Clinical utility and practical interpretation of the video head impulse test

BY MARIA HEUBERGER , NADINE LEHNEN, LEONEL LUIS AND ERICH SCHNEIDER

The head impulse test (HIT) is an essential bedside test to detect peripheral vestibular deficits. The video head impulse test (vHIT) is a new tool quantifying the HIT. In this article **Maria Heuberger and colleagues** point out the clinical utility of the vHIT and give practical advice on its interpretation.

Head impulse testing

The head impulse test (HIT) is a qualitative bedside test for the high frequency vestibulo-ocular reflex (VOR), which stabilises gaze in space. Patients with a deficient VOR cannot stabilise gaze and experience oscillopsia with head movement.

The head impulse test was first described by Halmagyi and Curthoys in 1988: the examiner turns the patient's head with high acceleration (up to 3000°/s²) and small amplitude in the plane of the horizontal semicircular canal while the patient looks at a target straight ahead (e.g. the examiner's nose). An intact VOR causes a compensatory eye movement in the opposite direction of the head movement, allowing the patient to fixate the target. With a deficient VOR the eyes follow the head movement until a quick eye movement brings gaze back to the target (catch-up saccade, see Figure 1). Catch-up saccades are indirect signs of a VOR deficit. They can occur after the head movement (overt catch-up saccades) or during the head movement (covert catch-up saccades, see Figure 2). Only overt catch-up saccades can be seen in the clinical HIT. Covert catch-up saccades can result in a false clinical test outcome.

Quantitative head impulse testing: the video head impulse test

The gold standard for quantitative head impulse testing is the search-coil-in-magnetic-field-technique. This is a semi-invasive, time-consuming, costly method that cannot be used at the bedside.
The video head impulse test (vHIT) was developed as a mobile tool for quick and easy non-invasive quantification of VOR function. It has been shown to have similar sensitivity and specificity as search coil testing [1, 2].

Set-up: The patient is seated at a distance of more than 70cm from a wall with a fixation point at eye level. The examiner applies head impulses just like in clinical head impulse testing (see above, peak head velocity 150-300°/s, amplitude 6-12°, 3) but from behind the patient (about 5-10 HITs to each side). Eye movements are recorded with video-oculography, head movements with inertial sensors (Figure 2A).

Interpretation: For quantification of the vestibular deficit, the VOR gain reflex as the ratio of angular eye to head velocity is calculated. In healthy individuals the vHIT gain of the vestibulo-ocular reflex is ≥0.75 at 60ms [3]. In addition to a gain deficit, catch-up saccades indicate a peripheral-vestibular deficit (Figure 2C,D).

"The vHIT can help differentiate central from peripheral vertigo in patients with acute vestibular syndrome."

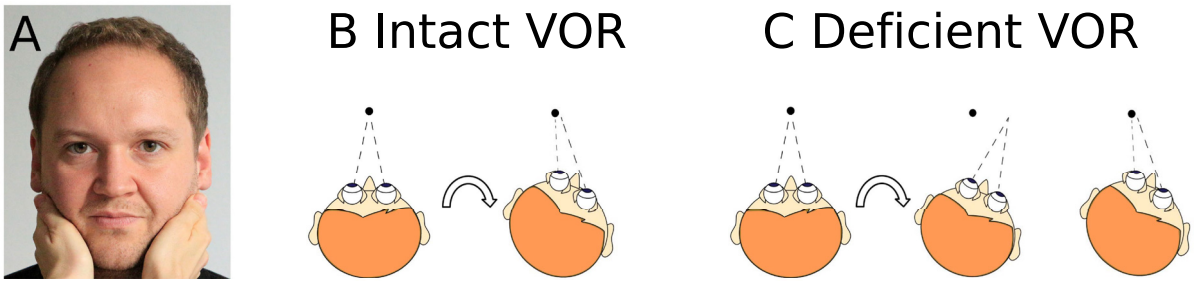


Figure 1: Clinical head impulse testing. A) Setting for clinical head impulse testing. B) Intact vestibulo-ocular reflex (VOR): the eyes move in the opposite direction of the head movement during head impulse testing, allowing the patient to fixate the target. C) Deficient VOR: The eyes follow the head movement until a quick eye movement (catch-up saccade) brings gaze back to the target.

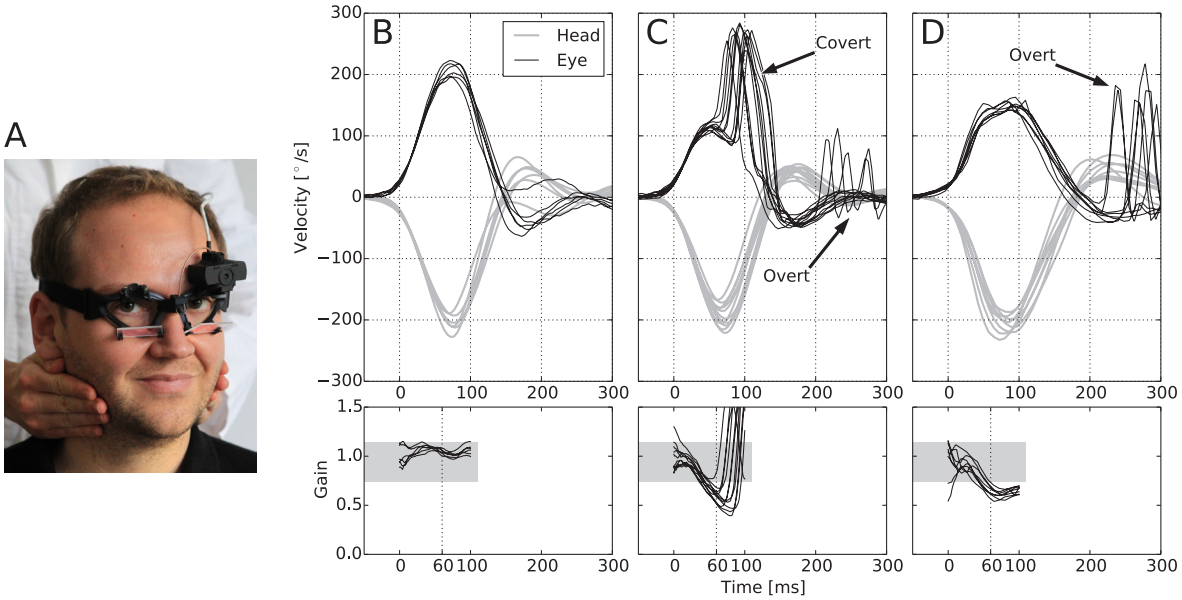


Figure 2: Quantitative head impulse testing with the video head impulse test (vHIT, example: EyeSeeCam). A) vHIT setting. B) Normal vHIT: eye movements in the contralateral direction compensate for head movements, gain ≥0.75, no catch-up saccades. C) Pathological vHIT with covert catch-up saccades: eye movements do not compensate for head movements, gain <0.75, catch-up saccades during the head movement. D) Pathological vHIT with overt catch-up saccades: eye movements do not compensate for head movements, gain <0.75, catch-up saccades after the head movement.

Clinical utility of video head impulse testing

What can be diagnosed with the vHIT?

The vHIT can help differentiate central from peripheral vertigo in patients with acute vestibular syndrome (vertigo, nausea, gait unsteadiness with head-motion intolerance and nystagmus). In acute vestibular syndrome, vHIT in combination with examinations of both skew deviation and nystagmus that changes direction on eccentric gaze distinguished a peripheral vestibular deficit (e.g. vestibular neuritis) from central pathologies (stroke) with a sensitivity and specificity of 100% compared to MRI [4].

In chronic vertigo / dizziness / gait unsteadiness the vHIT detects bilateral vestibulopathy. Detecting unilateral peripheral-vestibular deficits with the vHIT is helpful in the diagnosis and follow-up of Ménière's disease or vestibular neuritis. Additionally, the vHIT can be used as a screening tool for vestibular deficits due to gentamicin toxicity.

What distinguishes the vHIT from other tests of VOR function?

Compared to the clinical HIT, the vHIT has a higher sensitivity and specificity [1, 2]. Eye and head movements and consequently the VOR gain can be documented and quantified objectively. In contrast to the clinical HIT the vHIT can detect covert saccades (see above; Figure 2).

Other tests assessing VOR function include caloric and rotational chair testing, as well as head impulse testing using the search-coil-in-magnetic-field-technique. In contrast to these tests, the vHIT is portable (bedside use), non-invasive, quicker (approximately five minutes) and does not induce uncomfortable vertigo and nausea. It is thus also suitable for children or for the elderly [5].

In contrast to caloric testing, the vHIT is a more physiological stimulus testing higher frequencies (>1Hz, caloric testing <0.03Hz). vHIT – in contrast to caloric testing – is more suitable to test all six semicircular canals.

What pitfalls can occur when using the vHIT in clinical routine?

Contraindications: There are a few cases when the vHIT must not be performed, as in patients with acute spine syndrome, fractures, or cervical artery dissection.

Head stimulus: To ensure a correct interpretation (see above cervical artery), the quality of the vHIT-head stimulus is crucial. One key quality criteria is a sufficient velocity (150-300°/s) ensuring the detection of a vestibular deficit [6]. To provide a direct acceleration transfer to the head, it is sometimes helpful to ask patients to clench their teeth during the vHIT (Figure 2A).

Slippage: A frequent pitfall is goggle slippage resulting in an exaggerated gain (Figure 3A). Slippage can be detected by a non-horizontal continuous gain trajectory (Figure 3A; below). It is crucial to fasten the goggles tightly to the head to avoid slippage.

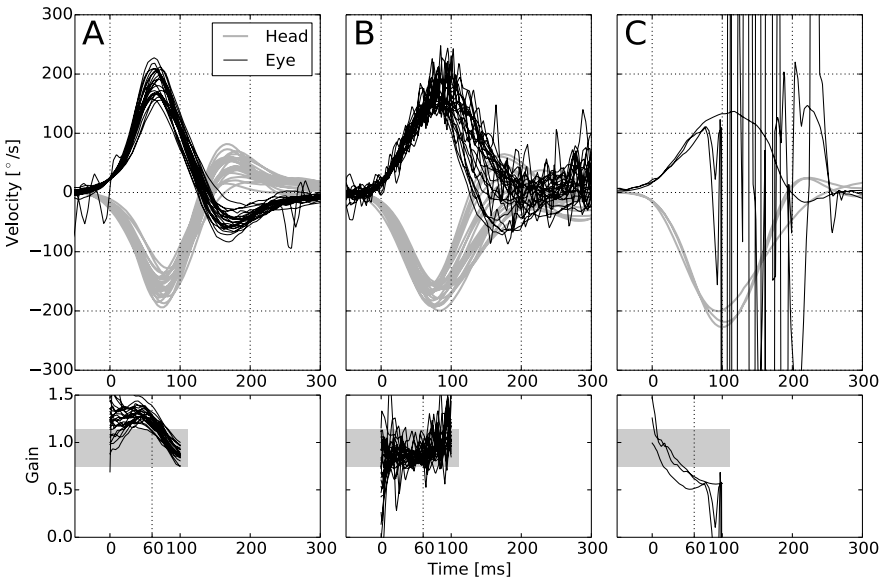
Noise: Another common pitfall is an obstructed pupil. The pupil is not correctly detected if covered by a drooping eyelid or if the detection is irritated by strong mascara (Figure 3B). Mascara can be removed and drooping lids tucked under the rims of the goggles.

Blinking: In Figure 3C the vHIT cannot be interpreted because the patient is frequently blinking during the test. The examiner should recognise this artefact and ask the patients to open their eyes wide during the test. Sometimes it is helpful to let the patients close their eyes for some seconds before testing.

Predictability: The timing and direction of the HIT should not be predictable for the patient to avoid exaggerated gain values [3].

Summary

The vHIT is a mobile, non-invasive, quantitative test for the vestibulo-ocular reflex (VOR). Compared to the clinical head impulse test (HIT) it provides a higher sensitivity and specificity. This is especially important for differentiating peripheral from central (e.g. stroke) pathologies in acute vestibular syndrome, but also for diagnosing chronic vestibulopathies. Unlike caloric testing, the vHIT is a physiological stimulus testing high frequencies of the VOR, it is less unpleasant, tolerated by children and suitable for better testing of all six semicircular canals. The vHIT has become an essential tool in the examination of patients with vertigo / dizziness.



"Compared to the clinical HIT, the vHIT has a higher sensitivity and specificity."

Figure 3: Video head impulse test pitfalls vHIT . A) Slippage: the eye movement precedes and surpasses the head movement, gain > 1.0, no straight horizontal gain trajectory. B) Noise: eye movement detection is distracted. C) Blinking: sharp vertical eye movement detection

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TAKE HOME MESSAGE

- vHIT is a quantitative test for the high frequency VOR providing a higher sensitivity and specificity than the clinical HIT
- vHIT can help differentiate peripheral and central vertigo and quantify chronic vestibulopathies
- vHIT quality can be ensured by tight goggles, head movement velocities of 150-300°/s and control of pupil detection.

ABOUT THE AUTHORS

Maria Heuberger MD is working as a resident in neurology at Munich University Hospital and as a postdoc at the German Center for Vertigo and Balance Disorders. Nadine Lehnen MD Phil (Cantab) did her residency in neurology at Munich University Hospital and is currently working as a Young Scientist Group Leader at the German Center for Vertigo and Balance Disorders. She is cofounder, shareholder and consultant to EyeSeeTec GmbH. Leonel Luis MD PhD, Consultant ENT Surgeon is currently the head of the Otoneurology unit at Hospital de Santa Maria and investigator at the Clinical Physiology Translational unit in the Faculty of Medicine of the University of Lisbon in Portugal. Erich Schneider PhD has a degree in physics and is Professor for Medical Informatics at the Institute of Medical Technology of the Brandenburg University of Technology Cottbus - Senftenberg. He is cofounder and general manager of EyeSeeTec GmbH, the manufacturer of EyeSeeCam vHIT.

Declaration of competing interests

NL received speaker honoraria and compensation for travel expenses from Interacoustics, Autronic Reglersysteme GmbH, and Meytec GmbH Medizinsysteme. She is a shareholder and paid consultant of EyeSeeTec GmbH. LL is an unpaid consultant to Interacoustics, Denmark, distributor of EyeSeeCam vHIT. ES is general manager and a shareholder of EyeSeeTec GmbH, Germany, the manufacturer of EyeSeeCam vHIT. He also acts as an unpaid consultant to and has received funding for travel from Interacoustics, Denmark, distributor of EyeSeeCam vHIT.