Video-oculography: A new diagnostic technology for vestibular patients

By Richard E. Gans

Video-oculographic recording of eye movement has been shown to be a highly effective non-invasive technology for evaluating eye movement.[1] Until recently, there were no commercially available systems that would allow the clinician to visualize linear and torsional eye movement; torsional eye movement could be detected only with research sclera coils, or 3-D analysis, which are not available to most facilities. With the emerging interest in the evaluation and management of vestibular patients and, in particular, differential diagnosis of BPPV (benign paroxysmal positioning nystagmus), the nature of the torsional/linear nystagmus has taken on new importance.

HISTORICAL PERSPECTIVE

For nearly 50 years, clinicians have depended upon electronystagmography (ENG) to evaluate peripheral and central vestibular function.[2] Although ENG remains the cardinal test in the identification and differential diagnosis of unilateral vestibular dysfunction (UVDs), the need to place electrodes around the eyes and the inability to record or observe a torsional nystagmus have represented significant limitations with this technology. Another drawback is that much of the testing must be performed with the patient's eyes closed. Therefore, clinicians have been dependent on the graphic, unidimensional recording to speculate as to what movement the eyes were actually making beneath closed eyelids.

"...video-oculographic recording offers several advantages..."

The advent of microprocessor-based ENG and software algorithms over the past decade has provided important advances in vestibular function tests. Likewise, active and passive head rotation tests such as the vestibular autorotation test (VAT) and the rotary chair have contributed significantly to our understanding of the vestibular ocular reflex (VOR) and the critically important relationship of eye and head position as influenced by the vestibular system.

EYE MOVEMENT AND VESTIBULAR EVALUATION

Abnormalities of eye movement provide valuable information about the location of the dysfunction or disease process. Many abnormalities are specific to certain pathophysiology or pharmacologic influences. The advantage of recording/evaluating eye movements versus other axial or limb musculature is that they are easier to interpret. Eye movement is limited to movement in three planes: horizontal, vertical, and rotational. This makes it fairly straightforward for quantitative analysis.

Eye movements may be categorized as those that stabilize vision during head movement and those that shift vision. The vestibular system stabilizes vision with head movement through the mechanoreceptors of the labyrinth, sensing the direction and speed of head acceleration and moving the eyes accordingly. When disease affects a particular semicircular canal within the labyrinth, nystagmus may occur in the plane of the involved canal. It is this anatomical and physiological relationship of the VOR that makes new technologic improvements in its assessment so important.

VIDEO-OCULOGRAPHY

Video-oculography is a method of recording eye movement through the use of digital video cameras. This is a significant change from electronystagmography, which uses the corneal retinal potential, which is the eye's battery-like effect. As the eyes move side to side and up and down, the corneo-retinal potential's positive and negative discharge is recorded.

VOG technology, however, uses infrared cameras to measure the eye's position. Small cameras, mounted in goggles, track the center of the pupil to provide the location of the eye. There are several types of VOG equipment, including one in which the camera is mounted directly in front of one eye while the patient uses the other eye to follow targets. This monocular approach is not ideal because it does not allow for binocular tracking and limits the recording to only one eye. If the patient has a unilateral neuro-ophthalmic track involve-

Figure 1. *Video goggles may be used with video recording.*

ment, the abnormality can be missed if the monocular camera is recording from the non-involved eye.

A preferable goggle type is one with dichotic filters placed inside the goggles. These act similarly to two-way mirrors, which reflect the infrared light as well as allowing the patient to be able to see normally. Computer algorithms then analyze the position of the eyes individually in cases where two cameras are present.

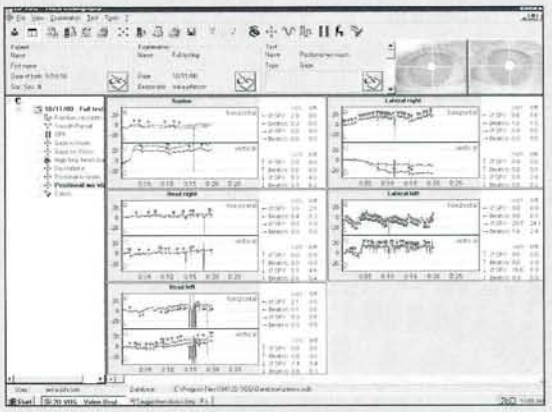

Figure 2. *VOG allows computer graphics and video imaging simultaneously.*

CLINICAL APPLICATIONS

For the clinician, video-oculographic recording offers several distinct advantages (Table 1). The first is a video recording using goggles, video camera, and VCR only (Figure 1). This gives the clinician a highly effective screening tool to qualitatively evaluate eye position. This evaluation may be accomplished through a simple yet robust screening procedure with eccentric gaze, headshake test, positional, and variations of modified Hallpike procedures.[3]

Table 1. *Advantages of VOG technology.*

(1) Allows visual observation and video taping of actual eye movement. Advantageous for differential diagnosis of BPPV variants and visualization of rotatory/torsional nystagmus.

(2) Two-camera VOG systems provide evaluation of the ocular motility of each eye independently.

(3) Does not require repeated calibrations, as are necessary with traditional ENG corneo-retinal-based technology.

(4) Does not require patient preparation and electrode placement.

(5) Patient is not required to close eyes, eliminating Bell's phenomenon and need for tasking.

(6) No need to maintain darkened test room environment.

(7) Preferable for pediatric testing.

(8) Allows correlation between actual eye movement and graphic algorithm analysis.

(9) Provides increased educational/clinical understanding of the neurophysiologic and neuromuscular basis of eye movement.

This procedure provides the clinician with a video recording of eye movement for spontaneous, dynamic positional and positioning maneuvers. It also allows a "bedside" type of neurovestibular evaluation of the patient's ability to hold gaze and the presence or absence of nystagmus in the aforementioned subtests. The price of video goggles, depending upon whether they come with one camera or two, may range anywhere from $1000 to $3000. This represents an economical way for clinicians to provide their patients with at least a screening investigation. As there is no computer software algorithm, the correct analysis of abnormal eye movement only does require that the clinician be knowledgeable in the anatomy and physiology of ocular motility and have an understanding of the variant forms of BPPV.

DIAGNOSTIC CAPABILITY

Perhaps the greatest advantage of the two-camera video-oculographic system is its ability to record and analyze eye movement from each individual eye. This is of particular importance in the ocular motor test subset, which consists of saccadic, pendular, and optokinetic pursuit tasks. Identification of abnormalities in either precision (gain or accuracy), latency, or peak velocity can provide the clinician and referring physicians with important differential diagnostic information regarding neural ophthalmic tract involvement.

For peripheral vestibular lesions which produce a positional or positioning nystagmus such as in the case of a non-stabilized, non-compensated unilateral vestibular dysfunction, or BPPV, the difference in the strength and nature of the nystagmus of the undermost vs. the uppermost ear during these positional and positioning tasks can be observed and recorded (Figure 2). As is the case with BPPV of the posterior canal, the eye of the undermost (involved) ear will show a stronger rotatory/torsional component, while the eye of the contralateral (non-involved) ear will have a more linear vertical component. It should be remembered that although the video recording aspect of the technology can record the rotatory torsional nystagmus, the ability to quantitatively analyze it is not available in most commercial systems. Two-camera systems are available from several manufacturers and may range in price from approximately $24,000 to $30,000. Single-camera systems cost somewhat less.

Table 2. *Technical considerations.*

(1) Video goggles can be weighty or slightly uncomfortable for some patients.

(2) Positioning of patient may require adjustment of camera angle(s).

(3) Patients with dark eyelashes, blepharochalasis (drooped eyelids) may require their eyes to be taped open.

(4) Ophthalmic hemorrhages may pose difficulty for the camera's tracking of the pupil.

SUMMARY

Video-oculographic technology offers numerous advantages over traditional ENG/corneo-retinal recording technique with limited technical concerns (Table 2). Clinicians wishing to develop and expand their technical skill and knowledge base of eye movement function and disorders will find this an invaluable diagnostic and educational advancement tool. The technology also offers a simple and inexpensive method to provide qualitative screening for patients with suspected labyrinthine or neurovestibular dysfunction. HJ

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