ORIGINAL ARTICLE

Relationship Between Video Head Impulse Test (vHIT) and Caloric Test in Patients With Vestibular Neuritis

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KEYWORDS
Video head impulse test; Vestibular neuritis; Vertigo; Videonystagmography; Diagnosis; Caloric test; Dizziness Handicap Inventory

Abstract
Introduction and objectives: The caloric test is the gold standard for the loss of vestibular function diagnosis. The video head impulse test (vHIT) assesses the same reflex by using a video-assisted examination of the impulsive manoeuvre. We intend to compare the variation of results of the vHIT and the caloric test in patients with vestibular neuritis with respect to their initial condition at two different moments of their evolution and to check the level of correlation between them and with that of the DHI test.

Methods: We explored 20 patients with neuritis by using both vHIT and the caloric test on the same day. We assessed the correlation between these two tests and with the DHI test for each patient at two different moments of their evolution.

Results: We calculated gain asymmetry and compared it with the canal paresis, but we found neither a linear correlation between them, nor a correlation between the DHI test or improvement of these two other tests. We conclude that the covert saccades maintain a similar speed whilst present in the VHT, but the overt diminish their speed over time.

Conclusions: The VHT and the caloric test show different responses of the vestibulo-ocular reflex, because they stimulate different frequencies of this reflex. No correlation was found between the VHT, the caloric test and the DHI test. The tests appear to complement one another.

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PALABRAS CLAVE
Video head impulse test; Neuritis vestibular; Vértigo; Videonistagmografía; Diagnóstico; Prueba calórica; Dizziness Handicap Inventory

Relación entre el video head impulse test (vHIT) y la prueba calórica en el estudio evolutivo de pacientes con neuritis vestibular

Resumen
Introducción y objetivos: La prueba calórica es hasta ahora la prueba de referencia para el diagnóstico y el examen de una hipofunción vestibular unilateral. El video head impulse test (vHIT) valora el reflejo vestibulo-oculomotor, mediante el registro videoassistido de la maniobra impulsiva. Se pretende comparar la variación de los resultados del vHIT y la prueba calórica en pacientes con neuritis vestibular respecto a su estado inicial en diferentes puntos de su evolución, y comprobar su grado de correlación entre sí y con el test Dizziness Handicap Inventory (DHI).

Métodos: Exploración en la misma sesión mediante vHIT y prueba calórica de 20 pacientes con neuritis vestibular. Valoración de la correlación de dichas pruebas entre sí y con el test DHI en 2 momentos diferentes de la evolución para cada paciente.

Resultados: La asimetría de la ganancia del vHIT y la paresia canalicular de la prueba calórica no evidenciaron una correlación lineal entre ellas. Tampoco se apreció una correlación entre el DHI y la recuperación de los parámetros de estas 2 pruebas. Las sacadas Covert mantienen una velocidad similar mientras están presentes en el vHIT, mientras que las Overt disminuyen su velocidad con el tiempo.

Conclusiones: El vHIT y la prueba calórica muestran diferentes respuestas del reflejo vestibulo-oculomotor, dado que exploran diferentes frecuencias del mismo. No se ha encontrado una correlación entre el vHIT, la prueba calórica y el DHI a lo largo de la evolución de la neuritis vestibular, siendo pruebas complementarias entre sí.

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Introduction

The OtoNeurology Commission of SEORL (Spanish Society of Otorhinolaryngology), in its 2011 update, classified vestibular neuritis (VN) as acute vertigo without hearing loss, which gives a clinical syndrome characterised by the sudden onset of a prolonged attack of vertigo, with nausea and vomiting, spontaneous nystagmus and postural imbalance, with no hearing symptoms or other neurological symptoms.1-3

One of the most important elements to examine in assessing patients with vertigo and balance disturbances is the vestibulo-ocular reflex (VOR). The caloric test (CT) has been the benchmark test to date for identifying a unilateral vestibular deficit by studying the RVO of the horizontal semi-circular canal. This can be explored clinically by the head impulse or Halmagyi manoeuvre,4-6 or by a new methodology based on video-assisted recording of ocular displacement induced by head impulse: the video head impulse test, commonly known as vHIT.

This article seeks to compare the results of vHIT and CT in patients with vestibular neuritis (VN) throughout the evolution of the disorder, to check its degree of correlation and to assess the development of the Dizziness Handicap Inventory (DHI).

Material and Methods

Twenty patients with VN were monitored under a prospective longitudinal study between June 2013 and April 2014. The patients were aged between 12 and 73 (mean=49.65 and σ=17.75). The distribution was 9 males and 11 females, and 7 left ears and 13 right ears.

All of the patients included in the database were diagnosed with VN according to the criteria of the OtoNeurological Commission of the SEORL in 2008.

All the patients underwent vHIT and CT, at the onset of symptoms and at a control point between one and 3 months after the onset of symptoms in a similar way to other studies.7,8 Both tests were performed during the same examination session, taking the vHIT recording first and then the CT.

We used vHIT ICS Impulse equipment from Otometrics (Copenhagen), and estimated the following values:

1. Gain in VOR response of the horizontal canal of each ear. This was obtained by integrating the curves recorded; the area under the eye movement curve and the area under the head movement curve were calculated by the software and then the ratio between them. In accordance with most authors, gains below 0.8 were considered pathological.

2. Gain asymmetry (GA) obtained from the gain of both ears. This was defined as: (healthy ear gain – affected ear gain)/(healthy ear gain + affected ear gain) expressed as a percentage. This is a parameter which enables the functional deficit of the affected ear to be expressed based on the healthy ear, unlike isolated gain, which only offers the degree of functionality of each ear separately. This parameter will be used later to relate it with canal
paresis. A gain asymmetry of below 8% is accepted as normal.
3. Refixational covert/overt corrective saccades: saccades were considered corrective when they had a velocity greater than 100 /s repeated in more than 20% of the head impulses.
4. Maximum velocity of said saccades.

All the recordings used in the study had a standard deviation (σ) below 0.10. In cases where the standard deviation was higher than this figure, the recording was rejected and the test repeated.

The CT was performed with an Ulmer videonystagmograph (Marseille) to obtain the canal paresis: In bithermal CT with water at 30° and 44° using 150 cc of water for each irrigation, with a pause between each of 10 min. Canal paresis was quantified according to the Jongkees formula; a value greater or equal to 22% was considered pathological.
The Dizziness Handicap Inventory (DHI) used was a standard test comprising 25 questions referring to the patient’s feelings of dizziness and how their daily life was affected, 100% being the maximum degree of incapacity caused by an episode of vertigo.
The first examination took place within the first 5 days after the onset of the clinical symptoms of vertigo. The second examination described in this article took place between 30 and 90 days (mean=67 and σ=21) after the onset of symptoms.
The aim of this study was to contrast the results of the vHIT with those of the CT, to try to clarify whether these tests are equivalent. In order to do so, the evolution of the DHI (to date the benchmark test) was also compared with the vHIT and the CT in each patient.
In order to be able to compare the evolution of the vHIT, the CT and the DHI, the variations of said parameters were calculated for each patient and any relationships or associations between them were considered:

- Variation of gain asymmetry (ΔGA): (initial GA – end GA)/initial GA.
- Variation of canal paresis (ΔCP): (initial cP – end cP)/end cP.
- Variation in the score of the DHI test (ΔDHI): initial DHI – end DHI/initial DHI.

All the patients taking part in the study initially underwent clinical ENT, otoneurological (spontaneous nystagmus, gaze-evoked nystagmus on lateral gaze, head-shaking nystagmus, clinical impulse manoeuvre and cover test) examinations, and liminal tonal audiometry. They were all diagnosed with vestibular neuritis. Hearing loss or associated tinnitus were criteria for exclusion from the study. Subsequently they underwent an instrumental examination with vHIT and a CT with videonystagmography.

Because cervical vestibular evoked myogenic potential tests were not performed (VEMP), patients with involvement of the upper branch of the vestibular nerve were included in this study, without distinguishing cases where the lower branch of the vestibular nerve was affected.

**Figure 1** Comparison between gain asymmetry, canal paresis and DHI.

**Results**

Firstly the data obtained from vHIT and CT of the sample studied were examined.

The first parameter to be analysed in the examination by vHIT was the gain in both ears. A mean gain of the healthy ear of 0.892 was obtained at the start and of 0.926 at the control point between 30 and 90 days. Despite a slight decrease in gain in the healthy ear being described and subsequent increase as the disease progressed, the gains in the healthy ear do not show statistically significant differences when compared at the start and at the control point. The gain in the unhealthy ear increased from a mean of 0.509 to a mean of 0.71 at the control point.

There is a significant difference between the initial GA and the end GA (initial mean=28.03% and end mean=14.23%; P<.5) (Fig. 1).

Not all the patients studied showed covert and overt corrective saccades in the two vHIT tests. Almost all the patients presented corrective saccades in the initial examination: 19 patients (95%) presented overt saccades; 16 patients (80%) presented covert saccades. At the control fewer patients presented corrective saccades on examination: 11 patients (55%) presented overt saccades and 13 patients (65%) presented covert saccades. Analysis of the mean maximum speed of the saccades in the patients who presented them showed the following results: the mean maximum velocity of the overt saccades was significantly reduced (231.32 /s at the start and 183.91 /s at the control, P<.05). Moreover, the mean of the covert saccades did not significantly reduce (220.69 /s at the start and 236.31 /s at the control, P>.05).

The cP obtained from the CT showed an initial mean of 85.2% and an end mean of 48.65% (P<.05) (Fig. 1).

The initial mean of the DHI test was 64.7 points and the end mean was 24.6 points (P<.05) (Fig. 1).

The ΔGA was compared with the ΔcP by linear regression analysis, contrasting both parameters without obtaining a clear association between the evolution of either test (Pearson’s R test=0.367) (Fig. 2).

The relationship between ΔDHI and ΔGA was studied in order to check whether an improvement in gain on the vHIT implied an improvement in the subjective feeling of dizziness reported by the patient. The linear regression graph does not show an association between the DHI test and the
improvement in gain on the vHIT (Pearson’s R test=0.368) (Fig. 3).

When the same operation was performed with the $\Delta$DHI and the $\Delta$Pc, similarly no linear correlation was seen between either parameter, therefore it does not seem that the variation in canal paresis is associated with the patient’s subjective feeling of dizziness (Pearson’s R test=0.155) (Fig. 4).

### Discussion

The data obtained in our study coincide with the data gathered in the most recent articles on vHIT.\textsuperscript{6-11} In the acute phase of vestibular neuritis an increase in canal paresis occurs and a decrease gain in the affected ear on the vHIT. In the sequelae or chronic phase the canal paresis starts to recover slowly, remaining high, whereas the gain on the vHIT recovers at greater velocity. This is why no linear relationship was found between either test.\textsuperscript{6,7,9}

As in other studies,\textsuperscript{7,8} we performed DHI, vHIT and CT on the patients on the same day. The control days on which these test were performed were not the same for each patient, they were undertaken in a time interval of between 30 and 90 days. It would probably be best to study all the patients at the same points in time during the progression of the disease, but this would be difficult to apply in clinical practice.

In line with recent scientific literature\textsuperscript{6,7} we did not find a linear relationship between the subjective status of the patient determined by DHI, CT or vHIT. These tests do not appear to be indicative of the subjective clinical status of the patient at any given time. Therefore we cannot establish a clear relationship between the CT or the vHIT and the DHI, which, after all, is a subjective test which attempts to assess parameters that are difficult to standardise, as are dizziness and imbalance disorders.

The data obtained from our sample support the hypothesis that the vHIT and the CT explore different frequencies of VOR.\textsuperscript{6,7,9} The vHIT stimulates at higher frequencies (2–5 Hz), similar to the physiological stimuli of daily life, whereas the CT stimulates lower VOR frequencies (0.003 Hz), and is also a non-physiological stimulus. Therefore, these tests should be considered to complement one another, and not be considered equivalent or as substitutes for one another.

Despite the fact that we did not find a parallel evolution of the vHIT with the CT, it is true that cases where the vHIT is normal and the CT is pathological are very unusual (only 4.6% in the Rambold’s\textsuperscript{9} studies). It is usual in the evolution of VN that recovery of VOR (and therefore normalisation of the vHIT) is faster than normalisation of the CT. This is why it is common to find a pathological CT in patients who have not reported symptoms of dizziness for some time. In these patients the vHIT is usually normal.\textsuperscript{9} Canal paresis therefore takes a very long time to recover and remains as a sequela of the vestibular process. Therefore, a discrepancy between the cP and the DHI is expected. Nonetheless, and in line with numerous studies, the lack of a relationship between the vHIT and the DHI is striking, given that the impulse manoeuvre explores movement frequencies which are similar those that are affected by movements in daily life.

In this context, as documented by McCaslin,\textsuperscript{7} vHIT maximises its discrimination from 39.5% canal paresis. The vHIT is proposed as a fast, easy to perform, physiological and non-invasive test. With these advantages and bearing in mind the different effect of vHIT in different diseases, Rambold\textsuperscript{8} suggests using the vHIT as the test of choice in diseases with vestibular deficit. If it is normal, a CT would be performed. By contrast, according to said article, a CT would
be suggested as the vestibular test of choice in patients with Menière’s disease.

Given that the CT is the benchmark test for diagnosing a unilateral vestibular deficit, it is logical that the vHIT would show ambivalent results in terms of sensitivity and specificity parameters, since the CT remains pathological even years after the patients have recovered from their VN and are asymptomatic.

Associated with recovery of gain, the overt saccades tend to diminish in amplitude or even to disappear, whereas the covert saccades maintain their amplitude or, if they had not existed beforehand, appear. Subsequently, when gain has been recovered, the covert saccades also tend to disappear, showing a normal vHIT recording. This is in line with the conclusions found in other studies which confirm that in VN the natural evolution is towards a reduction in velocity of the overt saccades or their complete disappearance, with the appearance of new covert saccades or the covert saccades remaining until the ear’s gain returns to normality.6,10,11

All the patients studied were diagnosed with VN and were tested using vHIT equipment which explores the 2 horizontal semicircular canals. This is why our results might differ from other studies which use vHIT to test 6 canals, 8,10,11 since, according to Milonski and Mangabeira, up to 42% of patients present disturbances in the posterior semicircular canal, 10 and 17% in the superior semicircular canal. It has been reported that up to 17.8% of cases present a pathological vHIT in 2 canals simultaneously.12 Furthermore, results can also differ from studies which analyse patients with vertigo, without differentiating cases of VN from other vertiginous diseases with preserved VOR, such as benign paroxysmal positional vertigo or Menière’s disease in the non-acute phase.7–10,12

Furthermore, there are cases of vestibular neuritis with simultaneous involvement of the superior vestibular nerve and the inferior vestibular nerve. These cases of neuritis require cervical VEMP to diagnose the involvement of the inferior vestibular branch. In this study, we did not differentiate cases of vestibular neuritis only affecting the superior vestibular nerve from those also affecting the inferior vestibular nerve.

It is possible therefore, that the sensitivity and specificity of the vHIT might be being undervalued because they are being compared with the CT as the benchmark test, due to the slow evolution and recovery of this test’s parameters. Including patients with dizziness without filtering in studies to assess the sensitivity and specificity of vHIT might also give confusing results, as experience and the most recent literature appear to confirm that the gain in VOR at physiological frequencies recovers at around the 3rd–6th month of evolution, and is not affected in some diseases where vertigo is the main symptom.

Conclusions

The vHIT and the CT explore different frequencies of VOR. This is why the tests are not equivalent to one another, but they do complement each other.

We have found no correlation between the evolution over time of both tests.

The DHI does not relate significantly with the results of the vHIT or the CT.

It has been demonstrated that in the acute phase of vestibular neuritis there is an increase in canal paroensis and a decrease in vHIT gain. In the sequela phase, canal paroensis recovers at a slow pace, whereas the vHIT gain recovers at greater velocity until normality returns.

With recovery from the process, the overt saccades tend to decrease in amplitude or even to disappear, whereas the covert saccades appear to maintain their amplitude or to appear if they had not been present beforehand. Finally, the covert saccades disappear when gain normalizes.

We consider, therefore, that the vHIT is useful instruments for testing vestibular function; especially if we perform it in certain diseases such as vestibular neuritis, at all times taking into account the clinical context.

Conflict of Interest

The authors have no conflict of interest to declare.

References

Relationship Between vHIT and Caloric Test
