIMP: Suppression Head Impulse Paradigm, *Independent samples test, $p<0.05$

Table 4: Number of overt, covert, and overt-covert saccades in SCCs in the VM and control groups

	VM group		Control group	
	Present	**Absent**	**Present**	**Absent**
Right lateral SCC overt saccade	12	8	0	19
Right lateral SCC covert saccade	1	19	0	20
Right lateral canal overt-covert saccade	1	19	0	20
Left lateral SCC overt saccade	9	11	0	20
Left lateral SCC covert saccade	1	19	0	20
Left lateral canal overt-covert saccade	1	19	0	20
Right posterior SCC overt saccade	0	20	0	20
Right posterior SCC covert saccade	0	20	0	20
Right posterior canal overt-covert saccade	0	20	0	20
Left posterior SCC overt saccade	0	20	0	19
Left posterior SCC covert saccade	0	20	0	20
Left posterior canal overt-covert saccade	0	20	0	20
Right anterior SCC overt saccade	0	20	0	20
Right anterior SCC covert saccade	0	20	0	20
Right anterior canal overt-covert saccade	0	20	0	20
Left anterior SCC overt saccade	0	20	0	20
Left anterior SCC covert saccade	0	20	0	20
Left anterior canal overt-covert saccade	0	20	0	20

VM: Vestibular Migraine, SCC: Semicircular Canal

compared to healthy individuals. However, they did not find a statistically significant difference between the two groups. They observed catch-up saccades in 52.3% of individuals with VM. As a result, they suggested that the presence of catch-up saccades should be assessed during vHIT evaluation, as it indicates vestibular involvement.[25] The normal range of gains and the presence of catch-up saccades in approximately half of the patients in our study show similar results.

Our study found significant differences between the VM and control groups regarding all subgroups of the DHI and the total scores. Additionally, significant differences in BDI scores were noted between the two groups. Zhu *et al*. evaluated dizziness and depression in patients diagnosed with VM and BPPV before treatment and after a 3-month follow-up using questionnaires.[26] Before treatment, the average DHI scores for BPPV and VM were 34 and 60, respectively, while the average DHI scores after the 3-month follow-up were found to be 0 and 22. In our study, the DHI results show similar outcomes to those reported by Zhu *et al*. They used the Hospital Anxiety and Depression Scale to assess anxiety and depression, finding that approximately half of the VM patients exhibited anxiety and depression. Similarly, in our study, depression scores in the VM group were observed to be higher compared to the control group. Zhu *et al*. suggested that the reduction in DHI scores after treatment in VM is associated with a decrease in depression and anxiety.

In another study investigating depression, dizziness, and various parameters in individuals diagnosed with migraine and VM, it was found that BDI scores in individuals with VM were higher, similar to our findings. Additionally, a decrease in quality of life measures was observed in individuals with VM who exhibited moderate disability on the DHI.[27] It has been suggested that disorders characterized by episodic attacks are associated with greater psychiatric comorbidity compared to chronic vestibular disorders.[28] We believe that high imbalance scores in diseases with episodic attacks are related to the development of depression.

In another study, the DHI, BDI, and sleep quality were evaluated in patients with VM, BPPV, Meniere's disease, and unilateral loss. The highest DHI scores were observed in Meniere's disease, while the highest BDI scores were found in the VM group.[29] In the VM group, DHI scores were lower compared to our study, while BDI scores were higher. Due to the impact of the disease on individuals and the subjective assessment of the imbalance and depression experienced by the

individuals, slight differences can be observed. This study suggested that patients with vestibular symptoms experience increased psychosocial stress and decreased sleep quality, in addition to physical and functional complaints.

One limitation of this study is the absence of an anxiety index, despite the inclusion of the BDI to assess depression. The inclusion of an anxiety assessment could have provided additional insights into the psychosocial impact of vestibular disorders on patients.

In conclusion, in individuals with VM, the gains observed in vHIT and SHIMP during the interictal period do not play an effective role in determining the vestibular dysfunction. However, overt saccades seen in vHIT can be considered an indicator of vestibular dysfunction. Psychological assessment should be performed alongside neurological examination in individuals with VM.

DISCLOSURE

Conflict of interest: None

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Appendix 1

Diagnostic criteria for definite vestibular migraine

A. At least 5 episodes with vestibular symptoms1 of moderate or severe intensity, lasting 5 min to 72 hours
B. Current or previous history of migraine with or without aura according to the International Classification of Headache Disorders (ICHD-3)
C. One or more migraine features with at least 50% of the vestibular episodes: headache with at least two of the following characteristics: one sided location, pulsating quality, moderate or severe pain intensity, aggravation by routine physical activity photophobia and phonophobia, visual aura
D. Not better accounted for by another vestibular or ICHD diagnosis