The clinical utility of search coil horizontal vestibulo-ocular reflex testing

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Abstract

Conclusion. Testing of the horizontal vestibulo-ocular reflex (VOR) with head rotations (including head impulses) using the magnetic scleral search coil technique (SCT HHI) provides valuable additional diagnostic information in patients with persistent dizziness, oscillopsia or imbalance. It identifies high and low frequency/acceleration vestibular abnormalities that are frequently missed using other methods.

Objectives. To evaluate the diagnostic utility of SCT measurement of the horizontal VOR in the multidisciplinary neurotology clinic of a tertiary referral centre.

Patients and methods. The records of 127 consecutive patients referred for persistent dizziness, oscillopsia, imbalance, or with clinical findings suggestive of high frequency/acceleration vestibular dysfunction were reviewed. All had been tested with clinical head impulses, bithermal calorics and vestibular-evoked myogenic potentials. VOR gain (peak eye velocity/peak head velocity) had been measured both in response to sinusoidal oscillations in a rotating chair (0.1–11 Hz) and to manually delivered horizontal head rotations (peak head velocities 50–500°/s) using SCT. Results. Agreement between the different test modalities of horizontal semicircular canal function was moderate. Relative to SCT HHI, clinical HHI showed the highest sensitivity and the lowest specificity (both 70%). SCT HHI appeared to have the greatest diagnostic yield, when compared with calorics and SCT ROT (23% of all abnormalities shown were detected only by SCT HHI) and also allowed detection of significant asymmetries in patients with bilateral vestibular dysfunction.

Keywords: Dizziness, vertigo, semicircular canals, diagnostic techniques and procedures, caloric test

Introduction

Dizziness, vertigo, oscillopsia and imbalance often represent challenging symptoms for the diagnostician [1]. Tests of the vestibulo-ocular reflex (VOR) as an indicator of vestibular function have been studied extensively over the past few decades. The VOR is integral in maintaining a stable retinal image by producing equal but opposite conjugate movements of the eyes relative to head movements. Its apparent simplicity allows it to be tested both clinically and in the laboratory.

One widely used clinical test specific for horizontal rotational VOR function is the horizontal head-impulse test (HHI) developed by Halmagyi and co-workers [2]. The head is turned in the yaw plane by 10–20° at high acceleration and velocity (typically exceeding 300°/s) while the subject maintains visual fixation on a stationary object. A refixation saccade (or series of corrective saccades) is thought to indicate a deficit in lateral canal function on the side with ampullopetal stimulation, although in theory, any part of the VOR pathway could be deficient. Measurements after a clinically successful vestibular nerve section demonstrate that this reflex is severely impaired mainly on the side of the lesion and does not recover [3]. VOR gain (eye velocity/head velocity) values are particularly low after bilateral vestibular deafferentation [4].
The same basic stimulus can be applied over a wide range of accelerations (including classic, high acceleration head impulses) to produce an individual profile of the VOR gain, offering an opportunity to characterize a partial vestibular impairment, such as an isolated high frequency/acceleration vestibular loss [5]. The superiority of the head impulse test over the bithermal caloric test, which measures only low frequency/acceleration function, has been shown by its ability to detect persistent vestibular dysfunction in patients with chronic symptoms following vestibular neuritis [6].

Magnetic scleral search coil testing (SCT) is a powerful tool that accurately measures eye and head rotations. It remains the gold standard for investigating high velocity/acceleration vestibular eye movements [7–10]. Because of the technical expertise required, its high cost and the relative lack of literature, it is used in only a small number of clinical and research centres. Its clinical value also remains to be further characterized.

The purpose of this study was to evaluate the diagnostic utility of magnetic scleral search coil techniques using both horizontal head rotation (including impulses) and the rotational chair in the clinical setting of a tertiary referral centre for patients suffering from persistent dizziness, oscillopsia or imbalance.

Patients and methods

Patients

All patients had been examined at the Multidisciplinary Neurotology Clinic of the Department of Otolaryngology, University Health Network, University of Toronto between 2001 and 2005. This is a tertiary centre, which receives referrals from otolaryngologists and neurologists across North America. A retrospective review of the patient records provided the basis for this study.

Indications for search coil testing were: the persistence of symptoms of dizziness, vertigo, imbalance or oscillopsia despite normal physical examination and standard laboratory testing; apparent failure to compensate for a unilateral vestibular deficit, as reflected by persistent symptoms or clinical findings (head-shake nystagmus [11], reduced dynamic visual acuity (DVA, i.e. objective oscillopsia), etc.) [12]; an abnormal head impulse test accompanied by persistent vestibular symptoms, despite normal standard laboratory testing [2]; confirmation and quantification of high frequency/acceleration vestibular dysfunction in topical or systemic ototoxicity; or medico-legal assessments following motor vehicle accidents and disability claims.

Investigations

The senior authors (J.R. and P.R.) performed a complete clinical neurotologic evaluation of all patients. Standard audio-vestibular testing included the following: pure tone audiometry, conventional electronystagmography with bithermal caloric testing, and vestibular-evoked myogenic potentials (VEMPs). A subgroup of patients also underwent magnetic resonance (MRI) or computed tomographic (CT) imaging.

SCT

Magnetic scleral SCT was carried out using a cubic three-dimensional rotating electromagnetic field with a side length of 2 m (CNC Engineering, Seattle, WA, USA). Subjects were seated on a custom-built rotational chair (Zonic Technical Laboratories Inc., Cincinnati, OH, USA) with the mid-point of the interpupillary line in the centre of the field. The rotational chair was powered by a 10 hp motor hydraulic pump drive with a maximum torque of 138 m·kg. Patients were seated with the head immobilized with padded clamps, and the trunk, legs, ankles and shoulders were secured with belts in order to couple them tightly to chair movement. Sinusoidal whole-body yaw oscillations (ROT) were carried out at defined frequencies (0.5, 1, 3, 5, 7, 9 and 11 Hz, corresponding amplitudes 5, 5, 2, 1.25, 1, 1.25 and 1.5°, non-harmonious progression due to technical limitations, peak head velocities 20, 30, 40, 45, 50, 85 and 120°/s). Subjects were instructed to fixate visually on a cross-shaped target at 3.1 m in light. The same oscillations were also performed in darkness with the subject fixating on the remembered target.

Head rotation VOR testing in the yaw plane [2] was performed manually with the patient fixating on the examiner’s nose at a wide range of peak velocities (50–500°/s) with on average 20 rotations to either side. The timing, peak head velocity and direction varied randomly between individual stimuli.

Eye movement responses were recorded with a dual search coil annulus (Skalar Medical Supplies, Delft, The Netherlands) placed on the sclera of the right eye, which had previously been anaesthetized with proparacaine-HCl 0.5%. Coil signals were calibrated in vivo with the subject fixating on predefined targets on a tangent screen positioned at a definite distance. Head movement was measured using a search coil mounted on a light-weight dental bite gripped by the upper teeth. The eye and
head rotational position signals were digitized at 400 Hz and stored for later analysis.

Head and eye position signals were differentiated to yield velocity profiles during rotational chair and HHI testing. Saccadic responses during the rotational chair tests were identified visually and removed from the eye movement traces. For the rotational chair tests, the mean values of peak eye velocities were divided by peak head velocities to calculate the VOR gains at different frequencies. For the horizontal head rotation tests, the VOR gain was calculated by dividing peak eye velocity by peak head velocity and in cases where a saccade was made before the occurrence of the velocity peaks, the maximum eye and head velocity that occurred immediately before the saccade onset were used. The peak eye and head velocity pairs of all individual head impulses were then plotted and fitted with a regression line (for high and low peak velocities, i.e. > and <200°/s) to estimate a mean gain value for each side (Figure 1). Rotational chair gain values were compared with the 95% reference range established by our laboratory. The normal range of VOR gains from horizontal head rotation testing has previously been described in detail elsewhere [13].

Conventional vestibular testing

Electronystagmography (ENG) with caloric testing was carried out using the Fitzgerald-Hallpike method of binaural alternating bithermal caloric stimulation [14]. Asymmetry was calculated with peak slow-phase velocities using Jongkees’ formula [15]. Abnormal caloric test results were classified in our testing laboratory with corrections for spontaneous nystagmus as follows. For unilateral caloric impairment: normal, <15% excitability difference (ED); mild loss, 15–29% ED; moderate loss, 30–50% ED; severe loss, 51–99% ED and no response to ice water calorics. For bilateral caloric impairment: moderate, sum of bithermal caloric responses <20°/s with caloric responses >3°/s with ice water; severe, ice water caloric response present but <3°/s on both sides; and profound, no response bilaterally to ice water calorics.

VEMP were elicited using acoustic clicks averaging the inhibitory potentials over both sternocleidomastoid muscles as described in detail elsewhere [16].

Statistics

The diagnostic yield of each testing method was calculated independently of any assumptions about gold standards. The kappa statistic was used to assess agreement between different diagnostic methods. Sensitivities and specificities (with 95% confidence intervals) were calculated for the clinical head impulse test, rotational chair testing and caloric testing using search coil head rotation testing as the reference test. Comparison of the frequency of abnormalities found by a pair of tests (comparison between SCT ROT and SCT HHI) was performed using a paired $\chi^2$ test. The ages of different groups were compared with the Mann–Whitney U test. The data set reported comprises measurements made on both ears of the respective patients. From a statistical point of view, measurements on two ears from the same patient would not normally be considered independent. However, statistical analysis was carried out treating test results in both ears of a single patient as independent. To justify this method of analysis, the above-mentioned paired $\chi^2$ test was replicated, using a sample comprising only one, randomly selected ear measurement per patient.
This yielded an identical conclusion (highly significant) and thus justified our treatment of ears, rather than patients, as independent experimental units.

**Results**

**Patient characteristics**

We studied the records of 67 women and 60 men (median age 48 years, range 15–82). The majority complained primarily of non-specific dizziness or imbalance (71/127, 55.9%). One-third reported episodes of rotatory vertigo (45/127, 35.4%). Symptoms suggestive of otolith organ dysfunction (such as sensations of linear pulsion or rocking, or a prolonged sensation of acceleration after cessation of head movement) were noted in 5.6% (7/127), and 2.4% (3/127) presented with combined sensations of rotatory and linear movement.

**Diagnostic yield of different tests of vestibular function**

Figure 2 and Table I show the frequency with which different tests and their combinations yielded an apparent abnormality in vestibular function. In these diagrams, the caloric test and the SCT HHI are compared with the clinical HHI in Figure 2A and Table IA and the rotation chair SCT in Figure 2B and Table IB. Relatively few abnormalities were detected by all three tests in each case (approximately 1/3 in both combinations). The overlap between caloric testing and SCT methods accounted for fewer than half of the abnormalities found. The largest concordance was found between the two SCT methods (49.7%), closely followed by the two HHI methods (46.7%). Clinical HHI had the greatest additional yield: a quarter of all abnormalities were only detected by the clinical HHI. When clinical HHI was excluded (Figure 2B), SCT HHI had an additional yield of 23%. In 6.3% of patients the SCT HHI was instrumental in unveiling a substantial asymmetry of high frequency vestibular function in bilateral vestibular disease (not shown in the figure). The diagnostic test with the lowest additional yield was the rotational chair SCT: it detected only an additional 4.2% of all abnormalities.

**Clinical versus SCT of the horizontal head impulse**

Both methods of assessing the horizontal head impulse were performed in 248 ears (Table IIA). The agreement between the two methods was only intermediate (κ = 0.39, Table IV). Table III shows that where the two methods were discordant the SCT method was more likely to be associated with a caloric abnormality (31%) than the clinical method (5%). This suggests that clinical HHI testing may lack specificity. If the scleral coil method is assumed to be the gold standard method for assessing the HHI then the sensitivity and specificity of the clinical HHI test are both about 70% (Table IV).

**Caloric testing versus scleral coil head rotation testing**

The results of caloric and SCT HHI testing were discordant in 27.5% of patients, in most cases because the SCT HHI detected an abnormality where the caloric test did not (Table IIB). Only one of these ears was otoscopically abnormal (with scarring and retraction of the tympanic membrane). Of those who had a positive SCT HHI and a negative caloric test, the majority of SCT HHI abnormalities (76%, 35/46) were combined high and low frequency/acceleration abnormalities and the rest (24%, 11/46) were isolated high frequency abnormalities. The opposite scenario where the...
caloric response was reduced but the SCT appeared normal occurred in 7.4%. In this group, caloric responses were mildly reduced in 53%, moderately in 29% and profoundly in 18%. Only one ear was reportedly abnormal on otoscopic examination (scarring) and none had had an otologic operation. There were no temporal bone abnormalities identified in the 13 who had a CT or MRI scan.

Overall, the agreement between caloric and SCT HHI testing was intermediate ($\kappa = 0.42$). Caloric testing had a sensitivity of 54% and a specificity of 87% compared with SCT HHI as a reference test (Table IV).

Search coil rotational chair testing versus search coil head rotation testing

Agreement between the two search coil investigations was moderate ($\kappa = 0.56$); 21% of results were discordant, usually because the HHI test was abnormal where the rotational chair was normal (Table IIC). The SCT HHI test detected a vestibular deficit significantly more often than the rotational chair test (42% vs 28%, paired $\chi^2$ test, $p < 0.001$). Rotational chair testing had a sensitivity of 59% and specificity of 94% compared with SCT HHI as a reference test (Table IV).

Partial vestibular lesions: semicircular canal versus otolith function

Evidence for a total or partial (semicircular canal and/or otolithic) vestibular lesion was obtained by comparing VEMP with either bithermal caloric responses or the results of the SCT HHI (bearing in mind that this assesses only the saccule and the lateral semicircular canal). There was evidence of both semicircular canal (calorics vs SCT HHI) and otolithic abnormalities in 11% and 13%, respectively (Table V). Purely otolithic abnormalities were detected in 12% and 9% and purely semicircular canal abnormalities in 15% and 25% depending on the method of testing: SCT HHI appeared more sensitive than bithermal calorics. No abnormality was found in 44–54%.

Oscillopsia in unilateral and bilateral vestibular disease

Table VI compares the results of SCT HHI testing with the presence of subjective oscillopsia and those with objective oscillopsia (i.e. abnormal DVA test).
clinically. Subjective oscillopsia was significantly less frequent than the clinical presence of objective oscillopsia, regardless of SCT HHI results. Where bilateral vestibular disease was documented by SCT HHI, objective oscillopsia was present significantly more often. In cases where the clinical HHI demonstrated a unilateral vestibular deficit and the patient reported oscillopsia and/or showed a reduced DVA, SCT HHI was able to identify bilateral vestibular disease in 5/17 patients (29%). Patients who did not experience subjective oscillopsia despite a bilaterally positive SCT HHI were significantly older (median 58 years) than those who did have subjective oscillopsia (median 46 years, \( p < 0.005 \), Mann–Whitney U test).

Discussion

Symptoms of dizziness and imbalance may arise from a large number of pathologies affecting several organ systems, including different parts of the vestibular system. Existing clinical and laboratory tests of vestibular function tend to examine only one part of the system, often in isolation. For example, while caloric testing specifically assesses lateral semicircular canal function, the stimulus is non-physiological and correlates better with low frequency vestibular function that in many instances fails to conform closely to the natural conditions of everyday life [5,17]. Nevertheless, it has been used as a reference test for assessing vestibular function in the past decades despite these limitations, which makes it difficult to compare existing investigations or assess the utility of new investigations. Currently patients are often assessed by combining the results of clinical examination with several laboratory investigations.

In this study, the agreement between the various vestibular investigations was generally only moderate, as illustrated by the kappa statistics in the range 0.4–0.5 and by the relatively small overlap of abnormalities detected by more than one test, as illustrated in Figure 2A and B. From these figures it appears that calorics, clinical HHI, SCT HHI and SCT ROT all identified abnormalities that were not detected by other tests. However, the additional contribution from SCT ROT was very small and it appears that few abnormalities would be missed if this test were excluded. Wiest et al. have previously demonstrated a lack of diagnostic sensitivity using sinusoidal chair rotations at higher frequencies and questioned whether the responses were in fact of vestibular origin [18].

Clinical HHI had the highest yield of any of the four investigations, but its overlap with SCT HHI results was incomplete. Both of these tests employ identical manoeuvres and measure the same reflex response, but for physiological reasons one would

<table>
<thead>
<tr>
<th>Test method</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Positive predictive value</th>
<th>Negative predictive value</th>
<th>Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical HHI</td>
<td>69.8% (60.1–78.3)</td>
<td>69.7% (61.5–77.1)</td>
<td>63.2%</td>
<td>75.6%</td>
<td>0.39</td>
</tr>
<tr>
<td>Calorics</td>
<td>54.0% (43.7–64.0)</td>
<td>86.8% (79.7–92.1)</td>
<td>76.1%</td>
<td>70.9%</td>
<td>0.42</td>
</tr>
<tr>
<td>SCT ROT</td>
<td>58.7% (48.6–68.2)</td>
<td>94.4% (89.2–97.5)</td>
<td>88.4%</td>
<td>75.7%</td>
<td>0.56</td>
</tr>
</tbody>
</table>

The samples included measures of two ears per patient. Note that the predictive values are only applicable to the selected clinic population studied.

Table V. Comparison of semicircular canal and sacculus function tests.

(A) VEMP intact VEMP absent Total

<table>
<thead>
<tr>
<th>Test method</th>
<th>VEMP intact</th>
<th>VEMP absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caloric normal</td>
<td>112 (53.6%)</td>
<td>24 (11.5%)</td>
<td>136 (65.1%)</td>
</tr>
<tr>
<td>Caloric reduced</td>
<td>32 (15.3%)</td>
<td>23 (11.0%)</td>
<td>55 (26.3%)</td>
</tr>
<tr>
<td>Total</td>
<td>144 (68.9%)</td>
<td>47 (22.5%)</td>
<td>191 (91.4%)</td>
</tr>
<tr>
<td>VEMP indeterminate or fluctuating</td>
<td>18 (8.6%)</td>
<td>209</td>
<td></td>
</tr>
</tbody>
</table>

(B) VEMP intact VEMP absent Total

<table>
<thead>
<tr>
<th>Test method</th>
<th>VEMP intact</th>
<th>VEMP absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCT HHI normal</td>
<td>93 (43.5%)</td>
<td>20 (9.3%)</td>
<td>113 (52.8%)</td>
</tr>
<tr>
<td>SCT HHI abnormal</td>
<td>54 (25.2%)</td>
<td>27 (12.6%)</td>
<td>81 (37.8%)</td>
</tr>
<tr>
<td>Total</td>
<td>147 (78.7%)</td>
<td>47 (21.9%)</td>
<td>194 (90.6%)</td>
</tr>
<tr>
<td>VEMP indeterminate or fluctuating</td>
<td>20 (9.3%)</td>
<td>214</td>
<td></td>
</tr>
</tbody>
</table>

Percentages were calculated based on the total, which included undetermined or fluctuating vestibular-evoked myogenic potentials (VEMPs). The samples included measures of two ears per patient. (A) Comparison between bithermal caloric and VEMP responses \( (n = 209) \). (B) Comparison of search-coil horizontal head impulse (SCT HHI) and VEMP responses \( (n = 214) \).
assume that SCT should record this far more accurately than clinical assessment, given the velocities of the eye movements observed (the visual pursuit system of the observer is insufficient to follow movements exceeding 2 Hz, which are in turn used to detect high frequency/acceleration deficits in the HHI) [5]. It therefore seems reasonable to use SCT HHI as a reference standard against which to compare clinical HHI. This suggests that the sensitivity and specificity of clinical HHI are both around 70% and that the high additional yield of the clinical HHI test is the result of its lack of specificity, not its superiority over the other methods. The vast majority of caloric responses were normal in those with positive clinical HHI and negative SCT HHI tests, which is consistent with the view that these are false positive results.

SCT HHI may detect abnormalities that are missed by clinical HHI because of mid-rotation correction saccades that could not be perceived visually by the examiner [5,19]. One advantage of the SCT is its ability to identify a low VOR gain immediately before the beginning of such correction saccades. The higher percentage of caloric reductions in this group also supports the interpretation of false-negative clinical head impulses.

SCT HHI therefore appears to have the greatest additional yield of 22.7% of abnormalities that were detected by it alone. A further benefit of SCT HHI is that it revealed substantial asymmetries in cases of bilateral vestibular disease, which may have implications for targeted rehabilitation.

We have also used SCT HHI as a 'gold standard' against which to compare calorics and SCT ROT in the calculation of sensitivities and specificities. While this investigation cannot be considered a true gold standard to date, it appears to be the best candidate of the investigations considered by this study for both empirical and physiological reasons: its diagnostic yield is greater and it measures the horizontal VOR at a variety of frequencies/accelerations within the normal everyday physiological range. However, other tests of lateral canal function, such as the bithermal caloric test, appear to detect some abnormalities not revealed by SCT HHI. Currently it is not possible to determine whether these are true or false positives. Generally speaking, a highly selected group of subjects, in whom a high prevalence of abnormal test results is expected by the test readers, such as the patient group reported, is likely to provide more false positive test results.

SCT HHI revealed a vestibular deficit in 20% of ears with normal caloric responses. This number is similar to our previous findings [5] but lower than has been reported in a cohort of patients with chronic symptoms after vestibular neuritis [6]. An isolated high frequency/acceleration vestibular loss (at head velocities >200°/s) was found only in around a quarter of these ears. The other three-quarters demonstrated a decreased VOR gain over the whole range of HHI frequencies: it is not clear why caloric testing failed to identify the latter group.

While caloric testing is technically simple and allows separate testing of each ear, it is limited by the unpredictable thermal energy transfer to the labyrinth and by its non-physiological nature. According to Hess et al. [17], responses to the caloric test best correlate with responses to rotational stimuli of the lateral semicircular canal at frequencies (0.0125–0.2 Hz or 4.5–72/s) far below the range encountered during everyday head movements (most head movements in everyday life range between 1 and 8 Hz [20]).

In cases where a caloric reduction was identified but the SCT was normal, two explanations are possible. First, anatomical variations in the middle ear air space and bony covering of the lateral semicircular canal (as well as any pathological changes involving the middle ear and mastoid) could artificially reduce caloric responses. However, in our series only one patient had an abnormal tympanic membrane at otoscopy (scarring), no otologic operations had been performed in this group, and all imaging studies available revealed normal temporal bone anatomy. Second, it is conceivable that there might be a symptomatic isolated low frequency vestibular loss. However, in the low frequency range visual–vestibular interactions typically provide a means of suppression of symptoms and compensation for vestibular deficits. We currently favour the first explanation, which is supported by the observation that the caloric reductions present were generally identified to have mild loss excitability differences.

The frequencies of apparently isolated saccular or lateral canal lesions were similar when comparing the results of VEMP with caloric, but SCT HHI (because of its greater sensitivity) suggested that the proportion of semicircular canal lesions was relatively higher than saccular lesions. The frequency of pure saccular involvement revealed by VEMP, using either calorics or SCT HHI to evaluate

<table>
<thead>
<tr>
<th>SCT HHI</th>
<th>Subjective oscillopsia</th>
<th>Objective oscillopsia</th>
</tr>
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<tbody>
<tr>
<td>Normal</td>
<td>7 (13%, n = 55)*</td>
<td>9 (69%, n = 13)</td>
</tr>
<tr>
<td>Abnormal unilaterally</td>
<td>3 (9%, n = 35)*</td>
<td>9 (75%, n = 12)</td>
</tr>
<tr>
<td>Abnormal bilaterally</td>
<td>9 (25%, n = 36)*</td>
<td>20 (95%, n = 21)*</td>
</tr>
</tbody>
</table>

*p ≤0.003 (χ² test).
Acknowledgements

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References


lateral semicircular canal function, was slightly higher than previously reported [21]. This may reflect the highly selected nature of patients undergoing SCT or the more sensitive clinical acumen of clinicians within this tertiary referral centre, resulting in a higher yield of otolith-affected patients referred for testing. Otolith organ disease may also be overestimated by VEMP for technical reasons such as falsely absent potentials because of middle ear dysfunction or insufficient neck muscle contraction.

Both objective and subjective oscillopsia were more frequent in patients with bilaterally abnormal SCT HHI than unilateral or normal SCT HHI results. However, subjective oscillopsia was surprisingly infrequent in those with clear evidence of bilateral VOR impairment. This may reflect age-related changes in perception as these patients were significantly older. It may also result from incomplete data collection, as not all patients were asked about oscillopsia or underwent DVA assessment. The analysis of SCT HHI results in symptomatic patients showing unilateral vestibular disease using clinical HHI demonstrated that more than a quarter had bilateral disease as documented by SCT HHI. This indicates an additional benefit of the search coil technique in explaining the patient’s symptoms and provides an organic substrate for their inability to compensate for a suspected unilateral vestibular loss where in fact bilateral disease was present.

In conclusion, the concordance between various tests of vestibular function in a selected group of patients in a tertiary neurotology clinic was moderate. Clinical HHI had the highest additional yield but this resulted largely from its lack of specificity. Nevertheless this finding provides further evidence of its value as a clinical tool in the assessment of patients suffering from persistent dizziness, vertigo or imbalance. These patients should all be examined with clinical HHI in addition to vestibular laboratory studies. If there still remains doubt about vestibular function or if test results are contradictory, referral for search coil testing should be considered. SCT HHI appeared to have the greatest additional yield (23%) of true abnormalities. It also allowed detection of significant asymmetries in patients with bilateral dysfunction. In contrast, SCT ROT detected very few abnormalities that could not be detected with caloricics or SCT HHI. It is possible that our findings may not be as applicable to patient populations that differ from the highly selected cohort investigated here; for example, the false positive rate may be lower in less highly selected groups. In the absence of a defined gold standard vestibular test, patients with persistent or unexplained symptoms will continue to require multi-modal investigation, to which SCT HHI can make a major contribution.


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