What Is the Best Test to Follow Glaucomatous Optic Nerve Damage?

Measuring macular thickness with Fourier-domain OCT can aid the diagnosis of glaucoma.

BY ROBERT BRASS, MD

Glaucoma is a chronic disease that begins as damage to the retinal ganglion cells and their respective axons. The gold standard for the diagnosis and treatment of glaucoma is based on the visual observation of the optic nerve head (ONH) and the evaluation of visual function using standard automated perimetry. The Ocular Hypertension Treatment Study (OHTS) showed that optic disc changes were present in more than half of the patients who progressed to a diagnosis of glaucoma, prior to detectable visual field loss. Significant ganglion cell loss has been shown to occur before standard automated perimetry can detect functional deficits. Gold standards are slow to change, but newer imaging techniques can more accurately show and measure structural changes in the retinal nerve fiber layer (RNFL) and the ONH.

Figure 1. A Fourier-domain OCT image of the ganglion cell complex in a normal eye (top) compared with a glaucomatous eye.

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CURRENT DEVICES

Current imaging techniques include confocal scanning laser ophthalmoscopy, such as on the HRT II (Heidelberg Engineering GmbH, Heidelberg, Germany). This device images the ONH and peripapillary RNFL using transaxial laser scanning. Another technique, scanning laser polarimetry, is employed by the GDx VCC (Carl Zeiss Meditec, Inc., Dublin, CA). This unit scans the RNFL using the birefringence of a laser beam. Finally, optical coherence tomography (OCT) is used by machines from Optovue Inc. (Freemont, CA), Heidelberg Engineering GmbH, and Carl Zeiss Meditec, Inc. This technique produces cross-sectional imaging of the retina and optic nerve using low-coherence near-infrared light. All of these devices image and measure the ONH and/or the RNFL, although in different manners and slightly different areas.
Visual fields (A, B). Note the corresponding inferior visual field loss. In addition to possibly showing preperimetric nerve damage, optical coherence tomography testing (C, D) helps confirm possible nerve damage in studies that may have fixation losses, false-positive and/or negative errors on visual field testing.

This example shows visual field and optic nerve studies in a 57-year-old black man. His family history is unknown, and his past medical history is unremarkable, with no diabetes or hypertension. The patient’s manifest refraction was -2.75 -0.25 X 90 OD and -2.25 -0.50 X 120 OS. Clinically, the optic nerve cup-to-disc ratio was 0.85 OU. Pachymetry yielded thin corneas measuring 522 µm OD and 525 µm OS. His IOPs were 26 mm Hg OD and 24 mm Hg OS (powers are actually higher adjusting for his thin corneas). This is a clear case of glaucomatous optic nerve damage. Optical coherence tomography shows more signs of nerve damage than the visual field does, which likely represents preperimetric nerve damage. Visual fields may be limited by poor testing performance by the patient. In this case, optical coherence tomography clearly confirms extensive retinal nerve fiber layer and ganglion cell complex (GCC) damage.
They have all evolved in their means of data acquisition, the way they process the data into images, and the normative databases they use to provide comparative values as they relate to glaucomatous damage. The results obtained with one device are not interchangeable with those from a different device. Each type of device has great diagnostic capabilities in terms of repeatability, sensitivity, and specificity. Most of the published studies regarding how well they identify structural damage, however, are based on patients with documented visual field loss. The ability of these products to diagnose glaucoma on their own has not yet been proven.

**COMPARING MODALITIES**

Two major studies that compared the aforementioned imaging modalities came to similar conclusions.4-5 All were excellent for confirming RNFL and ONH damage in known glaucoma patients or in those at high risk for the disease. The studies, however, suggested no significant differences in their ability to distinguish glaucomatous eyes from controls. Caprioli et al found that OCT may identify glaucomatous damage earlier than other imaging techniques in the perimetrically unaffected eyes of patients with primary open-angle glaucoma.6

The mentioned studies compared confocal scanning laser ophthalmoscopy and scanning laser polarimetry to early-time-domain OCT (TD-OCT) devices, which were limited in their ability to measure the inner RNFL due to poor resolution and slow acquisition of the image. TD-OCT uses a mechanically scanning reference arm, which requires longer time to acquire scans and diminishes the image’s resolution. Spectral-domain or Fourier-domain OCT (FD-OCT) provides faster imaging by employing a stationary reference arm to obtain an interference spectrum, which then undergoes Fourier transformation to allow for the simultaneous measurement of all of the echo time delay of light. The faster imaging speed of FD-OCT decreases motion artifacts and allows better image resolution. More recent studies have shown that FD-OCT can discriminate between normal eyes and those with glaucoma.7

**AIDING GLAUCOMA DIAGNOSIS**

Measuring macular thickness with FD-OCT can facilitate the diagnosis of glaucoma. Although earlier studies with TD-OCT showed that total macular thickness measurements are not diagnostic for the disease,8 diagnostic accuracy can be improved if macular thickness measurements focus on the inner retinal layers of the macula using FD-OCT.9-11 These retinal layers consist of the nerve fiber, ganglion cell, and inner plexiform and inner nuclear layers. Measurements focus on the inner retinal layers of the macula using FD-OCT.9-11 These retinal layers consist of the nerve fiber, ganglion cell, and inner plexiform and inner nuclear layers.

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are referred to as the ganglion cell complex. It contains the axons, cell bodies, and dendrites of the ganglion cells, which are the cells most affected by glaucoma (Figure 1). Mapping the ganglion cell complex is on par with and complementary to RNFL imaging.

**CONCLUSION**

It is an exciting time in the development of retinal imaging. Today’s devices can measure structural changes in the inner retinal layers with micron precision. Combined with improved software algorithms, it is only a matter of time until eye care specialists routinely use OCT measurements to detect glaucomatous damage. Eventually, OCT imaging will not only enhance standard automated perimetry’s value in the diagnosis and management of glaucoma, but it may replace visual field testing altogether.

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