2005

Comparative study of the Gaze Stabilization Test (GST) and the Dynamic Visual Acuity Test (DVAT) for detecting patients with unilateral vestibular dysfunction

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COMPARATIVE STUDY OF THE GAZE STABILIZATION TEST (GST) AND THE DYNAMIC VISUAL ACUITY TEST (DVAT) FOR DETECTING PATIENTS WITH UNILATERAL VESTIBULAR DYSFUNCTION

by

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**An independent study
submitted in partial fulfillment of the
requirements for the degree of:**

**Master of Science in Speech and Hearing –
Emphasis in Audiology**

**Washington University
Department of Speech and Hearing**

May 20, 2005

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Introduction

The vestibulo-ocular reflex (VOR) stabilizes gaze during head movement. This allows for movement without becoming dizzy or feeling "off-balance" while still maintaining clear vision (Tian et al, 2001). At rest, the human vestibular system sends a balanced resting signal to the brain. This signal is then recognized as an absence of motion (Goebel, 2000). During head movement, the afferent firing rate increases on the side ipsilateral to the movement and decreases on the contralateral side, allowing for spatial orientation (Goebel, 2000). In patients with a compromised vestibular system, the firing rate of the involved ear decreases and the brain receives asymmetric input. These conflicting signals then cause a spontaneous nystagmus, often directed toward the "normal" side and in turn cause the patient to perceive vertigo. Patients with vestibular insufficiency frequently experience visual blurring, also known as oscillopsia during movement (Schubert et al, 2001). It is thought that the cause of the oscillopsia is due to the inability of the VOR to maintain gaze, resulting in a retinal slip (Schubert et al, 2002). This retinal slip compromises fixation and clear vision (Schubert et al 2002). If the vestibular system is compromised, several other movements may contribute to the stabilization of the eyes including the optokinetic system and the cervico-ocular reflex (COR), known as the neck eye loop (Herdman et al, 2001).

Dynamic Visual Acuity Testing (DVAT) measures visual acuity during head movement, which can be difficult for those with inner ear problems. The DVAT is a functional measure used to examine the role of central programming of eye movements and efference copy in maintaining gaze stability (Herdman et al, 2001). The DVAT was designed to assess the VOR by attempting to elicit oscillopsia and compare visual acuity with head still and head moving using progressively smaller moving targets. The Gaze Stabilization Test (GST) is a test designed to detect inner ear problems in patients with or without visual abnormalities; it is a modified test of the VOR. It assesses the VOR by attempting to elicit oscillopsia with different head movement velocities and measures the oscillopsia in terms of the maximum head velocity that the patient can move their head and still maintain visual acuity.

Previous studies have examined unilateral vestibular dysfunction by means of the Dynamic Illegible 'E' Test (DIE test) and by using the DVAT with unilateral head thrust. Longridge and Mallinson introduced the DIE test in 1987. This test measures the efficiency of the VOR by comparing visual acuity with head still and head moving. First, the patient reads the smallest line he/she can on the Snellen Eye Chart with their head still at a distance of fourteen inches. Then the patient is asked to move their head in a horizontal fashion (>2 kHz) and asked to read the smallest line they can visualize. An increase in optotype size of three lines or less is considered normal. An increase in optotype size of four or more lines is considered abnormal with unilateral vestibular loss being a possible etiology. The DIE test cannot localize the weakened vestibular side. The DVAT with unilateral head thrust has been used to detect the side of vestibular lesion; however, some confounding factors include predictive eye movement and target duration. Herdman et al. (1998) noted that while using the DVAT, the researcher/clinician is unable to control for periods of slower head movement where fixation or pursuit/optokinetic eye movements, rather than the VOR, is used to compensate for retinal slip. This fixation or pursuit/optokinetic eye movement would aid in target identification.

The purpose of this study is first to evaluate the sensitivity, specificity, and the positive/negative predictive value of the GST and the DVAT in identifying patients with unilateral vestibular dysfunction. This will be accomplished by comparing the two tests against each other as well as to the results obtained from the normal vestibular functioning patients. Our hypothesis is that the GST is superior to that of the DVAT in detecting patients with unilateral vestibular dysfunction.

Methods

Thirteen patients (mean age 64.8 years) with clinical evidence of unilateral vestibular dysfunction and eleven control subjects (mean age 41.7 years) without vestibular dysfunction were recruited from the dizziness and balance center. Participation was strictly on a volunteer basis. Each patient was administered a screening questionnaire to characterize the nature of the patients' balance complaints. Only the patients with vestibular deficits received a clinical neurotological examination before testing. Inclusion criteria included both male and female patients with a known unilateral vestibular loss as identified by a 50% unilateral weakness with bithermal binaural caloric testing. Exclusion criteria included any patients who displayed a history or past evidence of musculoskeletal abnormalities that limit head and neck movement.

Both groups of patients were administered three tests: Static Visual Acuity Test (SVAT), Gaze Stabilization Test (GST) and the Dynamic Visual Acuity Test (DVAT). During all tests, the patients were seated in a chair ten feet in front of a computer screen with a rate sensor on their head. This device monitored the patient's head velocity in deg/s. To quantify losses in visual acuity during head movement, the first step was to determine the patient's head fixed static visual acuity. The SVAT is visual acuity in the absence of relative motion (Tian et al 2001). A sequence of the optotype "E" of predetermined size and in one of four possible random orientations (up, down, left, or right) was displayed on the computer monitor. When the patient correctly identified the orientation of at least 3 of 5 successive "E" presentations of a given size, the optotype size was reduced and the process repeated until the orientation of the optotype "E" could no longer be reliably determined. Static visual acuity was then based on the smallest optotype "E" that could be identified accurately. The visual acuity was then used as a reference for the GST and DVAT. Based on the reference point from the Dynamic Illegible 'E' Test, where an increase of three optotype sizes or less is normal, the SVA was increased by three optotype sizes for the DVAT and GST.

Each patient was assigned six trials consisting of three GST and three DVAT in a random order. During the GST, patients were asked to look at the letter "E" which remained a constant optotype size (three sizes above the SVA), while moving their head in the horizontal plane. In the GST, patient's head velocity was increased according to the accuracy of the patients' response to the orientation of the "E." When the patient could no longer accurately tell the orientation of the "E," the test was complete. The end point is the peak velocity at which the targets remain identifiable. In the DVAT, the patient was also asked to look at the "E" while moving their head in the horizontal plane, only during this test, the "E" decreased in size while the head velocity remained constant at 120°/s. The rate of 120°/s is used as previous studies have shown at this head velocity, there is a smaller chance of optotype identification during a fixation period (Herdman et al, 1998). The DVAT used the same monitoring methods as the GST for accurate head velocity. The patient's head velocity was displayed on the screen in either a red or green box. When the box was green, the head velocity was within the range specified for that condition. If the box was red, it indicated that the head velocity was significantly faster than the target velocity, which would adversely affect the results. If the head velocity dropped below the desired target, a screen would appear that would lead the examiner to re-instruct the patient. After all random trials were performed, the patient was asked to complete three more trials of the

GST, but this time the size of the optotype "E" was increased to four optotype sizes above the SVAT to determine if the affected vestibular system was more readily identified.

Results

DVAT Results

The study was divided into two groups: the control subjects and the unilateral vestibular lesion (UVL) subjects. The dynamic visual acuity of the subjects was converted to a LogMar scale. The lower the LogMar number, the better the visual acuity of the patient during a 120°/sec head movement. The mean LogMar (± 2 standard deviations (SD)) of the control subjects was 0.197 ± .078. The mean LogMar (± 2 SD) of the UVL subjects on the affected side was 0.389 ± 0.187 and on the unaffected side it was 0.309 ± 0.162. This data was then used to determine a criterion cut point (mean + 2 SD) to be >0.356. If the patients LogMar score on the affected side was greater than 0.356, the patient was considered to have a UVL and the data was compared with the caloric testing to determine sensitivity and specificity. Sensitivity was 60% and specificity was 85% in determining UVL with the DVAT.

GST Level 3 Results

For the GST results, the focus was on the maximum head velocity that patient could maintain and still report the orientation of the "E." The greater the head velocity, the better their vestibular system. The mean head velocity (± 2 SD) of the control subjects was 151.21 ± 30.50. The mean head velocity (± 2 SD) of the UVL subjects on the affected side was 76.67 ± 18.25 and on the unaffected side it was 101.04 ± 40.40. This data was then used to determine a criterion cut point (mean - 2 SD), which was <91.61 deg/sec. If the patients maximum head velocity score on the affected side was <91.61 deg/sec, the patient was considered to have a UVL and the data was compared with the caloric testing to determine sensitivity and specificity. Sensitivity was 75% and specificity was 90% in determining UVL with the GST3.

GST Level 4 Results

The same conversions were done for the GST level 4 as the GST Level 3. The mean head velocity (± 2 SD) of the control subjects was 166.67 ± 33.45. The mean head velocity (± 2 SD) of the UVL subjects on the affected side was 88.03 ± 36.13 and on the unaffected side it was 119.09 ± 42.45. This data was then used to determine a criterion cut point (mean - 2 SD), which was <99.77 deg/sec. If the patients maximum head velocity score on the affected side was <99.77 deg/sec, the patient was considered to have a UVL and the data was compared with the caloric testing to determine sensitivity and specificity. Sensitivity was 64% and specificity was 78% in determining UVL with the GST4.

DVAT and GST Combination Results

After analyzing the data for each individual test, an analysis was performed to see if performing both the DVAT and the GST would increase the sensitivity and the specificity of the test. DVAT and GST level 3 were compared (see table 1). When evaluating patients with UVL using the DVAT and GST together, the sensitivity is increased by 25%. The specificity is essentially unchanged from the GST3 alone, but has a 5% increase from the DVAT.

Table 1- Comparison of DVAT to GST3

	Sensitivity	Specificity
DVAT	60%	85%
GST3	75%	90%
DVAT and GST3	100%	90%

Discussion

The DVAT is difficult to perform in patients with visual disorders such as cataracts and macular degeneration, which may affect the results of the test. However, the GST measures the oscillopsia in a way that underlying eye conditions will not affect the results. The GST also documents peak head velocity, which can be used as a foundation for rehabilitation exercises and used to monitor progress after rehabilitation. Studies have shown that vestibular exercises can improve postural stability and decrease the sensation of dizziness in patients with abnormal vestibular function (Telian SA et al, 1990; Horak FB et al, 1992; & Herdman SJ et al, 1995). Administering the GST and DVAT before and after vestibular rehabilitation would be beneficial for those patients who have subjectively noted an improvement in their vestibular functioning. Our results support our hypothesis that the GST Level 3 was the most sensitive and specific for the detection of unilateral vestibular dysfunction when compared to the DVAT and GST Level 4. By raising the optotype one step in the GST Level 4, the test became too easy and masked the identification of a UVL. We also found the DVAT to be less sensitive to unilateral vestibular dysfunction than previous studies report.

After analyzing the data from the DVAT and GST, we found that the "unaffected" side of the UVL patients was not equivalent to the normal control subjects. The UVL "unaffected" side was statistically weaker than the vestibular systems of the normal control subjects.

The advantages of headshake DVAT and GST include minimizing predictive eye movements and excellent test-retest reliability. When used together, the sensitivity increases to 100% and the specificity to 90% in identifying UVL. In the future we would like to include a larger patient population with varying levels of dysfunction. Evaluation in the vertical plane using DVAT and GST should also be examined.

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