Challenges to the Common Clinical Paradigm for Diagnosis of Glaucomatous Damage With OCT and Visual Fields

Donald C. Hood1,2 and Carlos Gustavo De Moraes2

1Department of Psychology, Columbia University, New York, New York, United States
2Department of Ophthalmology, Columbia University, New York, New York, United States

Many clinicians diagnose glaucoma based on the following tests: a visual field (VF) test with a 6° grid (e.g., the 24-2 or 30-2 test pattern) and an optical coherence tomography (OCT) scan of the disc, as well as photos and/or examinations of the optic disc. While disc photos typically are assessed qualitatively, in general, VF and OCT tests are compared based on objective metrics, such as the mean deviation (MD), pattern standard deviation (PSD), glaucoma hemifield test (GHT) of the 24-2/30-2 VF test grid (e.g., the 24-2 or 30-2 test pattern) and an optical coherence tomography (OCT) scan of the optic disc. Furthermore, these tests are assessed based upon quantitative metrics (e.g., the pattern standard deviation [PSD] of the VF and the global retinal nerve fiber thickness of the OCT disc scan). This CCP is facing three challenges. First, the macular region (i.e., ±8° from fixation) is affected early in the glaucomatous process, and the CCP can miss and/or underestimate the damage. Second, use of the typical VF and OCT metrics underestimates the degree of agreement between structural (OCT) and functional (VF) damage. Third, resolution of the OCT scan has improved, and local glaucomatous damage can be visualized like never before. However, the clinician often does not look at the OCT scan image. Together these challenges argue for a modification of the VF test pattern and OCT protocol, replacement of metrics with a comparison of abnormal regions on VF and OCT, and careful inspection of actual OCT scan images. In principle, the CCP could be modified easily. In practice, change is facing a number of impediments.

Keywords: glaucoma, OCT, visual field

The most common clinical paradigm (CCP) for diagnosing glaucoma includes a visual field (VF) with a 6° test grid (e.g., the 24-2 or 30-2 test pattern) and an optical coherence tomography (OCT) scan of the optic disc. Furthermore, these tests are assessed based upon quantitative metrics (e.g., the pattern standard deviation [PSD] of the VF and the global retinal nerve fiber thickness of the OCT disc scan). This CCP is facing three challenges. First, the macular region (i.e., ±8° from fixation) is affected early in the glaucomatous process, and the CCP can miss and/or underestimate the damage. Second, use of the typical VF and OCT metrics underestimates the degree of agreement between structural (OCT) and functional (VF) damage. Third, resolution of the OCT scan has improved, and local glaucomatous damage can be visualized like never before. However, the clinician often does not look at the OCT scan image. Together these challenges argue for a modification of the VF test pattern and OCT protocol, replacement of metrics with a comparison of abnormal regions on VF and OCT, and careful inspection of actual OCT scan images. In principle, the CCP could be modified easily. In practice, change is facing a number of impediments.

Keywords: glaucoma, OCT, visual field
Challenge 2: Structural (OCT) and Functional (VF) Damage Typically Agree, and VF and OCT Metrics are a Poor Way to Assess This Agreement

The second challenge comes from an improved understanding of the relationship between functional damage, as seen on VFs, and structural damage, as seen on OCT scans. While it commonly is assumed that structural damage precedes functional damage, the actual situation is more complex.\textsuperscript{23,24} In particular, the extent to which structural damage appears before functional damage depends upon the test performed (e.g., OCT macular vs. disc scans; 24-2 vs. 10-2 VFs) and the metrics used (e.g., VF GHT vs. PSD vs. MD vs. cluster criteria), as well as their measurement error. It also depends upon the level of cpRNFL thickness and 24-2/30-2 visual sensitivity of the patient when healthy (i.e., before glaucoma develops).\textsuperscript{23} Structural damage often will be detected before functional damage when using the 24-2/30-2 VF, OCT disc scan, and standard metrics. However, these metrics miss clear damage seen by comparing abnormal regions on VF and OCT probability maps. That is, the CCP does not make full use of the information available to us from either VF or OCT testing.

Implications for the CCP

These two challenges suggest that radical changes should be made to the CCP. First, scans that include the macula and disc are necessary so that macular RGC and RNFL thickness can be assessed, in addition to the typical measure of the cpRNFL thickness around the disc. The scan protocol can be a single scan that includes the macula and disc or two separate cube scans, one centered on the fovea and one on the disc. The resulting RGC and RNFL thickness maps should be turned into probability/deviation maps to facilitate comparison with VFs.\textsuperscript{1,2,25} Second, VFs should be obtained with a pattern that includes a finer test grid in the macular area or 24-2 and 10-2 tests should be performed within the first two visits. Finally, instead of conventional metrics, VF and OCT results should be compared topographically. That is, abnormal points seen on VFs should agree topographically with the local abnormal regions on RGC and RNFL probability maps, and this region of agreement should resemble known patterns of glaucomatous damage.\textsuperscript{2,25}

We have designed a one-page report that incorporates these suggestions.\textsuperscript{2,25,26} Two OCT manufacturers are incorporating the basic elements of these suggestions in a new report, and a third has a report that has some of these elements.
Challenge 3: Details of Glaucomatous Damage Can Be Seen on OCT Scans

The improvement that has occurred in the quality of the OCT images provides a third challenge to the CCP, as well as providing the opportunity to improve our understanding and diagnosis of glaucoma. Retina specialists routinely look at the b-scans of OCT images, while glaucoma specialists typically do not. Why? The answer is simply, “because we never did.” That is, early time-domain OCT reports were based upon averaged circle (Fig. 1A) scans and the circumpapillary image presented was too small to be of use, which was understandable given the quality of the time-domain image. Figure 1B shows an enlarged circumpapillary image from the original time domain OCT instrument for a healthy eye. Compare the quality of this image to that of a typical spectral domain image in Figure 1C, which is from an eye with glaucomatous damage. Circumpapillary images of this quality have been available for 8 years or so. However, most recent OCT glaucoma reports still show OCT circumpapillary images that are too small to be of use, and some recent reports do not show any OCT images.

Why look at the actual scan images? First, by examining the circumpapillary image, the clinician can assess the quality of the scan and, more importantly, the quality of the software’s automated delineation (segmentation) of the borders of the RNFL. Second, an OCT scan through the fovea often will reveal non-glaucomatous damage due to age-related macular degeneration, epiretinal membrane, macular edema, holes, and so forth. Finally, local details of damage can be seen on circumpapillary images, such as in Figure 1C, and this can help the clinician understand and follow changes in glaucomatous damage. For example, Figure 1D shows the temporal half of the image in Figure 1C compared to the adaptive optics scanning laser ophthalmoscopy images for the same locations. Local damage clearly is visible on the OCT image.

Implications for CCP

OCT scans have approximately 100 times the resolution of a magnetic resonance imaging (MRI) scan. We would not trust a computer algorithm to follow a tumor in the brain without a radiologist actually looking at the scan. At the very least, clinicians routinely should scrutinize an enlarged image associated with a circle around the disc. Preferably this image would be obtained from an averaged circle scan, although for most purposes it could be derived from OCT cube scans that include the optic disc. Also, we advise examining a scan through the fovea for the reasons mentioned above. In addition, contrary to commonly held beliefs, examination of scan images allows one to study eyes with high myopia or advanced glaucoma. Let us consider the latter first.

It is generally held that OCT is not suitable for following severe glaucoma, defined as a 24-2 MD worse than −15 dB. It is true that regional (i.e., clock hours or quadrants) and global cpRNFL thickness approaches an asymptotic thickness, or floor, for a population of eyes with MD ≤ −15 dB. While this suggests that you cannot use the global cpRNFL thickness to follow these eyes, it does not mean that you cannot use the OCT. In fact, if a small portion of the VF is remaining, you will see a relatively preserved region of cpRNFL matching that location on the VF. This is illustrated in Figure 2, where the 24-2 VF shows a region of preservation. There is a corresponding region of preserved cpRNFL on the circumpapillary scan in Figure 2B, which can be followed to assess progression.

Are We in the Middle of a Paradigm Shift?

There is some evidence that the CCP is (very) slowly changing. Compared to 5 years ago, more clinicians are obtaining 10-2 VFs and OCT macular scans to assess early glaucomatous damage. However, most clinicians still depend largely upon 24-2 VFs and OCT disc scans, and relatively few look at the actual circumpapillary image typically will allow for an assessment of glaucomatous damage, as well as allow one to follow this damage for progression.

Acknowledgments

Supported by National Institutes of Health Grants EY02115 (DCH) and EY025253 (CGDM).
Challenges to Clinical Paradigm for Diagnosis of Glaucoma

Disclosure: D.C. Hood, Topcon, Inc. (C, F, R), Heidelberg Engineering (C, F, R); C.G. De Moraes, None

References


