Clinical Use of the Suppression Head Impulse Paradigm

Subjects: Otorhinolaryngology

Contributor: Leonardo Manzari, Sara De Angelis, Alessandro Antonio Princi, Giovanni Galeoto, Marco Tramontano

he instrumental assessment of the vestibular system has made significant progress. Two protocol tests are available in the clinical practice to evaluate the vestibular ocular reflex (VOR) function through the use of the video head impulse test (vHIT): the head impulse paradigm (HIMP) and the suppression head impulse paradigm (SHIMP). These tests can be used alone (in the case of HIMP) or in combination to test semicircular canal function and to determine the residual VOR gain and the visuo-vestibular interaction. The suppression head impulse paradigm (SHIMP) has a potential clinical application in patients with unilateral and bilateral vestibulopathy. The SHIMP could be a useful tool to diagnose a VOR alteration in patients with unilateral and bilateral vestibulopathy. Further well-designed studies are needed to evaluate if the new paradigm could replace the HIMP in both the acute and chronic phases of vestibulopathy.

Keywords: vestibulopathy ; vestibular system ; SHIMP

1. Introduction

The oculomotor response to impulsive rotation of the head represents the output for a short latency brainstem reflex that originates from the activation of the semicircular canals. This phylogenetically old reflex, the vestibular ocular reflex (VOR), consists of a disynaptic elementary pathway that allows the task of stabilizing the images on the retina during the movements of the head in the activities of daily living [1]. However, despite its simplicity, this reflex arc is anything but stereotyped. Rather, its response characteristics have been shown to be extraordinarily adaptable to behavioral needs [2].

The instrumental assessment of the vestibular system has made significant progress in recent years.

Two protocol tests are available in the clinical practice to evaluate the VOR function through the use of the video head impulse test (vHIT): the head impulse paradigm (HIMP) and the suppression head impulse paradigm (SHIMP) [3]. These tests can be used alone (in the case of HIMP) or in combination to test semicircular canal function and to determine the residual VOR gain and the visuo-vestibular interaction [4].

The basic physiology underlying both the HIMP and the SHIMP is the fluid displacement in the semicircular canals, which deflects the hair bundles of receptor hair cells, generating coordinated eye movements to stabilize the gaze during an unpredictable head turn [5].

The head turn stimulus and the eye movement recording are identical. All that is changed are the instructions—from “look at that fixed target on the wall” to “look at the moving target”.

For the SHIMP test execution, during the passive head rotation the patient is instructed to look at a head-fixed target rather than the earth-fixed target utilized in the HIMP. Patients can understand the test paradigm much easier if they glance at the dot. The person does not realize he is making a saccade.

Compared to the HIMP, in patients with vestibulopathy the SHIMP shows a reversed saccadic pattern: HIMPs elicit compensatory saccades opposite to the direction of head rotation. In contrast, the SHIMP elicits anti-compensatory saccades in the direction of head rotation in healthy people. During the SHIMP protocol, patients with a VOR alteration in the very acute stage do not make corrective saccades, manifesting a vestibular hypofunction, whereas in the subacute or chronic stage of vestibular hypofunction, SHIMP anti-compensatory saccades indicate visuo-vestibular interaction and the recovery of residual vestibular function [4].

It is important to note that SHIMP saccades do not mean that there is a VOR suppression. Indeed, as Crane and Demer showed [6] in healthy people, VOR is fully operational during the latency time. For this reason, the VOR gains in HIMPs and SHIMPs are similar.

Both paradigms have the same basic physiology and can be characterized by two parameters: VOR gain and corrective or catch-up saccades. Before the SHIMP become available, the main parameters were VOR gain and the presence of covert and overt saccades, whereas from the development of the SHIMP, for the clinician, it is possible to better quantify the real value of VOR gain since it is rarely affected by the presence of covert saccades [4][7]. Furthermore, in individuals with vestibular neuritis (VN), substantial relationships between the HIMP and SHIMP quantitative characteristics were recently found [7]. Both HIMP gains (0.76) and SHIMP gains (0.66) showed 100% sensitivity and 100% specificity in identifying patients with BVL from normal controls. Similarly, with 100% sensitivity and 100% specificity, HIMP gains (0.76) and SHIMP gains (0.66) identified the affected side of UVL [3].

The SHIMP reveals two important advantages vs. the HIMP: first, it allows the measurement of the VOR gain slow phase, and second, the percentages of impulses containing SHIMP saccades in the affected side are reported [4]. In a healthy person whose head is abruptly rotated, the VOR will successfully maintain the eyes on an earth-stationary target (reflected by an absence of compensatory saccades on the HIMP and the presence of anti-compensatory saccades on the SHIMP); in contrast, in a patient with acute uncompensated unilateral vestibulopathy whose head is abruptly rotated towards the lesioned side, the eyes will be “dragged along” with the head such that the eyes remain on a head-fixed target (reflected by the presence of compensatory saccades on the HIMP and the absence of anti-compensatory saccades on the SHIMP).

The reappearance of saccades in the SHIMP is linked to the (even minimal) increase in VOR gain. The early vestibular input keeps the eyes on the original target location, but since the target has moved with the head, a visual error signal triggers a saccade to the updated target location. This phenomenon could be the manifestation of adaptive neural plasticity overcoming a deficit, providing information about the recovery through a visuo-vestibular interaction strategy in patients with VN.

2. Clinical Use

Researchers aimed to explore the clinical application of the SHIMP in the diagnosis of vestibulopathy in both the acute and chronic phases. All the included studies reported an alteration of the VOR gain in both UV and BV. The SHIMP was compared with other clinical and instrumental tests to diagnose BV [3][8][9][10][11][12] and UV [3][4][7][9][11][12][13][14][15]. Four studies [4][10][14][15] reported that the VOR gain can be suitably assessed with the SHIMP in a hospital setting and one [7] reported similar results in an emergency department. Furthermore, four studies included patients evaluated in the acute phase [4][7][12][13], suggesting that VOR gain evaluation with the SHIMP could be a valuable tool for the clinician in the acute phase in differentiating vestibulopathy from other forms of dizziness and vertigo.

Rey-Martinez et al. [11] provided significant evidence for the influence of predictability on the delay of SHIMP saccadic responses. Even though predictability had an effect on saccadic latency for the SHIMP method, this effect could have an impact on the test’s main outcome. Furthermore, a lower SHIMP VOR gain in combination with a lower SHIMP overt saccade prevalence is more likely to predict the onset of chronic symptoms and the need for a rehabilitation assessment [13]. The SHIMP could also be a useful tool for the vestibular assessment of the VOR slow phase and to evaluate the visually enhanced vestibulo-ocular reflex (VVOR) and vestibulo-ocular reflex suppression (VORS) [9]. Indeed, by proving the connection between the lesioned peripheral vestibular system and the central nervous system’s adaptation process, VVOR and VORS testing might be added to the standard video head impulse test procedure. The vestibular loss can be efficiently cancelled, and retinal slip during head movements can be reduced by substituting another type of eye movement system [16]. Corrective saccades are then used as part of an adaptive technique to supplement the VOR’s slow-phase component for vestibular rehabilitation [17]. When the goal is a visual fixation on a stationary earth-fixed dot (HIMP), any passive impulsive head rotation generated in healthy people is eye rotation in the skull suitable for stabilizing the retinal image [2]. In contrast, if the intended goal is a fixation on a target moving with the head (SHIMP), eye rotation in the skull is not completely sufficient for stabilizing the retinal image. Indeed, at the end of the head rotation, the eyes of the people being examined ae on the dot and, at that point, a rapid, saccadic, ocular movement must be used to bring the eyes back to the target, which is head-fixed. Researchers termed this phenomenon as the visuo-vestibular interaction [4] and noticed that, in each paradigm, HIMP vs. SHIMP, the eye movements are quite similar; both response patterns remain suitable for the common goal of stabilizing the chosen retinal image [2].

Menière’s disease was considered in two studies that enrolled 20 patients with UV [12][15]. Patients with Menière’s disease treated with intratympanic gentamicin injections were considered chronic unilateral vestibulopathy patients with a reduction of HIMP VOR gain values. These results are consistent with the study by MacDougall et al. [3] in which altered

SHIMP and HIMP gain values were obtained in patients with bilateral and unilateral vestibular loss. The researchers[3] affirmed that the SHIMP encourages a more exact estimation of the VOR pick-up by killing the larger part of the catch-up saccades during the test. Shen et al. [12] affirmed that the SHIMP can also be utilized to decrease estimation mistakes of the VOR pick-up resulting from covert saccades and spontaneous nystagmus. After the SHIMP was introduced, the peak saccade velocity and frequency of saccadic response have been suggested as alternative parameters. Indeed, peak saccade velocity could be a useful parameter in identifying patients with acute VN by generating SHIMP saccades during head rotation. Other tests, such as HIMP VOR gains and the caloric test, may not be able to explain what SHIMP VOR gains and peak SHIMP saccade velocity could reveal [7]. Lee et al. suggested the importance of the SHIMP parameters in the symptom recovery of VN. Indeed, the anti-compensatory saccades of SHIMPs do not appear during vestibular compensation in the recovery phase of an acute VN, and they might predict that residual symptoms could remain in the chronic phase. On the other hand, patients demonstrating rapid VOR gain recovery at 1 month are more likely to be symptom-free at 6 months [14].

References

1. Wilson, V.J.; Jones, G.M. The vestibular system and the cerebellum. In Mammalian Vestibular Physiology; Springer: Boston, MA, USA, 1979; pp. 169–184.
2. Bloomberg, J.; Melvill Jones, G.; Segal, B. Adaptive plasticity in the gaze stabilizing synergy of slow and saccadic eye movements. Exp. Brain Res. 1991, 84, 35–46.
3. MacDougall, H.G.; McGarvie, L.A.; Halmagyi, G.M.; Rogers, S.J.; Manzari, L.; Burgess, A.M.; Curthoys, I.S.; Weber, K.P. A new saccadic indicator of peripheral vestibular function based on the video head impulse test. Neurology 2016, 87, 410–418.
4. Manzari, L.; Tramontano, M. Suppression Head Impulse Paradigm (SHIMP) in evaluating the vestibulo-saccadic interaction in patients with vestibular neuritis. Eur. Arch. Otorhinolaryngol. 2020, 277, 3205–3212.
5. Halmagyi, G.M.; Chen, L.; MacDougall, H.G.; Weber, K.P.; McGarvie, L.A.; Curthoys, I.S. The Video Head Impulse Test. Front. Neurol. 2017, 8, 258.
6. Crane, B.T.; Demer, J.L. Latency of voluntary cancellation of the human vestibulo-ocular reflex during transient yaw rotation. Exp. Brain Res. 1999, 127, 67–74.
7. Park, J.S.; Lee, J.Y.; Nam, W.; Noh, S.; Chang, S.O.; Kim, M.B. Comparing the Suppression Head Impulse Paradigm and the Head Impulse Paradigm in Vestibular Neuritis. Otol. Neurotol. 2020, 41, e76–e82.
8. Malara, P.; Martellucci, S.; Castellucci, A.; Belvisi, V.; Del Torso, A. Bilateral Vestibulopathy in Neuroborreliosis. Otol. Neurotol. 2021, 42, e579–e583.
9. Ramos, B.F.; Cal, R.; Carmona, S.; Weber, K.P.; Zuma, E.; Maia, F. Corrective Saccades in Unilateral and Bilateral Vestibular Hypofunction During Slow Rotation Expressed by Visually Enhanced VOR and VOR Suppression: Role of the Cerebellum. Cerebellum 2021, 20, 673–677.
10. De Waele, C.; Shen, Q.; Magnani, C.; Curthoys, I.S. A Novel Saccadic Strategy Revealed by Suppression Head Impulse Testing of Patients with Bilateral Vestibular Loss. Front. Neurol. 2017, 8, 419.
11. Rey-Martinez, J.; Yanes, J.; Esteban, J.; Sanz, R.; Martin-Sanz, E. The Role of Predictability in Saccadic Eye Responses in the Suppression Head Impulse Test of Horizontal Semicircular Canal Function. Front. Neurol. 2017, 8, 536.
12. Shen, Q.; Magnani, C.; Sterkers, O.; Lamas, G.; Vidal, P.P.; Sadoun, J.; Curthoys, I.S.; De Waele, C. Saccadic Velocity in the New Suppression Head Impulse Test: A New Indicator of Horizontal Vestibular Canal Paresis and of Vestibular Compensation. Front. Neurol. 2016, 7, 160.
13. Casani, A.P.; Canelli, R.; Lazzerini, F.; Navari, E. Prognosis after acute unilateral vestibulopathy: Usefulness of the suppression head impulse paradigm (SHIMP). J. Vestib. Res. 2021, 31, 531–540.
14. Lee, J.Y.; Kim, M.B. Importance of Video Head Impulse Test Parameters for Recovery of Symptoms in Acute Vestibular Neuritis. Otol. Neurotol. 2020, 41, 964–971.
15. Kirazli, G.; Hepkarsi, S.; Kirazli, T. Evaluation of high frequency horizontal VOR parameters in patients with chronic bilateral and unilateral peripheral vestibulopathy: A preliminary study. Acta Otolaryngol. 2020, 140, 1007–1012.
16. Han, B.I.; Song, H.S.; Kim, J.S. Vestibular rehabilitation therapy: Review of indications, mechanisms, and key exercises. J. Clin. Neurol. 2011, 7, 184–196.
17. Schubert, M.C.; Zee, D.S. Saccade and vestibular ocular motor adaptation. Restor. Neurol. Neurosci. 2010, 28, 9–18.