THE HIGH-FREQUENCY OSCILLOPSIA TEST

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Abstract - There is a need to develop bedside tests of the vestibulo-ocular reflex (VOR) that could be used in the clinical situation to screen patients who may be candidates for further evaluation. In 1984 Barber described the oscillopsia test, which compared visual acuity with and without head movement. Barber indicated that head movement should occur at greater than 1 Hz. This study was performed to evaluate the oscillopsia test at higher frequencies (2 to 7 Hertz) in the hope of improving its performance. The sensitivity and specificity of this test were evaluated using three examiners (the authors) and were referenced to clinical electronystagmographic results in 115 patients and 17 control subjects. The oscillopsia test evaluated in this study was highly specific, but not highly sensitive. It did not detect vestibular loss or subjective dizziness in more than 50% of cases. The high frequency oscillopsia test does not appear to be an effective screening test for VOR abnormalities or vestibular loss.

Keywords — oscillopsia; vestibulo-ocular reflex.

Introduction

There are many situations, in both the office and hospital setting, in which a simple reliable screening test for vestibulo-ocular reflex (VOR) abnormalities would be useful. Formal electronystagmographic (ENG) and rotary testing, while objective, are not always readily available or practical. To be effective as a screening tool, a testing procedure should be simple and quick to perform, be low in cost, cause little discomfort, and be both specific and sensitive. Such a test has been described by Barber (1), who recommended testing at frequencies greater than 1 Hz. The hypothesis of this study was that at higher frequencies the "oscillopsia test" would be more sensitive and/or specific.

The VOR is most important for gaze stabilization during head rotations with frequency above 1 Hz (1,2). Therefore, a test of the VOR may involve comparison of the visual acuity with and without head movement (3) in the frequency range. Use of a high frequency stimulus should theoretically make the test more sensitive to vestibular abnormalities, since oculomotor control by visual feedback is generally restricted to frequencies below 1.5 Hz. "Oscillopsia" is the visual perception of motion of the environment in the absence of motion. In this paper oscillopsia refers to visual blurring and loss of visual acuity during head movement, and is due to excessive slip of images on the retina (1).

Methods

The high frequency oscillopsia test used in this study was adapted from that described by Barber (1). Visual acuity without head movement was compared to acuity while the subject's head was oscillated horizontally using high frequency (>2 Hz) movements. Barber
describes using large amplitude random head movements at a frequency of 1 to 1.5 Hz. The high-frequency oscillopsia test incorporates low amplitude random head movements within a frequency range of 2 to 7 Hz. The subject was asked to read a standard Snellen eye chart (55 × 25 cm) illuminated by a 150-watt flood light (Figure 1). The distance between the subject and the chart was adjusted (3 to 7 m) until the subject could just read the bottom line or the second from the bottom line. The lowest line readable was that line in which 3 or fewer errors occurred. If the patient used prescription glasses, they were worn during testing (patients with aphakic lenses were excluded). After reading the chart with the head still, the examiner then grasped the subject below the malar eminences and over the parietal region and jiggled the head in a random fashion at high frequency (2 to 7 Hz and less than 20° of arc displacement) while the subject was asked to read the chart again. The direction of line reading was alternated to avoid memorization. If the subject lost more than 2 lines, including the line initially read, the test result was considered abnormal.

The head-shaking stimulus of each examiner was evaluated using a velocity sensor (Watson Industries Model-ARS-C151-1AR) mounted on a head strap. Several test runs for each examiner were recorded using the head velocity sensor. The velocity sensor data was digitized (sampling rate 200 Hz) and stored on floppy diskettes. The Fast Fourier Transform of the data was found using the ASYST 3.1 Scientific Software Package on a Zenith 286 computer.

The high frequency oscillopsia test was performed on 115 patients referred because of dizziness and on 17 control subjects. Control subjects were volunteers who had no past history of dizziness or other neuro-otologic problems. All patients entered into the study had formal electronystagmographic (ENG) testing. Unilateral weakness was calculated (4) and considered to be abnormal when greater than or equal to 25%. We consider bilateral vestibular weakness to occur when the sum of

![Figure 1. Examiner performing the high frequency oscillopsia test. The subject's head is jiggled in a random fashion at a frequency above 2 Hertz while the subject attempts to read the Snellen eye chart.](image-url)
the maximum slow phase eye velocities for all 4 caloric responses is less than or equal to 24° per second. Of the 115 patients entered in the study, 25 had a unilateral vestibular loss (25% to 100%), 10 had a bilateral vestibular loss (caloric sum 0 to 21/° s), and 80 had a normal ENG despite complaints of dizziness. All subjects had at least some vestibular function. Sensitivity, specificity, and reliability analysis were calculated using SPSS/PC+ statistical analysis software. Sensitivity is the percentage of subjects with an ENG abnormality (or dizziness) who also had an abnormal result for the high frequency oscillopsia test. Specificity is the percentage of control subjects with a normal ENG and no dizziness who also had a normal result for the oscillopsia test. Analysis of variance was used to evaluate the effect of test conditions on the test results. All procedures followed were in accordance with the standards of the committee on human experimentation.

**Results**

The results of different examiners on the number of lines lost during testing was evaluated using analysis of variance. Using all 132 patients and controls, the effect of "examiner" was found not to be significant ($P = 0.11$). The high frequency oscillopsia test was highly specific: no control demonstrated a loss of more than 2 lines (Figure 2). Sensitivity, however, was poor: the test detected unilateral or bilateral weakness or subjective dizziness less than 50% of the time.

The mean number of lines lost for each group of patients and controls is displayed in Table 1. Although the mean number of lines lost for patients (unilateral or bilateral weakness or subjective dizziness) is greater than that of controls, the difference is not statistically significant (reliability analysis: correlation = 0.29). For the unilateral weakness group a linear regression was performed. The number of lines lost (dependent variable) was regressed on the magnitude of the unilateral weakness (independent variable). The slope of

<table>
<thead>
<tr>
<th>Subject Group</th>
<th>Mean Number of Lines Lost</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>1.73</td>
</tr>
<tr>
<td>Unilateral loss</td>
<td>2.16</td>
</tr>
<tr>
<td>Bilateral loss</td>
<td>2.69</td>
</tr>
<tr>
<td>&quot;Dizzy&quot;-normal eng</td>
<td>1.69</td>
</tr>
<tr>
<td>Controls</td>
<td>0.82</td>
</tr>
</tbody>
</table>

Figure 2. The high frequency oscillopsia test was specific: all controls demonstrate a normal test result. Sensitivity was poor: vestibular weakness or subjective dizziness was detected in less than 50 percent of cases.
the regression line was not statistically significantly different from zero ($t$ test: $P > 0.1$). Fourier analysis of the head-shaking stimulus used for the high frequency oscillopsia test in this study indicated that the dominant frequencies of stimulation for all examiners were between 5 and 7 Hz (Figure 3).

Discussion

The high frequency oscillopsia test was intended to be used for selective evaluation of the VOR. The results obtained in this study indicate poor prediction of vestibular loss or VOR abnormalities. We conclude from our data that the amount of unilateral weakness does not predict the number of lines lost using the high frequency oscillopsia test. Barber (3) states that this type of test performed with random head movements at a frequency above 1 Hz will predict an inefficient or low gain VOR. Longridge and Mallinson (5,6) have reported reliable prediction of VOR abnormalities using a similar test: the dynamic illegible "E" (DIE) test. The DIE test uses a different eye chart, and the head is oscillated through 60° of arc at a frequency of 1 Hz. The VOR is most important at frequencies above 1 Hz. One would predict that higher frequency testing (2 to 7 Hz) would be more sensitive than lower frequency testing (1 Hz) for VOR abnormalities. This did not occur using the high frequency oscillopsia test.

Below 1 Hz, the visual pursuit system can compensate for retinal slip due to movement of the head, producing maximum eye velocities of 50° to 100°/s (7). There also may be input from the optokinetic system to stabilize gaze over this same range of low frequencies. The vestibular system can generate eye movements to compensate for high frequency (2 to 10 Hz) head movements (8), and this is the rationale for testing over this range. Frequency of head movement is not the only factor that determines if oscillopsia will occur. Visual acuity has been shown to be related to the velocity of images (RIV) on the retina (9): in normal controls, acuity is maintained with RIVs up to 4°/s. Another factor to be considered in the cause of visual acuity changes and oscillopsia is the amount of retinal slip that occurs with head movements. The amount of retinal slip that causes oscillopsia to occur varies widely (10). The high frequency oscillopsia test uses a stimulus frequency that varies over the 2- to 7-Hz range. The higher frequency components will necessarily be associated with small arc displacements due to physical constraints and subject comfort. It is likely that the frequency-displacement combinations used did not produce enough retinal slip or high enough RIVs to produce oscillopsia.

Another possible source of error is that in patients with subacute lesions compensation for VOR abnormalities may have occurred. There are a variety of mechanisms for compensating for VOR disorders, which will vary among individuals (11-13). These mechanisms include contribution of the cervico-ocular reflex, central perceptual adaptation, and the production of centrally programed compensatory eye movements.

It is possible that this study does not compare appropriate responses, although the caloric response is a standard clinical test. Barnes and Benson (14) stated that the caloric response can be modeled as a low-pass system with a cutoff frequency of 0.025 Hz. It may be inappropriate, then, to compare caloric stimulation to rotation at 2 to 4 Hz. If unilateral or bilateral losses are not appropriate comparators and the high frequency oscillopsia is valid, we would expect that the high frequency oscillopsia test may have high sensitivity and specificity in the group who were dizzy but had normal ENG results. Our data do not support this hypothesis.

The high frequency oscillopsia test was a poor predictor of VOR abnormalities, despite previously reported success with this type of testing at lower frequencies. The failure is probably related to insufficient retinal slip generated by the high frequency–low amplitude test stimulus and, possibly, to central compensation. Establishing the amount of retinal slip needed to degrade vision would be helpful in interpretation of test results. In addition, the relationship between retinal slip
Figure 3. Fourier frequency spectral analysis of the head-shaking stimulus used by each examiner. Dominant frequency contributions lie between 5 and 7 Hertz.
and RIV to the perception of oscillopsia needs to be established. It would be useful to have a clinical screening test that is more sensitive to VOR disorders than that used here. A lower frequency (1 to 3 Hz) higher amplitude (15° to 30° of arc) stimulus as originally alluded to by Barber (1) and Longridge and Mallinson (5) may be a more effective stimulus.

REFERENCES