Publications and Literature Overview of EyeSeeCam vHIT

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Head Impulse Testing Introduction

Head impulse testing has been used for the assessment of the horizontal semicircular canal vestibulo-ocular reflex (VOR) function for many years and was first described by Halmagyi and Curthoys in 1988.[1] Since that time there has been extensive research in VOR assessment by means of thrusting the head to reveal the high-frequency properties of the vestibular system. The head thrust test is based on the doll's eye reflex, whereby the patient's eyes are expected to remain on a target as the head is turned or thrusted from side to side. In the clinical head impulse test cHIT performed at bedside, the patient's eyes are monitored in response to the thrust, and the examiner can observe overt catch-up saccades in patients with impaired VOR function.

Perez and Rama-Lopez (2003) studied head impulse testing (in the yaw plane) compared to caloric testing in patients with dizziness.[2] 265 patients were evaluated using both methods of assessing horizontal semicircular canal VOR function. Results revealed a specificity of 97 – 100% and sensitivity of 34-39%. With larger caloric asymmetries the sensitivity improves. They found that a canal paresis value of 42.5 percent was considered the limit of normal with cHIT testing. The amount of canal paresis was significantly higher in patients with pathologic head impulse test results. It should be noted that the caloric response represents only one point in intensity and frequency and this is a very low, non physiological stimulus (0.002 – 0.004 Hz) [3]. They conclude that additional tests should also be included to improve the diagnostic outcome; these tests include head-shaking nystagmus and scleral coil testing to determine VOR gains during the impulses. It is noted in the discussion section that there are populations of subjects tested who have less common findings including (about 10-20%); these subjects can have normal caloric tests and abnormal cHIT results.

With the simple cHIT method of observation, the examiner may not be able to detect all corrective covert saccades with the naked eye in the case of vestibulopathy because they occurring during the head impulse and the response is too fast for the naked eye to see [2]. Therefore, recording the eye movements in response to head thrusts via a lightweight camera has been proposed by several researchers as an objective alternative clinical tool to the bedside head impulse test to assist the examiner in detecting both overt and covert saccades and improve the sensitivity.

As early as 2006, video tracking of eye movements with a head-mounted camera was being evaluated. Dera, Boning, Bardins, and Schneider (2006) measured three degrees of freedom of eye movements (horizontal, vertical and torsional) with a head-mounted camera that looks where the eyes look.[4] They were able process data of 3 degrees of freedom close to real-time, within 3ms using a standard laptop computer, resulting in a very minor reaction time.

As this technology improved over the next few years, Kumar et al (2009) devised a new eye tracking algorithm that was robust enough to be able to detect the pupil center with low computational complexity.[5] In their algorithm, a Fast Radial Symmetry Detector was used to estimate the location of the pupil. They used a filter to obtain an ellipse fit at the subpixel level. With this method of tracking, the pupil boundary was detected accurately in 96% of subjects, including those in which a portion of the pupil was occluded by artifacts, such as eyelids and eyelashes. The algorithm was also robust against changes in light in the environment.
Using this robust pupil tracking algorithm, Bartl, et al compared results of sclera search coil recordings to video oculography (VOG) recordings by measuring eye and head movements during standard head impulses in healthy subjects.[6] The VOG device consisted of a head-mounted camera on a mini goggle which measured eye movements at a rate of 300 frames per second. A pair of inertial measurement sensors were mounted on the goggles to measure movement of the goggles and then mounted on a bite bar to measure head movement directly. Although there was mild goggle slippage in this early design (sample patient results shown below), they concluded that the high frame rate of the VOG used along with the inertial sensor may be a promising tool for clinically measuring semicircular canal function.

EyeSeeCam Validation

Weber et al (2009) reported video head impulse test (vHIT) results comparable to a sclera coil search method when using a camera running at 250 frames per second and mounted on a lightweight spectacle to prevent slippage of the camera relative to the head.[7] They found that corrective saccades, both overt and covert, were easily detectable in patients with reduced horizontal canal VOR gain when delivering manually graded head impulses and then objectively analyzing the stimulus-response characteristics of the VOR. According to Weber et al, vHIT is easy to use in the clinical setting and is a more practical technique than the sclera search coil method. MacDougall et al (2009) reported similar findings.[8] They recorded horizontal head impulse test (HIT) simultaneously with vHIT at 250 Hz and sclera search coils at 1000 Hz in 16 subjects, half normal and half with known vestibular pathologies. No significant differences between the two methods of recording were measured. vHIT was as successful as coils in detecting overt and covert catch-up saccades in all patient groups evaluated, as is a much easier tool to use in the clinic setting. Just recently Agrawal et al (2013) published their data with 6 elderly patients comparing ESC vHIT results with the scleral coil data. The documented a significant correlations between ESC and coil data at instantaneous gain measurements between 30 – 60 ms[9].

Normative data for horizontal VOR gain using the EyeSeeCam video-oculography device was obtained by Mossman, Mossman, Purdie and Schneider (2012).[10] 60 normal subjects with an age range of 20 to 80 years were tested with vHIT, whereby the subjects' heads were rotated rapidly in the horizontal plane while observing the eye movements with VOG goggles to quantify eye and head movements and calculate gain as a ratio of angular eye velocity to angular head velocity. The lowest and highest gain measurements obtained in this group of normal subjects was .76 and 1.18, respectively. They reported a very minimal reduction in VOR gain with age, as well as nonphysiologically high gain when subjects were tested in an overly predictable pattern. Their results revealed VOR gain measurements that were very similar to sclera search coil VOR gain studies. Blöwdow et al[11] confirmed these results in 2012 using the ESC vHIT on 117 patients and 20 healthy controls. The results showed an average gain of 0.96/0.97 for the healthy controls, similar to the findings from Mossman's group. The lower gain limit was 0.79.

Blödow's group further confirmed reduced gains in patients with several different know vestibular peripheral pathologies. They also were able to identify refixation saccades in these abnormal subjects, both overt and covert. They concluded that 14% of acute or chronic peripheral vestibular disorders have covert saccades which would be missed without the aid of a video HIT such as ESC. Kremmyda's group[12] analyzed 16 Cerebellar Ataxia (CA) patients with pathological bedside tests, comparing VOR gains in vHIT, scleral coils and caloric tests. Half of the subjects had normal caloric responses and the other half had reduced caloric responses. There results indicate that the bedside HIT test is less reliable in patients with CA.

In conclusion, the literature reports the optimal methods used to test and collect data using a video recording of the patient's eye movements in response to head impulses, defines normative data for VOR gain using vHIT evaluation, and supports the usefulness of this measurement technique for the clinical assessment of VOR function.

Literature list

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