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RESEARCH ARTICLE

Subjective visual vertical in patients with unilateral definite Meniere's diseases

Azamsadat Hosseini Fard[1*], Nasrin Yazdani[2], Nima Rezazadeh[3], Marzieh Sharifian Alborzi[1], Alireza Akbarzadeh Bagheban[4]

[1]- Department of Audiology, School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Tehran, Iran

[2]- Otorhinolarygology Research Center, Tehran University of Medical Sciences, Tehran, Iran

[3]- Department of Audiology, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran

[4]- Department of Basic Sciences, School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Tehran, Iran

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Abstract

Background and Aim: Subjective visual vertical (SVV) test is a clinical tool to evaluate the utricular function and the gravity perception pathways in peripheral and central vestibular lesions. Meniere's disease (MD) involves cochlear and otolithic organs. The prevalence and features of otolithic dysfunction in the acute phase of this disease are unknown. The aim of this study was to evaluate of SVV test in the acute phase of MD and to investigate the validity of SVV test for detection of otolithic disorders in MD patients.

Methods: Thirty two patients with unilateral definite Meniere's disease and thirty two normal subjects were enrolled in this study. Pure tone audiometry, tympanometry, and SVV test were performed.

Results: There was no significant difference between the mean SVV in the normal group and the mean SVV in the healthy side of the patient group, while a significant difference was observed between the mean SVV in the normal group and the mean SVV in the affected side of the patient groups. Also, in the patient group, the difference in the mean SVV between the healthy and affected sides was significant.

Conclusion: Patients with MD have difficulties in perception of verticality that is probably due to utricular dysfunction. In order to improve the level of diagnosis of MD it is suggested to add SVV test to the test battery.

Keywords: Meniere's disease; otolith; subjective visual vertical test

[*] **Corresponding author:** Department of Audiology, School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Damavand Ave., Tehran, 1616913111, Iran. Tel: 009821-77561721, E-mail: az.hosseini@yahoo.com

Introduction

Subjective visual vertical (SVV) is a valuable clinical test to evaluate utricular function and the routes of gravity perception in central and peripheral vestibular disorders [1]. The Meniere's disease (MD) is an inner ear disease without involving central structures. The clinical symptoms of MD include episodic rotational vertigo, hearing loss, and tinnitus with or without aural fullness. Vertigo attacks differ in severity and may last several minutes to hours, often are accompanied by nystagmus, nausea, and vomiting. There are no neurological symptoms during attacks [2,3]. This disease is usually unilateral, and it is more likely for the opposite side to be affected by the time; a state that is reported in 2-78% of cases [3]. In addition to

the cochlea, the otolithic organs that have a detrimental role in maintaining balance through the perception of gravity, linear acceleration, and centrifugal force are affected by MD [3].

Previous studies on patients with MD have concentrated on endolymphatic hydrops of cochlea and saccule while less attention has been paid to the utricular dysfunction. Animal studies have demonstrated, occlusion of endolymphatic sac is the main cause of endolymphatic hydrops leading to malfunction of sac such as mechanical obstruction and chemical fibrillation or in other words, the sclerotic changes around the endolymphatic, sac viral invasion, immunological inflammation and ischemia due to vascular mechanical obstruction of the sac. More ever abnormalities lead to difficulties in the absorption process in the endolymphatic system can cause hydrops. 3D analysis of spontaneous nystagmus in these patients indicates the effects of MD on vestibular system that, in turn, can result in semicircular canal (SCC) malfunction. However, cochlea and saccule are more susceptible to damage compared with the horizontal SCC. In the final stage of the disease, severe inflammation or collapsing ampullary walls as well as severe atrophy of vestibular sensory organ may occur. Repeated vestibular membrane rupture may lead to the partial or complete collapse of labyrinth membrane. This condition is called vestibular atelectasis. Based on the cytopathological findings, it is less likely that hydrops originates from SCC. Saccule is the second most common site of hydrops, and severe hydrops often is observed in saccule [4,5]. However, saccular or utriclar hydropse can lead to dysfunction of these organs [3,6].

Because of the nature of the disease, the tests for vestibular function are very useful in the examination of MD patients. One of the most important tests in this regard is vestibular evoked myogenic potentials (VEMP). Results of this test in MD patients show the absence of the waves, decreased amplitude, increased threshold, and significant changes of the amplitude ratio without significant changes in latency [5,7-10].

Among the other vestibular tests is the SVV test that indicates the utricular function and otolith data processing by cortex. In this test, the person should adjust an oblique line vertically [11,12]. The SVV test can be performed in static or dynamic conditions. In the static SVV test, visual background is stationary while it is moving in the dynamic SVV test [13]. Studies using the static SVV test in patients with MD indicate that errors in vertical adjustment of the line have occurred in acute phase, because hydrops of utricle on one side causes asymmetry of otolithic responses and abnormal vertical perception [3,14,15]. However, due to no precise definition of the acute phase of the disease and limited studies regarding SVV test results in the acute phase of the disease, the incidence and characteristics of otolith anomalies in the acute phase of MD is still unknown. Therefore, this study aimed to investigate abnormalities of the static SVV test in the MD acute phase and examine the test validity for detection of the otolith disorder in MD patients.

Methods

This historical cohort study was conducted on 32 patients with unilateral definite MD (15 male and 17 female) with mean age of 38.66 ± 6.29 years and 32 normal subjects (12 male and 20 female) with mean age of 23.75 ± 2.82 years. The tests were conducted at Rehabilitation Faculty of Shahid Beheshti University of Medical Sciences (SBMU). The two groups were not similar in terms of age, but based on the previous studies [16], the age less than 60 has no effect on static SVV results.

The inclusion criteria for the normal group were: age between 18 and 50 years, normal hearing (hearing threshold better than 25 and tympanogram type An), no history of any type of vertigo or other disorders in balance system or neurological system, ability to perform fine movements by hand in order to adjust the SVV angle, no alcohol ingestion, sedations, vestibular suppressant drugs, antidepressant and anti-stress agents at least 24 hours before the test, no history of psychological problems, and having normal or corrected vision.

For the MD group, the inclusion criteria were as

the same as those of the normal group for the abovementioned parameters except the diagnosis of definite MD based on the criteria of American Academy of Otolaryngology-Head and Neck Surgery (AAO-HNS). The patients were referred by ENT specialists from Amiralam Hospital.

Based on AAO-HNS, the criteria of definite MD are as follow: two or more spontaneous episodes of vertigo lasting at least 20 minutes, audiometric documented, hearing loss on at least one session, tinnitus or aural fullness in the affected ear, and other causes excluded. Moreover, there was no problem in the external and middle ear of the patients, and hearing threshold was less than 25 dBHL. Although a large number of patients had weaker hearing threshold in low frequencies compared to high frequencies, only patients were selected whose hearing thresholds in all frequencies was less than 25 dBHL. To have a homogeneous patient group and accurate definition of the MD acute phase, patients who had suffered from MD for less than five years and passed less than one week from the last attack of vertigo took part in the study. The involved ear was selected based on the patient's explanation of symptoms and somewhat on the results of audiometry. Normal group were selected from students and staff of the Rehabilitation Faculty, SBMU. In order to meet ethical considerations in this study, written consent was obtained from the participants.

After case history collection, all the participants underwent PTA, tympanometry, and SVV tests. Among the limitations of the study was that the type of patient's treatment was not taken into consideration. In order to reduce the effect of this limitation, all the patients were asked not to use vestibular suppressant drugs 48 hours before the test.

The SVV test was conducted in a dark room by a device made by synapsys (France) while the participant sat on the chair two meters away from the monitor, with SVV goggle on the eyes that could provide binocular vision through a small hole. A luminous oblique line with 20 degree angle of tilt was back-projected to a stationary black screen randomly (in terms of positivity or negativity of the angle at the beginning of the test) [11,12] in front of the individual.

First, the patient was instructed how to manage the test. The examinee was asked to adjust the luminous line with own SVV. The examiner would move the line to the left and right side as the examinee determined and stop moving whenever the examinee recognized the verticality and finally, recorded the angle. The luminous line appeared once in the negative angle (counterclockwise rotation) and a second time in the positive angle (clockwise rotation).

Every adjustment was repeated twice so as to obtain four values for tilt angle (two for starting in the negative angle and two for starting in the positive one). In the normal group, for simplification of data analysis, we calculated the mean of the four values obtained from adjusting the oblique line and used the mean value in final analysis. However in the MD group, the healthy and affected ears were first recognized based on specialist's diagnosis, observed symptoms, and previous test results. Then, the test started twice at the angle of tilt toward the healthy ear and twice at the angle of tilt toward the affected one. Finally, four values for angle of tilt (two for the healthy and two for the affected ears) were obtained. Then, the mean value for each side was calculated and compared with the mean value of the normal group. A ±2 degrees deviation from verticality was considered as normal; otherwise, it was recognized as pathologic.

For data analysis, independent t-test was used to compare the mean values between the groups and paired t-test to compare the mean values between the two ears of MD patients. The ROC curve was employed to determine the diagnostic power of SVV test. The analyses were performed using SPSS 20 with a significant level of 0.05.

Results

In this study, two groups of unilateral definite MD patients and normal participants were examined. All the normal participants adjusted the oblique line vertically with degrees less than ±2 degrees deviation in all four measurements.

Table 1. Mean (standard deviation, minimum, maximum) values of deviations from the vertical line in patients with definite Meniere's disease and normal group

		Deviation from vertical line (degree)			
Group		**N**	**Mean (SD)**	**Min**	**Max**
Normal		32	0.35 (0.39)	-0.45	1.22
Meniere's disease					
	Affected ear	32	2.34 (1.64)	-0.6	5.60
	Healthy ear	32	0.49 (1.54)	-2.30	4.35

However, independent of the initial tilt angle, the MD patients adjusted the oblique line with a deviation toward the affected side. In other words, although sometimes the test was started with angle of tilt toward the normal ear, the patients adjusted the oblique line toward the involved side. In some patients, we did not observe pathologic deviation in every four stages of measurement but the final mean values of the four measurements were out of ±2 range.

The mean value of SVV deviation in the normal group was 0.35 (SD=0.39) while it was 0.49 (SD=1.54) in the MD patients for the normal side and 2.34 (SD=1.64) for the affected side (Table 1). There was no significant difference between the mean SVV deviation value of the normal group and that of the MD patients' normal side ($p>0.05$), whereas there was a significant difference between the mean SVV deviation value of the normal group and that of the involved side of the MD patients group ($p<0.05$). Moreover, a significant difference was observed between the normal side and involved ear of the patients ($p<0.05$).

The area under ROC curve was measured as 0.81 for tilt angle toward the affected side and 0.51 for tilt angle toward the normal side. The angle of tilt toward the affected and healthy sides was optimum in terms of sensitivity and specificity in the cut-off-points of 1.13 and 0.38, respectively (angle of tilt toward the involved side: sensitivity=0.75, 1– specificity of =0.03, and toward the normal side: sensitivity=0.50, 1– specificity=0.43; Fig. 1).

Discussion

Comparing the mean SVV deviation in the normal and involved side of MD patients showed a significant difference. In MD patients, endolymphatic hydrops involves otolithic organs in addition to cochlear and disturbs the function of peripheral vestibular system. If the central pathways are normal, the SVV test will indicate the good function of utricle [17]. Unlike previous studies introducing cochlear and saccule as the first involved places in MD, the present study showed obvious involvement of utricle.

Since it had not been a long time from onset of the disease in the patients participated in our study and considering that all the participants were evaluated in the acute phase of the disease, the widely-accepted order of involvement of the inner ear in the MD patients may not be accurate; in other words, the order of involvement in all MD patients may not be first cochlear, second saccule and finally, utricle; also, utricle may be affected as the same as saccule by hydrops; anyway, utricular dysfunction may occur due to endolymphatic hydrops.

In case of normal bilateral vestibular system, similar signals are projected to higher centers and the person can correctly perceive the vertical line. However, when the vestibular system in one side is impaired a weak signal will be sent to the higher centers and hence, asymmetry in sending signals occurs. Therefore, the person will face problems in the perception of vertical line. In other words, in unilateral impairment of the otolith organs, stimulation of the neurons in

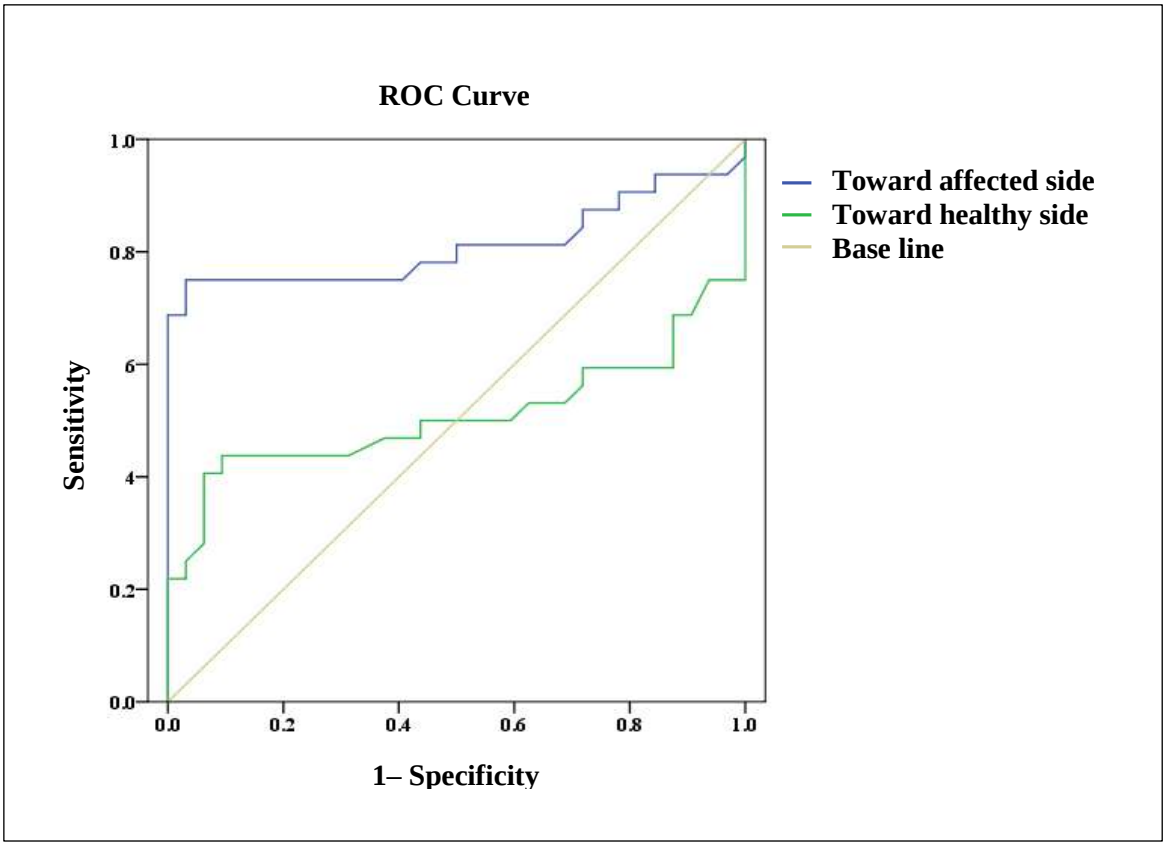

Fig. 1. Sensitivity and 1– specificity of deviation values from vertical line.

the normal side will push the SVV to the opposite side, i.e. the affected side. On the other hand, the neurons of abnormal side do the same action and push the SVV to the normal side (opposite side), but due to the weakness of this signal, SVV deviates toward the affected side (push-pull mechanism) and this deviation can represent the involved side [18].

Böhmer et al. showed that acute MD patients deviate considerably toward the affected side although this deviation gradually decreases and will be similar to the deviation of normal people. From their viewpoint, the SVV test is a useful tool for detecting the unilateral and acute impairment of otolith organs, while it is not efficient enough in the chronic phase of the disease [19]. Kingma [15], Pagarkar et al. [11], and Manzari et al. [20] reported that in the acute phase of Meniere's disease, the SVV test is affected by the involved side. In general, the obtained findings of these studies were consistent with ours.

However, in Friedmann's study, the MD patients had no pathologic deviation in the results of SVV test [21]. Studies have no precise definition of the acute phase of MD and some researchers have introduced the acute phase as long as the disease symptoms exist [11,20]. In Friedmann's study, the stage of disease at the time of testing has not been mentioned. However, in the present study, the acute phase was considered a week after the last attack of MD and all the tests were performed in this stage. Probably the inconsistency in the present study findings with Friedmann's findings is due to the disease stage in which the test has been conducted [21]. Faralli et al. [14] reported that there is a SVV pathologic deviation in the acute phase of MD which decreases by using drug. Unlike the other studies which believed that the SVV

deviation angle returns to normal after the acute phase of the disease. According to Faralli et al., in the progressive stages of the disease, the utricle function chronically decreases and causes the permanent deviation of SVV towards the involved side. Their findings [14] in the acute phase were similar to ours. Since there are a few SVV studies in the progressive stage, further investigation is needed regarding the permanent deviation angle of the SVV in progressive stages.

The SVV test shows the utricular function and otolithic data processing in the cortex. The patient's cooperation is one of the limitations of the SVV test. Moreover, this test does not show the abnormal results in case of compensation of otolith dysfunction by central system. Despite these limitations, SVV is a very reliable test to identify acute vestibular disorders, because asymmetrical otolith responses can lead to disruption in perception of verticality [12].

The SVV test is a useful clinical tool for all the patients who suffer from vertigo, dizziness, or oculomotor disease. This test is easy to administer and control as well as easy to interpret [13]. The SVV test can be performed in either static or dynamic conditions, although the dynamic condition is better for identifying the illness [13]. However, further investigation is needed in this context. Most studies reported ±2 degrees deviation from verticality as the normal range in SVV [11,13,15]. In the present study, normal people had less than ±2 degrees deviation while the patients showed a deviation more than ±2 degrees towards the affected side. Therefore, the SVV test has the ability to diagnose the affected side in the acute phase of MD.

Using ROC curve, the power of diagnosis of the deviation angle parameter toward the healthy and affected side in MD patients was calculated. The area under the ROC curve for SVV deviation was less toward the healthy ear than toward the affected ear, indicating the poor performance of this parameter in the diagnosis of patients. It also revealed that MD patients can adjust vertically the oblique line deviated toward their healthy side with an acceptable error by giving the specificity and sensitivity 50%. However, the deviation angle toward the affected side of the patients showed an acceptable area under the ROC curve (0.81).

All the research conducted with SVV test has reported ±2 degrees deviation from verticality as pathologic criteria [14,15,20]. However, based on cut-off-point in ROC-curve, we found if the deviation angle of ±1.13 is considered as the criteria, the sensitivity of SVV test will be 0.75 (97% specificity) and the chance of diagnosis of patients from normal people will increase. This result can introduce SVV test as a powerful diagnostic test in acute unilateral peripheral vestibular deficits.

Conclusion

In the present study, the SVV test was performed on two normal and unilateral definite Meniere's disease groups. The patients showed pathologic deviation toward the affected side in the SVV test. The findings confirmed involvement of the utricle in Meniere's disease. In general, the findings indicate that it is better to add SVV test to the diagnostic test batteries for increasing the power of diagnosis.

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REFERENCES

1. Kumagami H, Sainoo Y, Fujiyama D, Baba A, Oku R, Takasaki K, et al. Subjective visual vertical in acute attacks of Ménière's disease. Otol Neurotol. 2009; 30(2):206-9.
2. Arenberg IK, Balkany TJ, Goldman G, Pillsbury RC 3rd. The incidence and prevalence of Meniere's disease -- a statistical analysis of limits. Otolaryngol Clin North Am. 1980;13(4):597-601.
3. Minor LB, Schessel DA, Carey JP. Ménière's disease. Curr Opin Neurol. 2004;17(1):9-16.
4. Young YH, Huang TW, Cheng PW. Assessing the stage of Meniere's disease using vestibular evoked myogenic potentials. Arch Otolaryngol Head Neck Surg. 2003; 129(8):815-8.
5. Zarei M, Adel Ghahraman M, Daneshi A, Emamjomeh H, Memar F, Akbari M, et al. Comparison of the prevalence and latency of vestibular evoked myogenic potentials in normal participants and symptomatic and asymptomatic Meniere's disease patients. Audiol. 2009; 18(1-2):36-44. Persian.

6. Andrews JC. Intralabyrinthine fluid dynamics: Meniere disease. Curr Opin Otolaryngol Head Neck Surg. 2004; 12(5):408-12.
7. Chiarovano E, Zamith F, Vidal PP, de Waele C. Ocular and cervical VEMPs: a study of 74 patients suffering from peripheral vestibular disorders. Clin Neurophysiol. 2011;122(8):1650-9.
8. de Waele C, Tran Ba Huy P, Diard JP, Freyss G, Vidal PP. Saccular dysfunction in Meniere's disease. Otol Neurotol. 1999;20(2):223-32.
9. Rauch SD, Zhou G, Kujawa SG, Guinan JJ, Herrmann BS. Vestibular evoked myogenic potentials show altered tuning in patients with Ménière's disease. Otol Neurotol. 2004;25(3):333-8.
10. Taylor RL, Wijewardene AA, Gibson WP, Black DA, Halmagyi GM, Welgampola MS. The vestibular evoked-potential profile of Ménière's disease. Clin Neurophysiol. 2011;122(6):1256-63.
11. Pagarkar W, Bamiou DE, Ridout D, Luxon LM. Subjective visual vertical and horizontal: effect of the preset angle. Arch Otolaryngol Head Neck Surg. 2008; 134(4):394-401.
12. Valko Y, Hegemann SC, Weber KP, Straumann D, Bockisch CJ. Relative diagnostic value of ocular vestibular evoked potentials and the subjective visual vertical during tilt and eccentric rotation. Clin Neurophysiol. 2011;122(2):398-404.
13. Brandt T, Strupp M. General vestibular testing. Clin Neurophysiol. 2005;116(2):406-26.
14. Faralli M, Lapenna R, Mandalà M, Trabalzini F, Ricci G. The first attack of Ménière's disease: a study through SVV perception, clinical and pathogenetic implications. J Vestib Res. 2014;24(5-6):335-42.
15. Kingma H. Function tests of the otolith or statolith system. Curr Opin Neurol. 2006;19(1):21-5.
16. Kobayashi H, Hayashi Y, Higashino K, Saito A, Kunihiro T, Kanzaki J, et al. Dynamic and static subjective visual vertical with aging. Auris Nasus Larynx. 2002;29(4):325-8.
17. Akin FW, Murnane OD. Subjective visual vertical test. Semin Hear. 2009;30(4):281-6.
18. Böhmer A, Mast F. Assessing otolith function by the subjective visual vertical. Ann N Y Acad Sci. 1999; 871:221-31.
19. Böhmer A, Mast F, Jarchow T. Can a unilateral loss of otolithic function be clinically detected by assessment of the subjective visual vertical? Brain Res Bull. 1996; 40(5-6):423-7; discussion 427-9.
20. Manzari L, Tedesco AR, Burgess AM, Curthoys IS. Ocular and cervical vestibular-evoked myogenic potentials to bone conducted vibration in Ménière's disease during quiescence vs during acute attacks. Clin Neurophysiol. 2010;121(7):1092-101.
21. Friedmann G. The judgement of the visual vertical and horizontal with peripheral and central vestibular lesions. Brain. 1970;93(2):313-28.