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

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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 and the global or quadrant circumpapillary retinal nerve fiber (cpRNFL) thickness/probabilities of the OCT disc scan. We focused on three aspects of what we will call the common clinical paradigm (CCP): use of the 24-2/30-2 VF to assess functional damage, use of an OCT disc scan to assess structural damage, and use of summary metrics for defining and/or comparing abnormal VF and OCT tests. We argued here that this CCP is facing three challenges and should be modified.

Challenge 1: Early Glaucomatous Damage Includes the Macula

Early glaucomatous damage typically includes the macula and the CCP misses and/or underestimates this damage (see reviews1–3). By the macula, we mean the region within ±8º of fixation, which is only approximately 2% of the retinal area, but includes over 30% of the retinal ganglion cells (RGC).3 This region is vital for everyday visual tasks, such as reading, driving, and recognizing faces.4–6 Four recent lines of evidence question the efficacy of the CCP in detecting glaucomatous damage of the macula. First, glaucomatous defects near fixation are missed and/or underestimated with the 24-2/30-2 VF.7–11 For example, in a recent study,15 the commonly used criteria of an abnormal PSD and/or GHT on the 24-2 VF test missed 13 (22.8%) of 57 glaucomatous eyes, and 11 of these 13 had macular damage. Interestingly, early static perimetry, and even earlier Goldmann perimetry, studies showed examples of eyes with glaucomatous damage near fixation.7,14–17 More to the point, one early study17 suggested that damage occurred first in the macula, and a second7 that this damage was missed by a 30-2 test pattern. However, until recently, this work was largely ignored as evidenced by the paucity of references to these studies, and the lack of impact on the CCP. In part, this is due to a belief that the axons from the macular RGCs entered the relatively less vulnerable region of the optic disc, the temporal quadrant, and, thus, are the last to be affected by glaucoma. This resulted in a generally held belief that the 10-2 is useful only in the case of advanced glaucoma or threat to fixation.

Second, we now have an anatomic basis for early damage to the macula. In particular, the inferior RGCs of the macula (i.e., those associated with the superior VF defects near fixation), enter the highly vulnerable inferior quadrant.1,2,18 Of note; only 2 of the 24-2/30-2 VF test locations fall within this highly vulnerable location so important for daily activities.1

Third, early macular damage is missed and/or underestimated by the OCT disc scan of the CCP, especially if metrics, such as global, quadrant, or clock-hour cpRNFL thickness and probabilities, are used.19 Interestingly, other early OCT studies20–21 also suggested macular damage was common, and these also had little impact on the CCP. Finally, the fourth line of evidence is that early diffuse damage due to glaucoma also can affect the macula, and the OCT disc scan of the CCP can miss this damage as well.22

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. 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). 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. 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.

We have designed a one-page report that incorporates these suggestions. 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.
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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. 

Challenge 3: Details of Glaucomatous Damage Can Be Seen on OCT Scans

The temporal half of the disc circle scan (NSTIN view) showing a preserved region of RNFL within the region of the scan corresponding to the macular region (±8° from fixation). The arrows indicate corresponding regions of the VF and RNFL.

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 corresponding region of preserved cpRNFL on the circumpapillary scan in Figure 2B, which can be followed to assess progression.

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.

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