Vorteq™ VHIT

White Paper

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What is the VORTEQ™- VHIT

Vorteq VHIT is Micromedical's version of the video head impulse test. Vorteq has long been used by Micromedical to measure the Vestibular Ocular Reflex (VOR) gain and symmetry in patients complaining of dizziness. Other clinical tests that measure VOR gain in the lateral canals are the caloric and rotational chair tests. The clinical head impulse/thrust test (HIT or HTT) method was first described by Michael Halmagyi MD in 1988 where he performed manual head thrusts clinically and observed the corrective saccades caused by retinal slip in patients with vestibular loss. Today with the availability of fast cameras and small angular velocity sensors, the Video Head Impulse Test (VHIT) will generate traces to help “see” saccadic intrusions. VOR gain is also calculated for numeric evaluation.

Advantages of Micromedical’s VHIT over the competition

Binocular high speed (150 to 250Hz) eye video recordings (both eyes simultaneously) are not affected by a prosthetic eye, a lazy eye, a cataract in one eye, or blindness in one eye since the “good” eye can be still be recorded. If you are restricted to goggles with one fixed right eye camera like our competitors Impulse™, then you will not be able to test some patients. Micromedical goggles are comfortable to wear and do not produce the “Impulse bump” during a head thrust. Micromedical VHIT calibration is automatic for each patient. VHIT is available either stand-alone or in combination with our VNG or Rotational Chair. With Micromedical there is no need to purchase a special product for one vestibular function test.

Goggles weight and slippage

The Micromedical goggles are comfortable and light (10oz). They hug the bony structure of the face and thus stay in place during head thrusts. Our goggles slip less than our competitor’s soft-tissue supported designs. How do we know our goggles are stable? Micromedical evaluated goggles slip using a sensor attached to the goggles and a second sensor in a patient bite block. In our study, both sensors were recorded simultaneously during head thrusts; we found that goggles slippage (shown in the figure below below) was insignificant. The center plot and gain graph are plots of one sensor versus the other. Here, sensor1 versus sensor2 gain is 1.0 and there is no hysteresis or slip apparent. Our competition has reported their soft tissue goggles do slip, resulting in a “bump” in the eye movement trace just at the point on the waveform where velocity gain measurement is the most important.

Figure 1: Left graph shows normal impulse amplitude. Center and right graph shows a strong linear correlation between goggles mounted sensor and bite block sensor in horizontal direction.
Figure 2: Left graph shows vertical head thrusts up and down. Center Graph shows a strong linear correlation between goggles mounted sensor and bite block sensor in vertical direction.

**Six canal testing**
To differentiate superior neuritis from inferior neuritis all six *semi-circular canals* (SCC) should be evaluated. Superior neuritis is the more common of the two. It involves the lateral and the anterior SCC, while inferior neuritis affects the posterior SCC. In our Spectrum 8.10 clinical software, all six canals can be tested with Vorteq VHIT.

**Lateral VHIT**
Perform the test by holding the patient’s jaw while standing behind the patient. During the test the patient’s jaw should be clenched so the impulse will be transferred to the head. Practice a few impulses before beginning the recording. This will familiarize the patient with the stimulus as well. Do not allow your hands to touch or move the goggles during head impulses as that movement will affect the gain calculation.
**Left Anterior Right Posterior (LARP) / Right Anterior Left Posterior (RALP) VHIT**

The modified vertical head impulse test method allows LARP and RALP VHIT to be performed using purely vertical eye tracking. The test is performed by placing both hands on top of the head or alternatively by holding the head with one hand on top and the other holding the chin, administering vertical impulses with head turned to the side by about 30-35 deg. This places the vertical canals in the direction of head travel producing a vertical eye movement response.

The patient's head is turned 30 deg to the right for LARP test and 30 deg to the left for RALP test. Arrow labels on the goggles indicate the direction of gaze and impulse to get the proper vertical canal stimulus. For the impulse, pitch head down about 10deg (chin drops 1 inch), then pitch head up about 10deg.

**Calibration and Testing**

A novel software algorithm eliminates the need for eye and head sensor calibration for each patient. The Vorteq sensor can then be placed in the vertical plane and does not need to be adjusted to the canal planes. This calibration algorithm significantly reduces test preparation time and improves accuracy of the test. During testing, audible and visual feedback informs you if your technique was correct and the head velocity was within the proper range. You only need 10 accepted thrusts in each direction to complete an evaluation of a canal pair. Eye velocity and head velocity waveforms are superimposed. Position gain is plotted as red and blue dots with an average line.
Clinical Examples

Figure 3. Normal Lateral VHIT. No compensatory saccades and normal, symmetrical gain.

Figure 4. Abnormal lateral VHIT three years after a left vestibular neuritis. Compensatory saccades and reduced, asymmetrical gain.

Figure 5. Normal RALP canals VHIT.

Figure 6. Normal LARP canals VHIT.
Clinical Findings
Covert corrective saccades (during head motion) and corrective overt saccades (post head motion) are strong indicators of a significant vestibular deficit. VHIT can measure these short duration events at up to 250 samples per second. Head velocity and eye velocity are displayed and position gains measured.

Clinical Usage
What can’t VHIT do? There is a lot of marketing hype about VHIT replacing VNG and Rotational Chair tests in dizzy clinics. The Head Impulse Test (HIT) has been used clinically for 25 years and there is no reason for us to believe that VHIT will be that much better than HIT. There will be fewer false negatives since covert saccades can now be captured. However, HIT was intended to identify complete loss of vestibular function on one side and now VHIT can maybe identify losses >50%. Caloric tests can and still identify partial losses (<25%) on one side. A rotational chair test gives the clinician insight into central compensation after a vestibular loss. This compensation information helps the clinician know whether vestibular rehabilitation is working. We recommend that you always use the patient’s history and other clinical tests before making a diagnosis or decision regarding vestibular therapy.

Gain
In the audiology world, amplifier gain is reported in dB, which is a logarithmic scale of signal gain (output over input). This scale permits easier visualization of big changes in signal strength. With the vestibular ocular reflex (VOR) the input (head movement) and output (eye movement) are equal if there is no retinal slip. Thus, VOR gain equals one in normal subjects and less than 1.0 in vestibular patients with corrective saccades. Normal VHIT position gain varies from 0.7 to 1.1. Lower gains suggest VOR weakness.

Position Gain vs. Velocity Gain
The purpose of the VOR is to maintain a stable world image on the fovea. Eye position is where your eyes are looking relative to where you want to look. That means when the head moves, your VOR moves your eyes to compensate. If you move your head 10 degrees then you want your eyes to rotate in their sockets by 10 degrees in the opposite direction to keep your eyes looking at the target.

For position gain, if your head moves 10 degrees and your eyes only move 4 degrees, then you are no longer looking at the expected target and your VOR position gain is a weak 4/10 = 0.4 = 40%. A patient with this weak VOR gain would inject a saccade during the head thrust to move their eyes forward to the target after their retina/brain identified the image slip. For a head thrust, this all happens in less than 500 milliseconds (½ second). In this clinical example, your head would move 10 degrees and your eyes would eventually move 10 degrees, albeit with corrective saccades, so in the end you are looking at the target. Thus, we calculate position gain as total eye rotation degrees divided by total head rotation degrees from the start of the thrust until the start of a covert corrective saccade. Head position is the area under the head velocity curve. There is no bump from slippage in our system and therefore no need to add errors to calculations from interpolating (guessing) eye position across a corrective saccade.

Rotational eye velocity is measured in degrees per second and represents how fast your eyes are moving at any point in time. But just like starting and stopping your car, the brain must accelerate your eyes to a maximum velocity then apply the brakes to stop eye rotation. Correspondingly, eye velocity and head velocity change significantly during a head thrust. For velocity gain, you pick a point in time; say 45msec after the start of head motion, as an instantaneous gain measurement point. You pick 45msec because you don’t want to pick a time point in time when the patient is injecting a corrective saccade; because, during that saccade, eye velocity will be very high and instantaneous gain would correspondingly be very high.
Velocity gain is used in tests like active head rotation (VORTEQ) and rotational chair (System 2000) because the stimulus is sinusoidal and thus periodic. Average velocity gain is very practical and appropriate for sinusoidal rotation stimuli. Another reason for using periodic stimuli is that you can measure phase, i.e. the timing relationship, between the stimulus and the response as an indicator of central vestibular pathology.

With head thrusts, there is a non-sinusoidal beginning and end to the stimulus. We hope to visually identify the injection of corrective saccades in the traces and also quantify how well the eyes match the head in maintaining the target. That is the purpose of the VHIT. We display eye velocity and head velocity so you can easily see corrective saccades.

FDA registration and IRB approval
VORTEQ is an FDA Class II device that was registered by Micromedical with the FDA with a 510(k). The FDA found that Vorteq was substantially equivalent to other devices already on the market. Vorteq is a tool for the assessment of the vestibular ocular reflex using a rate sensor and eye movement recording. VORTEQ tests include horizontal and vertical vestibular ocular reflex (VOR), horizontal and vertical Dynamic Visual Acuity Test (DVAT), and now head impulse tests (VHIT). Vorteq VHIT is listed on the FDA web site www.FDA.gov. IRB approval has been received at research centers using the Micromedical VHIT.

CE Mark
For those in Europe and countries outside the USA, the Vorteq, VisualEyes and System 2000 Reclining chair devices have passed EMC and Safety tests by an independent laboratory and are CE marked. Micromedical also proudly earned an ISO 13485 quality certification from BSI.

Medicare Reimbursement
Vorteq systems with the included gaze nystagmus tests are billed under 92541 (Medicare ~ $28) Vorteq can be billed by PTs and MDs using physical medicine assessment code 97110 Vorteq should not be billed using rotational chair code 92546. CPT 92700 has been discussed for VHIT billing, but there is no Medicare payment for this code.

Why VORTEQ™ - VHIT?
The patient’s VOR stabilizes gaze during rapid head movements by sensing motion and generating compensatory eye movements to keep the eyes on a fixed target. VOR is functional over a wide frequency spectrum from 0.001 Hz to 100 Hz. Caloric, rotational chair and VORTEQ each test different frequency bands of the VOR. Caloric stimulus and rotational chair are the gold standards with good reimbursement. We feel that VHIT is useful as a quick, easy test of high frequency VOR function and can help you evaluate all six semi-circular canals. LARP and RALP canal testing may identify patients with inferior vestibular nerve involvement that was missed by caloric and rotational chair.
Figure 7. Gain response of the VOR versus frequency of head motion

**Why Micromedical?**

Micromedical has for the past 25 years specialized in providing instruments for measuring the vestibular ocular reflex in patients with dizziness including VNG, Rotational Chair and VORTEQ. VORTEQ can be an economical VNG option rather than a stand-alone dedicated VHIT product because the PC, calibration target and goggles are also used for VNG! For clinicians who already own a non Micromedical VNG, our Vorteq-VHIT can be purchased as a stand-alone device without VNG and can even be upgraded later with VNG. No need for both a VNG and a VHIT system in your clinic since the Micromedical system is all-in-one.

Micromedical FireWire goggles are comfortable. Slippage is insignificant because the goggles fit securely on the patient’s face using nasal bones and temporal bones for stability. Micromedical binocular goggles with two cameras give you twice the opportunity to obtain superior eye tracking results. The VORTEQ head velocity sensor rotates to identify corrective saccades and measure gain of head thrusts in the lateral, LARP and RALP canal planes.

Clinicians familiar with Micromedical software can quickly learn VHIT. VHIT has been integrated into Micromedical’s Spectrum clinical software and test results can be combined with VNG for a concise patient report.

**New in Spectrum 8.10 for Video Head Impulse Tests -VHIT**

- Six semi-circular canal testing: lateral, anterior and posterior for each ear.
- Auto-calibration of eye and head sensor during testing for maximum accuracy.
- Quick interpretation - only two numbers displayed per test (after millions of calculations).
- Large head and eye velocity traces allow you to see corrective saccades.
- Highlight each head thrust/eye trace using the arrow keys.
- Spontaneous nystagmus and gaze nystagmus tests are included for the acute or uncompensated patient.
- Billable gaze nystagmus tests under CPT 92541
- One mouse click to locate and center eyes anywhere within the camera window before testing.
- Simple clinical evaluation mode or comprehensive research mode.

Visit [www.micromedical.com](http://www.micromedical.com) or call 217-483-2122 for more information or a quote.

References:
2. FDA 510(k) application KB91000 with FDA letter of substantial equivalence.
3. MacDougall Hamish G. et. al. The Video Head Impulse Test (vHIT) Detects Vertical Semicircular Canal Dysfunction. PLOS|one. April 2013, 8(4) e61488.