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Original Article

Subjective Visual Vertical and Horizontal in Vestibular Migraine

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OBJECTIVE: To assess the functional status of the otolithic pathway in vestibular migraine by comparing the results of static and dynamic subjective visual vertical and horizontal [subjective visual vertical (SVV) and subjective visual horizontal (SVH)] testing in patients with vestibular migraine with that of normal individuals.

MATERIALS and METHODS: This hospital-based prospective study was conducted in 82 normal adults and 66 adults with vestibular migraine. The SVV and SVH angles were measured under static and dynamic conditions using a software-based test protocol. The arithmetic mean of six readings in each situation was considered. The results were further analyzed by stratifying cases and controls into two age groups 20–40 years and 41–60 years and into gender.

RESULTS: The clinical profile of the patients with vestibular migraine was comparable to the available literature. The dynamic SVV and SVH in both age groups and the static SVH in the 41–60 years age group were significantly higher compared to normal individuals ($p<0.05$). The dynamic SVV and SVH were significantly higher in the cases compared to controls among both males and females ($p<0.05$).

CONCLUSION: There is evidence of otolithic pathway abnormalities in individuals with vestibular migraine. The inclusion of SVV and SVH testing for the evaluation of patients with vestibular migraine may be useful in the interpretation and rehabilitation of symptoms in these patients.

KEYWORDS: Vestibular function tests, subjective visual vertical, subjective visual horizontal vestibular migraine, migrainous vertigo

INTRODUCTION

The measurement of subjective visual vertical (SVV) and subjective visual horizontal (SVH) is a valid assessment of vestibular function primarily of the otolith organs and/or the central graviceptive pathways. Studies have determined that the SVV and SVH in healthy individuals in an upright static position do not deviate more than ±2.5 from true vertical or horizontal [1, 2]. The tilt of SVV and SVH is a very sensitive sign of vestibular tonus imbalance in the roll plane [3]. Recently, computer software-based methods have become available, making the test easy to conduct and enjoyable for the patient [4].

Static SVV and SVH are sensitive to acute vestibular loss. Static SVV and SVH however are compensated early as compared to dynamic SVV and SVH. Thus, dynamic SVV and SVH values hint at insults that may have occurred earlier along the otolithic pathway [5].

Vestibular migraine (VM), also called as migraine-associated vertigo or migrainous vertigo, is a well-established clinical entity. However, its pathophysiological mechanisms are still under evaluation. Some reports have suggested that patients with migraine have subclinical dysfunctions in the vestibular spinal reflex system, which may be partially due to the subclinical damage to the macula [6]. The abnormal information may influence the proprioceptive cues for postural control, resulting in unsteadiness. Another probable theory is that migraine-induced vasospasm causes decrease in regional blood flow to the inner ear (via the internal auditory artery from the anterior inferior cerebellar artery) causing ischemia to the labyrinth, thereby resulting in transient or permanent hearing or vestibular loss [7]. Abnormal findings of central oculomotor and cerebellar functions in persons with migraine between the attacks of VM suggest subclinical continuous neuronal dysfunction in the brainstem and cerebellar nuclei [8]. A study focusing on the probable pathophysiological links between VM and vestibular mechanisms has proposed complex interactions involving the vestibular nuclei, trigeminal system, and thalamocortical pathways [9].

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Although all clinical otoneurological tests are usually found to be normal, studies have suggested that approximately 25% of patients with migraine headaches had abnormal results on vestibular function tests. This clearly indicates the coexistence of vestibular anomalies in patients with migraine [10-12]. Prior studies have included subjects who underwent a battery of tests in the symptom-free periods but some studies conducted during the acute attack revealed findings that were suggestive of both central vestibular dysfunction and peripheral dysfunction [13]. An area that is however often not covered in these tests is the otolithic pathway. The otolithic pathway helps in perceiving the gravitational vertical and horizontal. Any abnormality in this pathway, which consists of the peripheral vestibular end organs, the utricle and saccule, and its central connections including the brainstem, thalamus, and vestibular cortex, may cause an erroneous sense of spatial orientation [14]. A test that detects pathology in this pathway may give valuable information.

The purpose of this study was to investigate the SVV/SVH abnormalities in patients with VM, which may contribute to subjective imbalance. The clinical profile of these patients was also studied.

MATERIALS and METHODS

This was a hospital-based prospective cross sectional study of a group of normal adults and patients with VM between July 2013 and August 2014. The institutional review board and ethics committee approved the study, and it was conducted in accordance with the Helsinki Declaration. The normative group consisted of volunteers aged between 20 and 60 years with no history of vertigo; otological complaints; head trauma; headache; ototoxic drug use; ear surgeries; or systemic illnesses, such as diabetes, hypertension, hypothyroidism, and with no abnormalities on otoneurological examination. The relatives of patients attending the audiovestibular clinic were recruited in the normative group.

The VM group consisted of consecutive patients aged between 20 and 60 years who were diagnosed with VM based on the Neuhauser's classification [15] in the audiovestibular clinic of our tertiary care setup. For a target sensitivity of 90%, an alpha of 0.05, and precision of ±10%, a sample size of 36 were required in each study population in each age group; 72 normal adults and 72 patients with VM were therefore required to be recruited for the study. After obtaining informed consent, both patients and volunteers were subjected to static and dynamic SVV and SVH testing. The technician who conducted the test was blinded to the status of the person being tested.

Procedure of the Test

The verticality of the SVV and SVH test was calibrated using a plumb line, which served as the reference line for the gravitational vertical. The subject was made to sit in a dark room (to avoid visual cues). The height of the chair was adjusted such that the subject's eye level corresponded to the middle of the screen. The subject was provided with a contour mask with binocular vision fitted with a set of three obturators to reduce the chance of visual cues. The vision was confirmed as binocular and not uniocular after fitting of the contour binocular spectacles.

The stimulus was projected on a large screen monitor mounted in front of the patient. The stimulus was a vertical illuminated "line" projected on the screen provided by the software from the SVV equipment (MUS_VS-V1.3.2.Rev B Synapsis, France).

The "line" was presented at a preset angle (between 5° and 20°). The subject was required to adjust the "line" to vertical as perceived by the subject using a joy stick (remote controlled potentiometer). For the dynamic assessment, the background was rotated clockwise and anti-clockwise.

The test was repeated six times each for static and dynamic settings and values were recorded. Varying preset angles were randomly allocated by the software for all the tests. The test was similarly repeated with a projected horizontal illuminated "line" to test SVH. At the end of the test, 24 values were obtained (6 each for static and dynamic SVV and SVH). These values were depicted either as positive or negative according to the direction of deviation. The average was calculated as the arithmetic mean irrespective of whether the value was positive or negative.

The clinical and audiovestibular profile of the patients with VM was also studied.

RESULTS

At the end of 12 months, 82 normal individuals and 66 patients were recruited. The age and gender profile of the cases and controls are summarized in Table 1.

Among the controls, the average age of the group 20–40 years was 28.2 years (range, 21–38 years), while the average age of the group 41–60 years was 48.2 years (range, 41–60 years). Among the cases, the average age of the group 20–40 years was 29.7 years (range, 20–38 years) and of the group 41–60 years was 48.7 years (range, 41–60 years).

Clinical Profile of the Cases

Forty-six patients out of 66 (69.6%) had a positive history of migraine headache in their family. The remaining 20 had no definite family history of migraine. The duration of onset of headache was assessed for these patients diagnosed with VM, stratified based on age groups. The overall mean duration of onset of headache was 4.3 years. In the age group of 20–40 years, the minimum duration since onset of headache was 1 month and maximum was 10 years. The mean duration since the onset of headache in this group was 3 (±2.8) years. Similarly, in the age group of 41–60 years, the minimum duration since onset of headache was 4 months and the maximum duration was 30 years. The mean duration since onset of headache in this group was 5.5 (±7.6) years.

Table 1. Age and gender profile of normal and VM patients

	Age group	Males (%)	Females (%)	Total
Normal	20-40 years	29 (58)	16 (53.3)	45
	41-60 years	23 (42)	14 (46.7)	37
	Total	52 (100)	30 (100)	82
VM	20-40 years	16 (61.5)	21 (52.5)	37
	41-60 years	10 (38.5)	19 (47.5)	29
	Total	26 (100)	40 (100)	66

VM: vestibular migraine

Table 2. Clinical profile of patients with VM

Clinical feature		Frequency (%)
Vertigo duration	<10 min	40 (60.6)
	11-30 min	13 (19.7)
	31-60 min	9 (13.9)
	>1 hour	4 (6.1)
Vertigo type	Surrounding rotatory	54 (81.8)
	Head rotatory	9 (13.6)
	Both	3 (4.6)
Aura	Present	53 (80.3)
	Absent	13 (19.7)
Hearing loss	Present	9 (13.6)
	Absent	57 (86.4)
Tinnitus	Present	14 (21.2)
	Absent	52 (78.8)
Comorbidities	Present	17 (25.7)
	Absent	49 (74.3)

Table 3. Mean and standard deviation values of SVV and SVH in normal and VM patients

Parameter		Normal	VM
Static	SVV	1.5˚ (±0.7)	1.5˚ (±0.9)
	SVH	1.6˚ (±0.8)	1.8˚ (±1.1)
Dynamic	SVV	1.9˚ (±0.6)	3.0˚ (±1.7)
	SVH	1.9˚ (±0.8)	3.3˚ (±1.7)

VM: vestibular migraine; SVV: subjective visual vertical; SVH: subjective visual horizontal

Patients diagnosed with VM had episodes of vertigo lasting from seconds to a few hours. For statistical analysis, these were categorized into four groups based on the duration (Table 2). The majority had vertigo lasting for less than 10 min. A significant proportion of the patients had comorbidities, including dyslipidemia, diabetes mellitus, hypertension, hypovitaminosis, and hypothyroidism. Few patients had more than one comorbidity. The clinical profile of the patients with VM is summarized in Table 2.

Audiometric Profile of the Cases

The pure tone average was calculated for the thresholds in 500 Hz, 1 KHz, and 2 KHz. The patients in the age group of 20–40 years had an average pure tone average of 18.7 (±19.4) dB for the right ear and 13.4 (±4.4) dB for the left ear. Similarly, the age group of 41–60 years had a pure tone average of 19.9 (±10.7) dB for the right ear and 20.4 (±12.0) dB for the left ear.

A significant proportion of the VM patients underwent imaging, such as brain magnetic resonance imaging (MRI), to rule out any secondary pathology in the brain that may be responsible for the symptoms. Thirty-six patients (54.5 %) out of the 66 underwent imaging and eight (12%) had abnormal findings on the MRI. These findings ranged from compression at cervical vertebra, vascular loops, lacunar infarcts, thecal compression, disc degenerative changes, and empty sella.

Comparison of SVV and SVH Values in the Cases and Controls

The mean and standard deviation for static and dynamic SVV and SVH for the cases and controls are summarized in Table 3. The SVV and SVH values were further categorized into age and gender groups. The mean values of SVV and SVH both in dynamic and static aspects for the cases and controls based on age are depicted in Table 4. Dynamic values, both vertical and horizontal, were significantly higher among patients with VM when compared to the normal individuals. It was also observed that the static horizontal values were significantly more in patients with VM compared to normal individuals in the 41–60 years age group.

Table 4. Comparison of SVV and SVH between normal and VM in the two age groups

	Group							
	20-40 years				41-60 years			
	Mean	SD	N	p	Mean	SD	N	p
Static vertical								
Normal	1.50	0.68	45		1.53	0.72	37	
VM	1.35	0.81	31	0.38	1.56	0.92	35	0.88
Dynamic vertical								
Normal	2.06	0.66	45	0.001	1.84	0.63	37	0.0004
VM	2.99	1.53	31		3.09	1.93	35	
Static horizontal								
Normal	1.63	0.90	45	0.76	1.65	0.68	37	0.04
VM	1.56	1.08	31		2.09	1.09	35	
Dynamic Horizontal								
Normal	2.05	0.78	45	0.0005	1.91	0.79	37	<0.001
VM	3.05	1.57	31		3.46	1.89	35	

VM: vestibular migraine; SD: standard deviation; SVV: subjective visual vertical; SVH: subjective visual horizontal

Table 5. Comparison of SVV and SVH between normal and VM patients based on gender

	Group							
	Males				Females			
	Mean	SD	N	p	Mean	SD	N	p
Static vertical								
Normal	1.5	0.7	52	0.22	1.4	0.7	30	0.35
VM	1.3	0.6	26		1.6	1.0	40	
Dynamic vertical								
Normal	2.0	0.7	52	0.03	1.8	0.6	30	<0.0001
VM	2.7	2.1	26		3.3	1.5	40	
Static horizontal								
Normal	1.7	0.8	52	1.0	1.6	0.8	30	0.24
VM	1.7	1.1	26		1.9	1.2	40	
Dynamic horizontal								
Normal	2.1	0.9	52	0.02	1.8	0.6	30	<0.0001
VM	2.9	2.1	26		3.5	1.5	40	

VM: vestibular migraine; SVV: subjective visual vertical; SVH: subjective visual horizontal

The mean static and dynamic values among the cases and controls based on gender are summarized in Table 5. The dynamic SVV and SVH were significantly more in patients with VM in both males and females, while the static values were not significantly different between cases and controls in both gender groups.

DISCUSSION

Many methods have been suggested for the evaluation of SVV in clinical practice. We have used a computer software-based SVV equipment (MUS_VS-V1.3.2.Rev B Synapsis, France), which has a remote controlled potentiometer for recording the SVV and SVH values.

The mean values among normal individuals were 1.5° for static SVV, 1.9° for dynamic SVV, 1.6° for static SVH, and 1.9° for dynamic SVH. These values were in accordance to other studies. Previous studies have suggested that the normal values of static SVV and dynamic SVV range from ±1.5° to ±3.0° [1, 16-18].

VM is more common in females than in males [15, 19], and our study has additionally shown a female preponderance (60.1%). VM can occur at any age [19] and these patients usually have associated aura and a positive family history [19-22]. A family history of migraine was found in 69.6% of our subjects, and aura was reported in 80.3% of patients.

Studies have reported abnormal SVV findings in the Ménière's disease, vestibular neuritis, gentamycin toxicity, and after stapedectomy [23-26]. VM is the second most common cause of dizziness [27]. Patients can present with a spectrum of symptoms from spontaneous room spinning vertigo, positional vertigo, or nonspecific dizziness and symptoms may last for seconds to days [15]. In our study, a majority of patients diagnosed with VM had surrounding rotatory vertigo, which lasted <10 min. This was similar to findings in previous studies [28].

A significant outcome of this study was the observed dynamic SVV and SVH values in patients with VM, which were significantly higher compared to normal subjects. The static SVV values were not different from that of the controls, which implies that tonic vestibular compensation may have been achieved in these patients during the interictal phase (as these tests were conducted during the symptom-free periods). However, the fact that there is a significant difference in the static SVH (among 40–60 year olds) and dynamic SVV and SVH suggests that the dynamic compensation for the otlithic pathway defects have not been achieved in these patients. These abnormalities may also explain some of the symptoms in these patients in the context of other otoneurological examination and testing being normal.

VM is known to be the great "mimicker" of all diagnosis of vertigo [29]. The diagnosis of VM is based on patients history and diagnostic criteria have been well established [15, 30]. Further studies using SVV and SVH in individuals during episodes of vestibular migraine and pre- and post-treatment of VM may help explain the pathophysiology of VM better.

CONCLUSION

Patients with VM have spatial disorientation and a covert dysfunction of the otolithic pathway as shown in this study. The inclusion of SVV and SVH testing for the evaluation of patients with VM may be useful in the interpretation and rehabilitation of symptoms in these patients.

Ethical approval: Authors declared that the research was conducted according to the principles of the World Medical Association Declaration of Helsinki "Ethical Principles for Medical Research Involving Human Subjects", (amended in October 2013).

Informed consent: Written informed consent was obtained from all individual participants included in the study.

Peer-review: Externally peer-reviewed.

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