OCT and glaucoma

The most appropriate clinical diagnoses of glaucoma rely on thorough analysis and examination, not on imaging alone.

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Glaucoma is a group of diseases characterised by degeneration of the optic nerve with cupping of the disc and corresponding visual field loss. The definition of glaucoma has evolved over the past decades. Prior to the 1980s, elevated intraocular pressure (IOP) was almost exclusively used as the diagnostic criterion and clinical measure of progression. During the 1980s, the definition evolved to include elevated IOP and visual field (VF) defects. By the 1990s, optic disc and retinal nerve fibre layer defects were incorporated into the clinical definition.

The current gold standard for diagnosing glaucoma and identifying disease progression is optic disc photography (structure) and visual field testing (function). Structural changes at the optic disc usually occur before functional loss is seen on VF testing. The relationship between structural damage of the retinal nerve fibre layer (RNFL) and optic nerve axons and functional visual field loss continues to be extensively studied. The early diagnosis of glaucoma and the detection of progression are critically important as much of the functional damage is asymptomatic until late stages of the disease.

Ocular Hypertension Treatment Study

Of the patients with elevated IOP who developed glaucoma after five years, 57 per cent were diagnosed based on optic disc changes, 33 per cent based on visual field changes and 10 per cent with co-existing visual field and optic disc change.

Visual field testing has been the mainstay of detecting glaucoma and progression; however, there is a small but significant group of patients in which accurate fields are unobtainable. Imaging technologies can now provide an objective assessment of the retinal nerve fibre layer which can be used by the ophthalmologist as part of the overall clinical assessment of patients with glaucoma.

Technological advances

The past decade has seen the introduction of imaging technologies, particularly retinal tomography (HRT), optical coherence tomography (OCT) and scanning laser polarimetry (GDx).

The development of imaging technologies was driven by the desire to:
• improve the diagnosis of glaucoma
• predict disease progression (risk modelling)
• detect disease progression.

OCT produces high-resolution, cross-sectional tomographical images of the retina. It is analogous to ultrasound B-mode imaging but OCT uses light rather than soundwaves. It projects a narrow slit (20 microns) of near infrared (850 nm) light across the fundus; images are obtained by detecting optical back-scattering (interferometry). The original time domain scans comprised 400 A-scans per second and

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measured the RNFL thickness around the optic nerve head along three high-density circular scans of 3.4 mm diameter. The new spectral OCT system captures 26,000 scans per second. Ultra-high speed OCT is able to capture 70,000 to 312,000 scans per second. OCT offers the advantage of objectivity in measurement reproducibility and ability to quantify change over time and measure the rate of change.

Spectral-domain OCT
Spectral-domain (SD) scanning is the newest generation of OCT technology and has largely replaced time-domain (TD) scanning. The faster image acquisition and better axial resolution gives better quantitative measurements of the peripapillary RNFL.

The larger 6x6 mm² zone increases the diagnostic capability as RNFL defects can now be identified in areas that would have been missed using the conventional circle scanner 3.4 mm. Acquisition time is less than one second and the raw scans are captured and the distribution around the clock hours printed and compared to a normative database. RNFL parameters are printed with inter-eye differences recorded and a symmetry graph provided (Figure 1).

Optic disc anatomy
One of the difficulties in providing an accurate normative database is the significant variability in the optic disc appearance in humans. The average area is 2.2 - 2.4 mm² with a vertical cup-to-disc ratio of 0.34. The neuro-retinal rim follows the ISNT rule (thicker inferiorly then superiorly, nasally and temporally). There is a linear correlation between optic disc cupping and the overall disc diameter, with larger discs commonly having a physiologically larger cup. Clinically, it is important not to overlook early glaucoma in small hypermytropic discs (Figure 2).

What is the role of OCT?
There is a reasonable correlation between OCT and RNFL measurements and visual field loss detected with standard automated perimetry; however, it is important to remember that not all statistically significant change is clinically significant, nor is it always related to the disease process.

Imaging tests should be done as part of a clinical work-up, not as a screening test, as the false positive rate will result in an unacceptable number of ‘suspect’ cases. As with most studies, the gold standard reference for glaucoma is based on visual field defects, which tends to exclude early glaucoma and can result in the sensitivity and specificity of OCT being over-represented in early glaucoma.

Consequently, one of the important clinical factors to keep in mind when assessing new technologies is that the sensitivity of structural testing may not be as good in early glaucoma as in moderate to advanced
glaucoma where the degree of neural tissue loss is significantly greater (Figure 3).

While the evolution of new technology is exciting, careful analysis of the clinical utility of these emerging tests is needed. The new SD-OCT images cannot be compared to images taken with the earlier TD-OCT technology. As progression is a key determinate of glaucoma control and the need for accelerated treatment, caution is required not to mistake the thinner RNFL images obtained with SD-OCT for glaucoma progression.

A limitation of OCT is the inability to identify optic disc haemorrhages, which are an important risk factor and have been shown to precede RNFL loss and field defects. They are an important sign for glaucoma diagnosis and progression, and highlight the reality that imaging alone cannot replace a careful examination of the optic disc. Any patient found to have a haemorrhage should be referred to an ophthalmologist for assessment even if an OCT scan is apparently normal.

**When is imaging helpful?**

1. **Abnormal optic disc and reliable visual field with corresponding defect**
   The diagnosis is evident and imaging is not required to either make the diagnosis or for follow-up.

2. **Abnormal optic disc and normal visual field**
   OCT imaging is not unreasonable to evaluate for pre-parametric glaucoma by seeking evidence of focal RNFL defects.

3. **Abnormal optic disc and unreliable visual field**
   ‘Objective perimetry’ was developed in an effort to provide reliable quantitative measurements in this subgroup of patients unable to accurately and reproducibly perform visual field testing. OCT can be cautiously used as a surrogate for field testing in these patients; however, clinical assessment of the optic nerve head by ophthalmoscopy remains the gold standard of monitoring progression.

4. **Normal optic disc and suspicious visual field**
   A normal OCT scan may support a decision not to treat and to keep the patient under observation with repeat VF testing. The abnormal VF may be due to non-glaucomatous pathology.

**Summary**

The clinical diagnosis of glaucoma is made by an ophthalmologist or optometrist, not by a machine in isolation. Careful examination of the optic disc through a dilated pupil is crucial and allows for identification of patients with possible optic nerve head damage who can then be referred. A high index of suspicion should be observed in those with a family history of glaucoma or recorded episode of elevated IOP. Optic disc changes should be identified clinically and correlated with visual field loss. Most cases are diagnosed clinically with imaging tests providing secondary support if evident.

Thoughtful application of imaging technologies in appropriate individuals may help identify those with healthy optic nerves or those who are already showing signs of optic nerve damage. Cross-sectional assessment of an individual is obtained by comparison to a normative database but the limitations of the database need to be carefully understood to prevent erroneous interpretations. Longitudinal assessment using change-analysis software uses the patient’s own scan as a baseline and is becoming more sensitive as the noise of the scans is reduced and the inter-test reproducibility and reliability improves.