eISSN 2444-7986
DOI: https://doi.org/10.14201/orl.19337

**ORIGINAL**

# VVOR AND VORS TESTING AS A TOOL IN THE DIAGNOSIS OF UNILATERAL AND BILATERAL VESTIBULAR HYPOFUNCTION

## *Pruebas de VVOR y VORS como herramientas de diagnóstico para la hipofunción vestibular unilateral y bilateral*

Bernardo FARIA-RAMOS[1]; Renato CAL[2]; Sergio CARMONA[3]; Konrad P. WEBER[4]; Francisco ZUMA e MAIA[5]

[1] *Universidad Federal de Espírito Santo. Brasil.* [2] *Universidad Federal de Pará. Brasil.* [3] *Universidad Nacional de Rosario. Argentina.* [4] *Universidad de Zurich. Suiza.* [5] *Clinica Maia. Brasil*

*Correspondence: sergiocarmona57@gmail.com*

Reception date: October 20, 2018
Date of Acceptance: November 14, 2018
Publication date: October 20, 2018
Date of publication of the issue: September 1, 2019

Conflict of interest: The authors declare no conflicts of interest
Images: The authors declare that the images have been obtained with the permission of the patients


SUMMARY: Background: In clinical practice, tests such as the head impulse test paradigm (HIMP) and suppression head impulse paradigm (SHIMP) stimulate high-frequency head movements so the visual and somatosensory system are somehow suppressed. In low frequencies, two tests could be useful tools for vestibular assessment: VVOR (visually enhanced vestibulo-ocular reflex) and VORS (vestibulo-ocular reflex suppression). The aim of this study is to explain the eye movements typically found during VVOR and VORS testing in patients with unilateral and bilateral vestibular hypofunction. Methods: Ten patients with unilateral vestibular hypofunction, two patients with bilateral vestibular hypofunction, and ten patients without vestibular symptoms (control group) were analyzed retrospectively through VVOR and VORS testing in an Otometrics ICS Impulse system. Results: In the VVOR test, patients with unilateral vestibular hypofunction exhibited catch-up saccades beating to the healthy side when moving the head to the affected side, while patients with bilateral vestibular hypofunction exhibited catch-up saccades beating to the opposite side of head movement. In the VORS test, patients with unilateral vestibular hypofunction exhibited catch-up saccades to the healthy side when moving the head to this side, while patients with bilateral vestibular hypofunction did not exhibit catch-up saccades during head movement to either side. Conclusion: Our data suggest that the VVOR and VORS tests yield the same findings as the HIMP and SHIMP tests in unilateral and bilateral vestibular hypofunction and can contribute to confirming peripheral etiology as well as the affected side.

KEYWORDS: vestibular function tests, eye movements, head movements, vestibular disorders, vestibule-ocular reflex.

RESUMEN: Introducción: En la práctica clínica, el paradigma de la prueba de impulso cefálico (HIMP) y el paradigma de supresión del impulso cefálico (SHIMP) estimulan los movimientos de la cabeza de alta frecuencia para suprimir el sistema visual y somatosensorial. Las dos pruebas también podrían ser herramientas útiles para la evaluación vestibular a bajas frecuencias: VVOR (reflejo vestíbulo-ocular visualmente mejorado) y VORS (supresión del reflejo vestíbulo-ocular). El objetivo de este estudio es analizar los movimientos oculares que se encuentran típicamente durante las pruebas de VVOR y VORS en pacientes con hipofunción vestibular unilateral y bilateral. Métodos: Se analizaron retrospectivamente diez pacientes con hipofunción vestibular unilateral, dos pacientes con hipofunción vestibular bilateral y diez pacientes con función vestibular normal (grupo control) mediante pruebas de VVOR y VORS con un sistema Otometrics ICS Impulse. Resultados: Durante la prueba VVOR, los pacientes con hipofunción vestibular unilateral mostraron nistagmo batiendo al lado sano al mover la cabeza hacia el lado afectado, mientras que los pacientes con hipofunción vestibular bilateral mostraron nistagmo batiendo al lado opuesto de los movimientos de la cabeza a cada lado. Durante la prueba VORS, los pacientes con hipofunción vestibular unilateral mostraron sacadas de recuperación hacia el lado sano cuando movieron la cabeza hacia este lado, mientras que los pacientes con hipofunción vestibular bilateral no mostraron sacadas de recuperación durante los movimientos de la cabeza hacia ambos lados. Conclusión: Nuestros datos sugieren que las pruebas VVOR y VORS arrojan la misma información diagnóstica que las pruebas HIMP y SHIMP en la hipofunción vestibular unilateral y bilateral, y pueden contribuir al diagnóstico de pérdida vestibular periférica, así como del lado afectado.

PALABRAS CLAVE: reflejo vestíbulo-ocular; movimientos oculares; movimientos cervicales; pruebas de función vestibular; patología vestibular.

## INTRODUCTION

Different classes of eye movements can be distinguished based on how they aid vision, their physiological properties, and their anatomical substrate. Clear vision requires that images of our environment during head movements be held still on the retina. This is made possible by several functional classes of human eye movements, such as pursuit (P), optokinetic (OKN), and the vestibulo-ocular reflex (VOR) [1].

It is possible to suppress a stimulus according to a goal purpose (goal planning/goal in mind). The pursuit reflex comprises an eye movement in order to stabilize the image of a moving target on the fovea. The ability of the pursuit reflex to overcome an inappropriate VOR, known as VOR suppression, is indispensable during combined eye-head tracking of a target that moves in the same direction as the head; otherwise, the VOR would move the eye in the opposite direction [2,3]. In addition, there is no difference between the eye movement of a pursuit reflex without head movement and head movement while staring at a fixed target [1].

The sensitivity of the visual, somatosensory, and vestibular system to detect head movements depend on frequency. Both the visual and somatosensory system are more effective at low-frequency head movements; conversely, the semicircular canals are more sensitive to high-frequency head movements [4].

In clinical practice, tests such as the head impulse test paradigm (HIMP) and the suppression head impulse paradigm (SHIMP) stimulate high-frequency head movements so that the visual and somatosensory system are somehow suppressed. In low frequencies, two tests could be useful tools for vestibular assessment: the visually enhanced vestibulo-ocular reflex (VVOR) and vestibulo-ocular reflex suppression (VORS). The HIMP and VVOR are almost identical, with both involving a fixed target and head movement. Similarly, the SHIMP and VORS are almost the same test, involving head movement to track a moving target. However, the HIMP and SHIMP tests are not influenced by the visual system, while in the VVOR and VORS tests, vision predominates over the vestibular system.

The aim of this study is to explain the eye movements typically found during VVOR and VORS testing in patients with unilateral and bilateral vestibular hypofunction.

## METHODS

The sample consisted of ten patients (six female) with unilateral vestibular hypofunction (UVH), two patients (one female) with bilateral vestibular hypofunction, and ten patients (five female) without vestibular symptoms, serving as controls. The VVOR and VORS findings of all participants, obtained using an Otometrics ICS Impulse system, were analyzed retrospectively. Patients with vestibular hypofunction were diagnosed on the basis of reduced VOR gain on video head impulse test affecting both the anterior and lateral semicircular canals, the posterior semicircular canal, or all semicircular canals in the affected ear or in both ears. VOR gain was considered reduced if less than 0.8 in the lateral semicircular canals and less than 0.7 in the vertical semicircular canals.

For the VORS, subjects were tested in the sitting position and asked to stare at a laser dot on the wall at 1.5 m. Their heads were slowly moved at a frequency of approximately 0.5 Hz and amplitude of 10° in the horizontal plane, while the laser dot moved with the patient's head. Patients were asked to follow the laser dot during the test.

For the VVOR test, subjects were asked to stare at a fixed dot on the wall at 1.5 m. Their heads were slowly moved at the same frequency and amplitude (about 0.5 Hz and 10° in the horizontal plane), but patients were asked to keep their eyes trained on the dot during the test.

## RESULTS

The age of the patients ranged from 20 to 75 years. Reduced VOR gain in the lateral and anterior left semicircular canals was observed in five patients, in the lateral and anterior right semicircular canals two patients, in the lateral, anterior and posterior left semicircular canals in three patients, and in the lateral, posterior and anterior semicircular canals bilaterally in two patients. All patients were tested during the first five days of vestibular symptoms, and two of them exhibited spontaneous nystagmus beating to the healthy side.

During the VVOR test, patients with unilateral vestibular hypofunction exhibited catch-up saccades beating to the healthy side followed by head rotation to the affected side. Patients with bilateral vestibular hypofunction exhibited catch-up saccades beating to the opposite side of head movement for both sides.

In the VORS test, patients with unilateral vestibular hypofunction exhibited catch-up saccades to the healthy side when the head was moved to this side, while patients with bilateral vestibular hypofunction did not show catch-up saccades during head movement to either side.

## DISCUSSION

Our data suggest that VVOR and VORS tests exhibited the same findings as the HIMP and SHIMP tests in unilateral and bilateral vestibular hypofunction and can contribute to confirm the peripheral etiology as well as the affected side.

In the acute phase of an UVH, there is an imbalance between the vestibular afferences from the left and right sides. In an UVH affecting the left side, the brain interprets that the head is rotating to the right; hence, the eyes move slowly to the left (slow phase of spontaneous nystagmus). To stabilize the image on the retina, the brain quickly moves the eyes to the right (fast phase of spontaneous nystagmus) [2]. An UVH also results in a leaky neural integrator, which explains the gaze nystagmus beating to the unaffected side, following Alexander's Law. Only two patients in our series exhibited spontaneous nystagmus, but their VVOR and VORS test findings were the same when compared to patients who did not have spontaneous nystagmus.

In an UVH, the HIMP shows reduced VOR gain followed by refixation saccades when the head is turned to the affected side. On the other hand, SHIMP demonstrates refixation saccades when the head is turned to the unaffected side, and no saccadic eye movement when the head is turned to the affect side [5,6,7].

The VVOR test assesses the patient's VOR with visual enhancement. Unlike the HIMP, it evaluates low-frequency head movements, which means that the pursuit reflex acts together with the VOR to move the eyes contralateral to the head movement [8]. For instance, in an UVH affecting the left side, there is reduced VOR gain when the head is turned to this side. In the VVOR test, when the head is turned to the right side, both the pursuit and vestibulo-ocular reflexes are intact, so that there is no abnormal eye movement. On the other hand, the VOR does not moves the eyes to the right when the head is turned to the left. Hence, a catch-up saccade beating to the right is needed at the start of the head movement to keep the target on the fovea, along with the pursuit reflex [1,2].

In a VVOR test performed in a patient with bilateral vestibular hypofunction, the VOR does not move the eyes to the side opposite to head movement. Therefore, a catch-up saccade beating contralateral to the head movement for both sides is needed to keep the image stable.

The VORS test assesses the patient's VOR without visual enhancement. Differently from the SHIMP test and like the VVOR, it evaluates low-frequency head movements, which means that the pursuit reflex moves the eyes in the same direction as the target, while the VOR tends to move the eyes in the opposite direction [6]. In an UVH affecting the left side, there is reduced VOR gain when the head is turned to this side. In the VORS test, the abnormal VOR gain does not move the eye to the right when the head is turned to the left; hence, there is no need for suppression, since the pursuit reflex moves the eyes to the left, following the target. On the other hand, when the head is turned to the right, the VOR moves the eyes back to the left. Hence, a catch-up saccade beating to the right side is needed to overcome the inappropriate VOR (VOR suppression) [1,2,3].

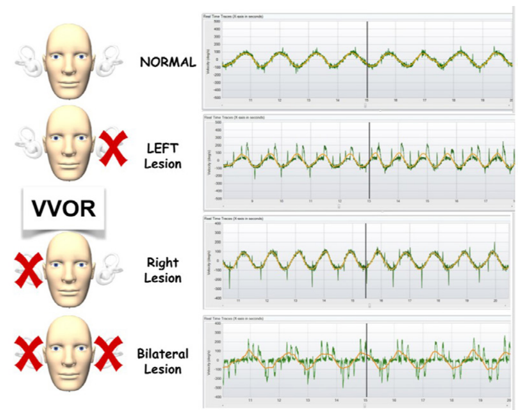


Figure 1. VVOR test results in controls, patients with unilateral vestibular hypofunction affecting the right and left sides, and patients with bilateral vestibular hypofunction.

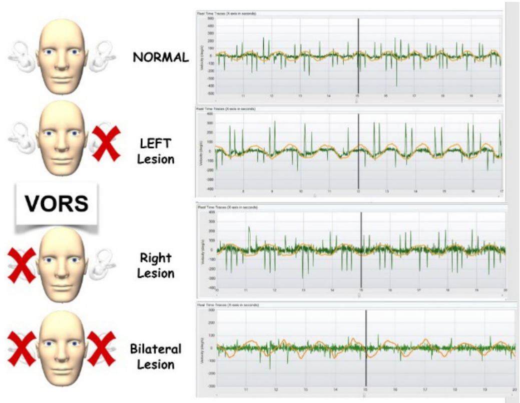


Figure 2. VORS test results in controls, patients with unilateral vestibular hypofunction affecting the right and left sides, and patients with bilateral vestibular hypofunction.

In the VORS test performed in a patient with bilateral vestibular hypofunction, the reduced VOR gain does not move the eye to the opposite side of the head movement. Therefore, there is no catch-up saccade during head movement to either side, since there is no need to suppress the VOR.

The small number of patients in our series could be considered a limitation. However, this was a descriptive study that showed similar findings in different groups; we believe that a larger sample would not have changed our results.

The HIMP and SHIMP are fundamentally the same tests as the VVOR and VORS respectively, examining different frequencies and exhibited the same findings in unilateral and bilateral vestibular hypofunction.

## FUNDING

The authors have no financial relationships relevant to this article to disclose.

## REFERENCES

1. Leigh RJ, Zee DS. The neurology of eye movements. 5th edn. Oxford University Press, Oxford. 2015.
2. Wong, AMF. Eye movement disorders. Oxford University Press, Oxford. 2007.
3. Gresty M, Leech J. Coordination of the head and eyes in pursuit of predictable and random target motion. Aviat Space Environ Med. 1977;48:741-4.
4. Kingma H, Van de Berg R. Anatomy, physiology, and physics of the peripheral vestibular system. Handb Clin Neurol. 2016;137:1-16.
5. Halmagyi GM, Chen L, MacDougall HG, Weber KP, McGarvie LA, Curthoys IS. The Video Head Impulse Test. Front Neurol. 2017;8:258.
6. Macdougall HG, McGarvie LA, Halmagyi GM, Rogers SJ, Manzari L, Burgess AM et al. A new saccadic indicator of peripheral vestibular function based on the video head impulse test. Neurology, 2016;87(4):410-8.
7. Weber KP, Aw ST, Todd MJ, McGarvie LA, Curthoys IS, Halmagyi GM. Head Impulse Test in Unilateral Vestibular Loss: Vestibulo-Ocular Reflex and Catch-Up Saccades. Neurology. 2008;70:454-63.
8. Halmagyi GM, Gresty MA. Clinical signs of visual-vestibular interaction. J Neurol Neurosurg Psychiatry. 1979;42:934-9.