ICS medical

State-of-the-Art Clinical Balance Disorder Testing

While diagnosis of the dizzy patient has been, and remains, a difficult task requiring a patient history, physical examination and diagnostic tests, the otoneurologic community is enjoying a recent significant advance in the technology available for eye movement testing. ENG has long been the primary test of the eye movements used on patients with complaints of dizziness or unsteadiness. ENG remains the primary test, but **videonystagmography** has become more available and robust. Where early versions were awkward to use, had difficulty tracking the eyes of many patients and had analysis algorithms that were untested, most of these problems have been addressed in newer versions. In the majority of vestibular test situations, VNG offers a number of advantages over conventional ENG.

Videonystagmography (VNG) is a method of recording eye movements that uses digital video image technology to determine eye position. This represents a major change from ENG, which relies on the corneo-retinal potential of the eye to determine changes in eye position. By using infra-red illumination, VNG technology can be used to establish eye position during tracking of visible targets (saccade, tracking, gaze, and optokinetic tests) as well as in an environment that includes no visible light (for position testing and caloric tests), thereby eliminating fixation targets for the patient.

When using VNG, small cameras mounted in goggles capture images of the eyes. Eye position is established from a digitized image by locating the pupil and tracking its center. Some systems do this with a camera mounted directly in front of the eye. This, however, precludes the use of that eye to view a target. Another approach is to use dichroic filters placed inside the goggles. Dichroic filters are somewhat like two-way mirrors. They reflect infra-red light and allow visible light to pass through them. Cameras mounted outside the line of sight capture a reflected image of the eyes. Because the light from visible targets can pass through the filters, images of the eyes are available as they are viewing these targets. Computer algorithms analyze the individual images of the eyes. These are taken 30 or 60 times per second. Those samples are used to locate the pupil and the pupil's position is passed to the data repository. Once the eye position is established, algorithms work as they do with ENG to plot, measure, and analyze the movements of the eye.

ADVANTAGES OF VNG

VNG is easy to use. There is no application of electrodes, no concern about poor connections, bad electrodes or leads. Adjustments are seldom required. And calibration is generally easier than with electrodes. Furthermore, only one calibration is necessary, as there is no dependence upon the corneo-retinal potential used for ENG. With ENG the corneo-retinal potential can change over time making it necessary to calibrate several times during a battery of tests. Patients generally prefer not having electrodes attached, although some may not like wearing the goggles.

VNG eliminates external electrical noise, biological noise from EMG, EKG, and EEG as well as electrical drift all of which have become accepted but annoying aspects of ENG testing. Tracings are amazingly "clean." (Refer to Figure 1.)

An advantage of VNG testing is a video image that allows the clinician to view the eye movements, even as the patient is in a completely darkened environment. This provides assurance that the recorded eye movements are consistent with actual eye movements, in order to help to abstract from artifact. Also, it is more convenient to view the eyes on a monitor than to attempt to view the eyes during difficult to observe postions, for example after a Hallpike maneuver. Finally, and perhaps most importantly, the eye movements can be recorded in standard video format (video that can be played back on a video cassette recorder (VCR)). This allows careful review of eye movement responses to stimuli and adds the ability to visually assess torsional movements. Assessment of torsional eye movements is of particular interest in the diagnosis and treatment of benign paroxysmal positional vertigo (BPPV). Proper assessment and treatment is heavily dependent upon knowledge of the torsional eye movement responses to stimuli and the responses to the maneuvers used to treat BPPV. Table 1 shows some of these responses and their implications.

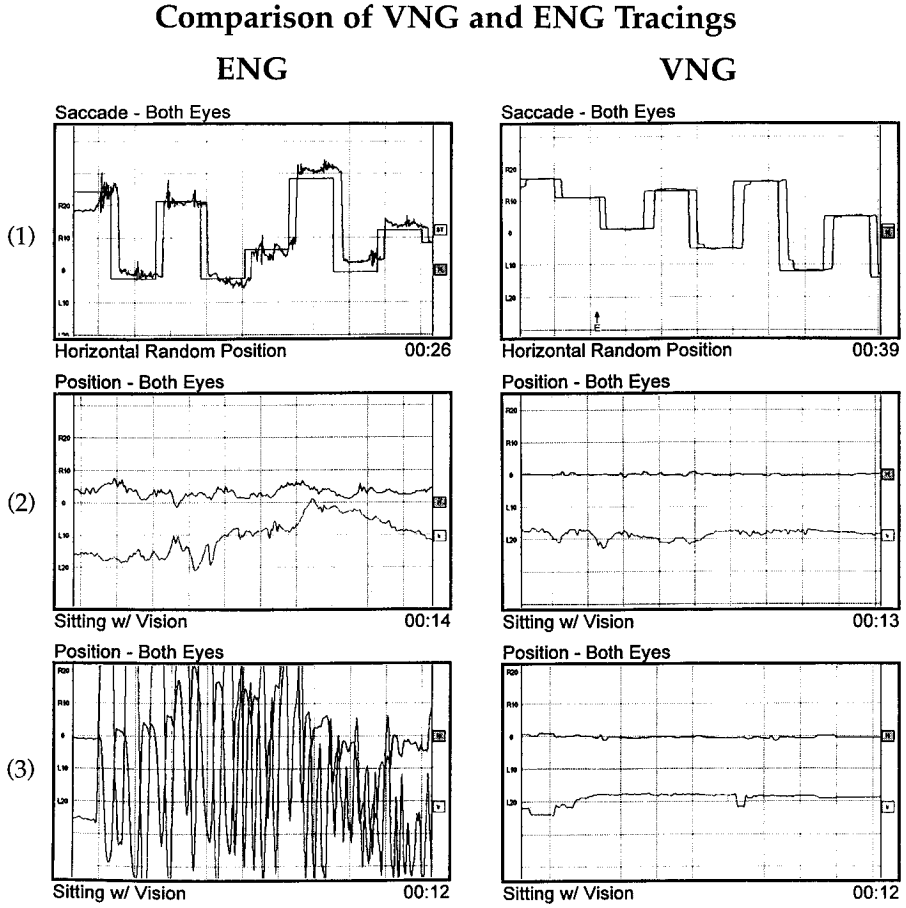

Figure 1. Comparison of VNG and ENG tracing. Tracings on the right are with a VNG system. Tracings on the left are made using ENG under the same conditions. (1) Gritting teeth, jaw movement: (2) Gritting teeth, jaw movement; (3) Excessive eye blinks.

Table 1. Pathology and Associated Nystagmus Response

Type of Pathology	*Identifying Features of Nystagmus Response to Provocative Maneuver*
Canalithiasis of right posterior canal	Upward & rightward torsional fast phases, <1 minute response duration.
Cupulolithiasis of right posterior canal	Upward & rightward torsional fast phases, >1 minute response duration.
Canalithiasis of left posterior canal	Upward & leftward torsional fast phases, <1 minute response duration.
Cupulolithiasis of left posterior canal	Upward & leftward torsional fast phases, >1 minute response duration.
Canalithiasis of right anterior canal	Downward & rightward torsional fast phases, <1 minute response.
Cupulolithiasis of right anterior canal	Downward & rightward torsional fast phases, >1 minute response.
Canalithiasis of left anterior canal	Downward & leftward torsional fast phases, <1 minute response.
Cupulolithiasis of left anterior canal	Downward & leftward torsional fast phases, >1 minute response.
Canalithiasis of right horizontal canal	Horizontal, geotropic fast phases, stronger right ear down.
Cupulolithiasis of right horizontal canal	Horizontal, ageotropic fast phases, stronger right ear down.
Canalithiasis of left horizontal canal	Horizontal, geotropic fast phases, stronger left ear down.
Cupulolithiasis of left horizontal canal	Horizontal, ageotropic fast phases, stronger left ear down.

Table 1. Analyzing BPPV Results (first two columns from "Summary Table"). From Herdman SJ and Tusa RJ, *Diagnosis and Treatment of Benign Paroxysmal Positional Vertigo*, pg 22, ICS Medical Corporation, Schaumburg, IL, 1999.

LIMITATIONS OF VNG

VNG cannot be used to test all patients. Patients with certain facial shapes and eye spacings are difficult to test because goggles may not fit properly. Some goggles are more flexible than others, but all have limitations. Some patients have eye characteristics that make them difficult to test, such as deep-set eyes and eyeliner tattoos. Some patients blink frequently enough that the video images are not useful. Long or heavily made up eyelashes also cause difficulty.

When doing tests in which the goggles are open to allow the patient to see targets such as those on a light bar during a tracking test, bright lights at inappropriate angles can cause reflections that make recording difficult. Reducing ambient light generally solves this problem.

VNG uses sampling rates that are marginal for measuring saccadic velocities. While rates of 30 Hz are certainly too slow to measure high speed movements, ICS Medical has tested its system using a 60 Hz sampling rate and gotten velocities that matched those measured with ENG at speeds up to 600 degrees per second.

SUMMARY

Videonystagmography can provide highly useful, easily administered testing of eye movements. Furthermore, it can offer incremental information that can prove of significant value to the diagnostic process. Of particular interest are the nearly noise-free tracings. VNG must, however, be complemented with an ENG capability in order to insure that all patients can be tested.

About ICS Medical Corporation

ICS Medical Corporation is an international leader in systems and services associated with the diagnosis of otoneurologic disorders. Based in northwest suburban Chicago, ICS Medical is the world's leading producer of systems used in clinical evaluations of patients with balance disorders. All ICS Medical products are Windows-based and supported with a full range of educational materials, seminars, courses and on-line services.