Editorial

The Role of Ocular Coherence Tomography in Glaucoma Diagnosis and Management

New technologies bring with them new hope and often unrealistic expectations. Optical Coherence Tomography (OCT) is no exception. The use of OCT has led to a much better understanding of the structure of the retina. It has, within the space of a few years, become irreplaceable in the management of retinal disorders. Therapy for macular diseases is now guided by OCT findings.

Glaucoma is a chronic slowly progressive neuropathy of the optic nerve and presents a different challenge. Screening tests generate a large number of false positives and frequently miss early cases. Recent large scale studies have shown that the mean intraocular pressure (IOP) at diagnosis is around 20 mm Hg making it a very poor screening tool[1,2]. Linking structural changes on the optic nerve head (ONH) to characteristic, functional changes in the field of vision is the cornerstone of glaucoma diagnoses and its management by lowering IOP. In general structural changes appear earlier than changes in visual fields. In the Ocular hypertension study (OHTS), more than half the patients who developed glaucoma from ocular hypertension, did so optic disc changes[3]. Unfortunately our current examination techniques and tests do not allow us to detect the disease early and we often rely on changes of visual field to diagnose glaucoma. It is estimated that at least 35% of the retinal ganglion cells have to be lost before any VF loss appears.

Traditionally, changes on the optic nerve head have been assessed by ophthalmoscopy. Optic disc stereo-photography is considered the gold standard for assessing optic discs. However, the limitations of photography preclude its universal adoption. These include the need for skilled technicians to take photographs and poor inter-observer agreement, even amongst experts[4]. Retinal nerve fibre layer defects may precede ONH and visual field changes by 4-7 years but their detection via ophthalmoscopy and photographs is difficult with advancing age and in myopia[5].

Confocal scanning laser ophthalmoscopy (CSLO, Heidelberg Retina Tomograph) to assess the ONH and scanning laser polarimetry (SLP, GDx Nerve Fibre Layer Analyser), to assess the peripapillary nerve fibre layer have been available for assessing structure in glaucoma for more than a decade. Studies indicate that both have good diagnostic ability to detect glaucoma. The adoption of both the technologies has not been wide spread as their findings often do not correlate to the clinical and functional assessment.

Rapid advances in image acquisition technology have made OCT reliable and reproducible for retinal imaging. Current Fourier Domain OCTs (FD-OCT) acquire 25 - 76,000 A scans per second and have superseded the slower time-domain OCTs (400 scans/ sec). What are we looking for with OCT scans in glaucoma? OCT findings in glaucoma are more subtle than in retinal disease. ONH changes and retinal nerve fibre layer (NFL) thinning due to loss of ganglion cell soma at the macula occur. Visible NFL defects involve a loss of 12,500 axons (1% of normal total) and measure about 21 – 47 µm in depth (ref). FD- OCT has a resolution of 5 – 10 µm and scans can detect NFL defects earlier than red-free photography. OCT for glaucoma involves detection and segmentation of the retinal layers and is essentially quantitative. The thickness of the NFL can be compared between hemispheres and eyes and the detected asymmetry in thinning may be due to a pathologic process, not necessarily glaucoma. For the optic disc the software measures the neuroretinal rim below an arbitrary plane and in most often doesn't coincide with the true neuroretinal rim. The thickness of various parameters is then compared to a normative database. Unfortunately segmentation algorithms in different scanners are mutually exclusive and are not comparable. Therefore long-term assessments need to be with the same OCT scanner and this is a serious limitation.

The first practical application of OCT in glaucoma was published in 1997 where time domain – OCT was shown to be useful in detecting glaucoma in an eye with optic nerve head drusen[6]. It became evident that retinal thinning could be topographically correlated to visual sensitivity in glaucoma[7]. However scanning for glaucoma was limited by the slow speed of scanning

and motion artefacts by the time domain OCT. Extensive research has been done on OCT – derived NFL thickness and macular thickness. OCT – detected macular changes have led to a better understanding of the structure-function relationship in glaucoma. Early work indicated that macular thinning was a less accurate measure for glaucoma detection than TD-OCT peripapillary NFL thickness and that inner macular thickness which included the ganglion cell layer has a higher diagnostic power[8].

OCT – derived optic disc parameters have so far not proved to be reliable indicators of the disease. Recently Chauhan et al have proposed that an ONH parameter, the Bruch's Membrane opening – minimum rim width is a reliable indicator for glaucoma[9]. Furthermore Chauhan and Burgoyne have proposed a radical re-think in the way OCT assessment for glaucoma is done. They suggest that the OCT scan output should be reviewed like a chest X-ray rather than trying to fit the OCT scan outcomes to the clinical appearance of the disc. This is because in glaucoma, often the clinical disc margin doesn't coincide with that determined by the OCT[10].

Is the OCT suitable as a 'stand alone' device to detect glaucoma? Unfortunately there appears to be no single device or test which can diagnose the disease with certainty. In normal human retinas and optic nerves, retinal ganglion cells count show a two-fold or greater variability. There is significant intra-session variability in OCT – measured RNFL thickness[11]. Very few studies have looked at the diagnostic capabilities of the OCT in 'real – life' scenarios. One such study from Hungary looked into the diagnostic accuracy of a commercially available FD – OCT in an unselected population. Normality was decided by the software-provided classification. Sensitivity was 73.6% for the optic nerve head parameters, and 62.7% for the other parameters. Specificity was high (94.6 – 100%) for most RNFL thickness and inner macular thickness parameters, but low (72.0 – 76.3%) for the optic disc parameters[12]. This study implies that the diagnosis of glaucoma cannot be made simply because the OCT is normal or abnormal.

The detection of glaucomatous progression is a critical aspect of glaucoma management but difficult to ascertain reliably. Corroborative change with different tests can be used as an alternative to single-test confirmation to detect glaucomatous progression. For example, if we are using three methods to detect progression (e.g. CSLO, OCT and perimetry) the detection of a concomitant change by OCT and HRT (preferably spatially correlated) allows earlier detection of progression compared to repeating a corroborative change result with any of these two tests. The OCT has a significant advantage over other methods. Consistent and spatially correlated change in two OCT parameters, RFNL and macular thickness would confirm progression. CSLO and SLP have helped significantly but often there is disconnect between progression as determined by these devices and that by visual fields. This may be due to 'noise' in both structural and functional tests. The hope is that with OCT there would be a greater degree of coherence between structural and functional progression. This has been confirmed in some recent studies, where the FD-OCT performed significantly better than the CSLO, SLP and the time-domain OCT in detecting progression[13-15].

Does the OCT have any drawbacks? The adage 'rubbish in, rubbish out' is very apt for OCT assessment for glaucoma. It is essential to ensure that the scan is of good quality. Head tilt and microsaccades may result in poor quality scans. Low signal scans due to media opacities may lead to a significant underestimation of NFL thickness. Artefacts due to incorrect segmentation of the retina may occur in 5-10% of cases. Diseases like myopia and epiretinal membranes confuse the software.

Technological advances in OCT continue at a rapid pace. Eye-tracking enables reliable OCT scans in eyes with poor fixation and accurate and repeatable alignment of OCT and fundus images. The Enhanced-depth Imaging OCT allows for visualisation of the lamina cribrosa[16]. Swept source OCT which uses longer wavelengths than FD – OCT and scan twice as fast (100,000 scans/sec) allows for simultaneous scanning of retina, optic nerve and choroid[17]. Another exciting prospect is that it can accurately scan the anterior chamber angle. This allows for accurate localisation and quantification of extent of iridotrabecular contact and peripheral anterior synechiae in angle closure glaucoma[18].

The OCT has improved our diagnostic capabilities for glaucoma and allows for earlier detection of progression. For once the early promise in a new technology has been vindicated. This is evidenced by the rapid and widespread adoption in routine glaucoma practise in the USA and Europe. However it is important to remember it is not a substitute to meticulous clinical and perimetric assessment of glaucoma.

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