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CLINICAL APPLICATIONS FOR FUNCTIONAL ELECTROPHYSIOLOGIC TESTING

These tests can provide information that subjective testing may miss.

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In optometry and ophthalmology, a number of functional tests and structural tests are used to help determine ocular health and to detect abnormalities. In the past 10 years, there have been major advances in structural analysis thanks to optical coherence tomography (OCT), which can show all layers of the retina so its full structure can be examined. However, the diagnosis of glaucoma remains somewhat dependent on subjective visual field tests. This leaves room for a large margin of error due to patient confusion, noncompliance, technician skill, and even malingering.

As good as our current testing is, electrophysiology tests have proven to show abnormalities much earlier. For example, Banitt and colleagues followed a group of glaucoma suspects for years.[1] These patients were tested using standard visual field tests, standard intraocular pressure (IOP) measurement tests, OCT, and a variety of functional tests, specifically pattern electroretinography (PERG). Somewhat surprisingly, PERG showed abnormalities in patients who developed glaucoma years earlier than did the structural OCT test. As early detection for glaucoma is key for timely therapeutic intervention, this was a clinically important finding.

ELECTROPHYSIOLOGY TESTING

Visual evoked potential (VEP) and PERG testing provide unique information that is not available with other methods of evaluation. By measuring the electrical activity at the level of the visual cortex, VEP can assist in early glaucoma detection. Activity is assessed according to amplitude and latency. The amplitude varies depending on the number of healthy retinal cells present and the ability of the visual system to distinguish between objects of different sizes. Latency denotes how much time it takes for the electrical signal to travel from the retina to the visual cortex. This can be compared to population averages and tends to vary minimally between healthy subjects.

Similarly, PERG also determines the amplitude and latency of an electric signal, but it does so through assessing the retinal ganglion cells rather than the optic nerve and visual pathway. It is effective in detecting diseases that have an expected pattern, such as macular degeneration, by combining the output of the electrically active cell types in the retina to elicit a stronger or weaker response depending on which cell types and locations are being searched for. PERG can be used in conjunction with VEP and other tests to help distinguish between retinal and optic nerve disorders and to improve diagnoses of neuropathies and maculopathies. This objective test is beneficial in the early detection of myriad disorders, including glaucoma.

Clinical electrophysiology has been in use now for several decades. While these tests have always been useful, the systems that are now available have become easier to operate, more comfortable for patients, and generally less costly than earlier instruments. For example, the NOVA Vision Testing System (Diopsys) incorporates noninvasive sensors, reference ranges, and improved output systems

that are very user-friendly, increasing the ability of eye care clinicians to perform electrophysiology on their patients.

CLINICAL APPLICATIONS: OPTOMETRY

We have utilized electrophysiology testing for quite some time in the university setting and have found that patients who especially benefit include glaucoma suspects, including patients who are poor visual field testers for any reason. Glaucoma is generally thought of as a bilateral condition, but in some cases, one of a patient's eyes can appear perfectly normal in regard to IOP, corneal thickness, disc, and retinal nerve fiber layer testing. Or a ganglion cell test with OCT might deliver normal results in one eye. In some of these patients, however, VEP can detect abnormalities that were not found by other tests.

Once glaucoma treatment has begun, electrophysiology testing can be used to monitor success of the therapeutic regimen, and in some cases improvement can be measured at the level of the occipital cortex with VEP.

In addition to glaucoma patients, I frequently use electrophysiologic tests for patients with other conditions. Many referred patients present with reduced vision and other symptoms with unknown causes. In these cases, we perform a standard OCT to determine whether there are any structural abnormalities. We also conduct electrophysiologic tests, specifically PERG and VEP, as these tests are capable of detecting functional abnormalities very early in the disease process, even before we see it clinically.

Electrophysiologic tests are particularly useful with children. When combined with OCT and fundus autofluorescence, these tests can help determine whether a youngster has Stargardt disease, the number one cause of macular degeneration in children. The tests are especially useful in confirming amblyopia, determining a prognosis, and identifying those few, seemingly amblyopic subjects, who really have disorders of the central nervous system, including brain tumors.

As these tests involve patients sitting in front of a monitor, at which children today are adept, test compliance is excellent. And because the results are objective, they are more reliable in pediatric patients than standard subjective tests. The latter point also applies to mentally challenged patients. It is often difficult in these patients to determine through subjective testing methods whether a concern is present. Objective electrophysiologic tests can put our minds at rest about these patients or detect a serious disorder that could have been missed without the tests.

These objective tests have also been valuable in determining whether or not an abnormality exists in patients who present with a history of trauma to the eye. In our experience, we have found that in about 90% of these cases, patients are malingering. These tests, in effect, serve as a type of ophthalmic lie detector.

CLINICAL APPLICATIONS: OPHTHALMOLOGY

We have long known that our understanding of glaucoma is limited, and thus, our current treatment options are limited to ocular structures and IOP. However, there is exciting new research in this field that is leading to the central nervous system. Sponsel and colleagues published research last year that demonstrated through refined data analysis of paired visual field tests the role of the central nervous system in optimizing binocular visual function in severe bilateral glaucoma.[2]

Electrophysiologic testing of the neurovisual pathways may be even more important for understanding the role of the brain in neuron degeneration in glaucoma. We have been using the Nova system for a little more than a year, collecting extensive data on every patient so that we can analyze our findings. Thanks to excellent technicians, we tend to have highly reproducible visual field test results for our patients, and we have found a strong association between a patient's degree of visual field loss and the likelihood of an abnormality in latency of the VEP signal. There is an almost linear correlation with mild, moderate, and severe disease. We have also observed that patients with visual defects typical of glaucoma often have problems with either VEP or ERG testing, but only occasionally with both tests. We have determined that symmetry analysis of the two paired eyes is the best way to detect early disease.

Glaucomatous disease is not just one entity, and electrophysiologic testing is needed to better characterize the disease and its subtypes. The better we understand each etiologic subtype, the more effectively we will be able to treat the disease.

CONCLUSION

Electrophysiologic tests not only provide objective, reproducible data; they also provide insight into the role of the central nervous system in many ocular diseases. Together with standard structural tests, electrophysiologic tests provide a comprehensive diagnostic package that imparts invaluable information on the health of the retinal and visual pathways for a large variety of patients. ■

1. Banitt MR, Ventura LM, Feuer WJ, et al. Progressive loss of retinal ganglion cell function precedes structural loss by several years in glaucoma suspects. *Invest Ophthalmol Vis Sci*. 2013;(54):2346-2352.
2. Sponsel WE, Groth SL, Satsangi N, et al. Refined data analysis provides clinical evidence for central nervous system control of chronic glaucomatous neurodegeneration. *Transl Vis Sci Tech*. 2014;3(3):1. eCollection 2014.

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