Continuing education CET

What you should know about OCT assessment

Part 2 - Disc analysis

To complete the CET exercise go to www.opticianonline.net/continuing-education/ and answer the questions

In the second part of her series about use of an OCT, **Dr Rachel Hiscox** discusses assessment of the optic disc. Module C38974, one point for optometrists and independent prescribers

Following on from the Part 1 of this series (31.10.14), which looked at macular scan interpretation, this article will review OCT disc analysis for glaucoma detection and monitoring.

Background

In 2013, the number of people with glaucoma worldwide was estimated to be 64.3 million, with this number predicted to increase to 76 million by 2020.[1] Without timely diagnosis and referral for treatment, the incidence of bilateral blindness secondary to glaucoma will also rise. Currently, identification of glaucoma in primary eye care relies upon the classic triad of optic disc assessment, measurement of IOP and visual field evaluation. However, a survey by the International Glaucoma Association revealed that at least one in three referrals for glaucoma are in fact false positives.[2]

With glaucoma defined as an optic neuropathy characterised by progressive structural loss of retinal ganglion cells, assessment of the structure of the retinal would seem to be key in the diagnosis and management of glaucoma.[3] OCT can be used to provide repeatable objective and quantitative evaluation of the retinal structure, with the ability to detect between healthy and glaucomatous eyes to a high degree of sensitivity and specificity.[3-7] It has been demonstrated that 40-50 per cent axonal loss may occur before any change in visual fields are detected.[8] With structural changes, including ganglion cell and retinal nerve fibre layer (RNFL) loss, preceding visual field loss, evaluation of patients with OCT could result in earlier detection of glaucoma.

When to use a disc OCT scan

The 6x6mm 3D disc scan consists of 128 B-scans, with each B-scan consisting of 512 A-scans. This high density of scans is important as it means that RNFL thickness values are not interpolated, as is the case for protocols which include fewer B-scans. Like the 3D macular cube scan, the 3D disc scan can be captured in just a few seconds, and captures information over the whole of the optic nerve head, allowing not only the RNFL thickness to be calculated, but also the optic nerve topography and shape to be imaged. OCT disc scans should be performed on all patients in order to establish baseline thickness measurements which can be used to determine progression over the following years.

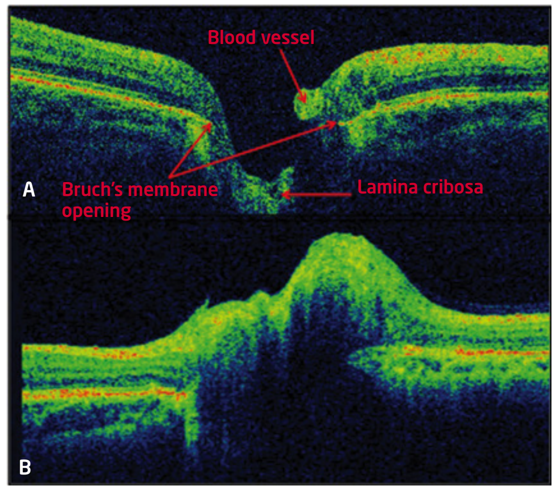

Figure 1 A healthy optic nerve head B-scan with (A) the structures identified and (B) a raised optic nerve head scan

OCULAR EXAMINATION

OPTIONS

What does a disc scan look like?

A healthy OCT B-scan of a disc is shown in Figure 1a, with the different structures identified. Observation of sequential B-scans across the disc allow visualisation of the anatomical disc (defined by the opening in Bruch's membrane), along with the size and depth of the cup. A cross-sectional view of the disc allows observation of optic disc swelling (Figure 1b), which may be associated with optic disc drusen, crowded optic nerve heads or raised intracranial pressure.

3D disc scan components

● Shadowgram

As discussed in the first article in this series, the shadowgram is a surface image of all the aligned B-scans. It plays an incredibly important role in the analysis of disc scans, giving an indication of whether the analysis performed is likely to be reliable. In a reliable scan, the shadowgram will appear sharp (indicating high scan quality) and will show no signs of fixation errors or blinks (Figure 2). Fixation errors, blinks and poor scan quality will all result in reduced diagnostic accuracy,[9] therefore the scan should be repeated. Poor scan quality can be caused by media opacities, incorrect focus, or even dry eye.

● Temperature thickness plot

The temperature thickness plot for disc scans gives a representation of the RNFL thickness across the scan area, with thicker areas appearing as warmer colours, and thinner areas as cooler colours. RNFL thickness is calculated between the inner plexiform layer and the outer edge of the RNFL. Observation of the temperature thickness plot can show whether the patient has a normal RNFL thickness pattern, and highlight any areas of thinning (Figure 3). In order for the thickness of the RNFL to be defined accurately, a high quality scan is needed. RNFL thickness measures should not be relied upon if scan quality is low. In addition, the high reflectance of blood vessels can cause the automated segmentation to miscalculate RNFL thickness measures, often making the RNFL appear thinner around the major blood vessels. The accuracy of the automated segmentation should be checked for each scan by applying the layer boundaries.

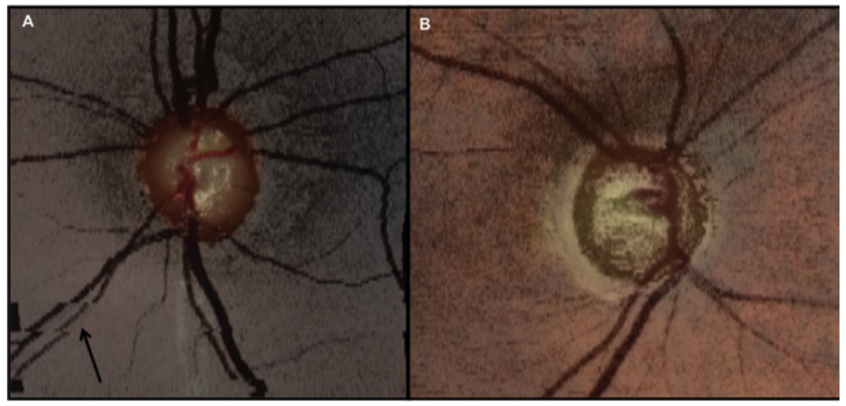

Figure 2 Disc shadowgrams. (A) Shadowgram showing high scan quality, but a fixation error (black arrow). (B) Shadowgram showing no fixation errors but poorer scan quality, shown by the less distinct blood vessels

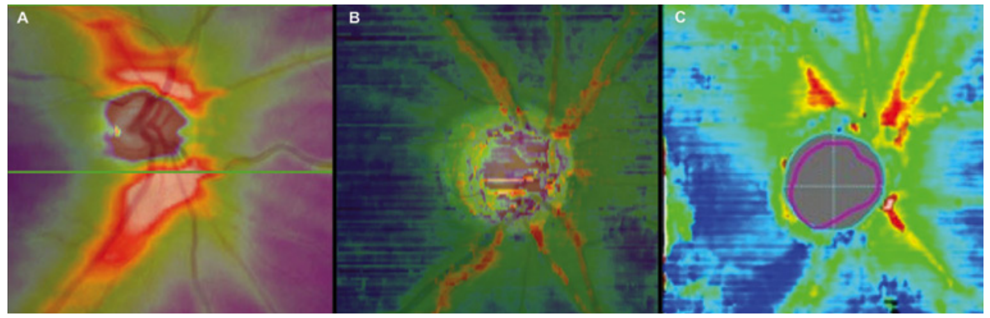

Figure 3 RNFL temperature thickness plots for 3 different right eyes. (A) A healthy RNFL, with RNFL thickest temporally and symmetrical across the horizontal raphe. (B) A 'cooler' plot, showing diffuse RNFL loss. (C) Inferior temporal RNFL loss, showing asymmetry across the horizontal raphe

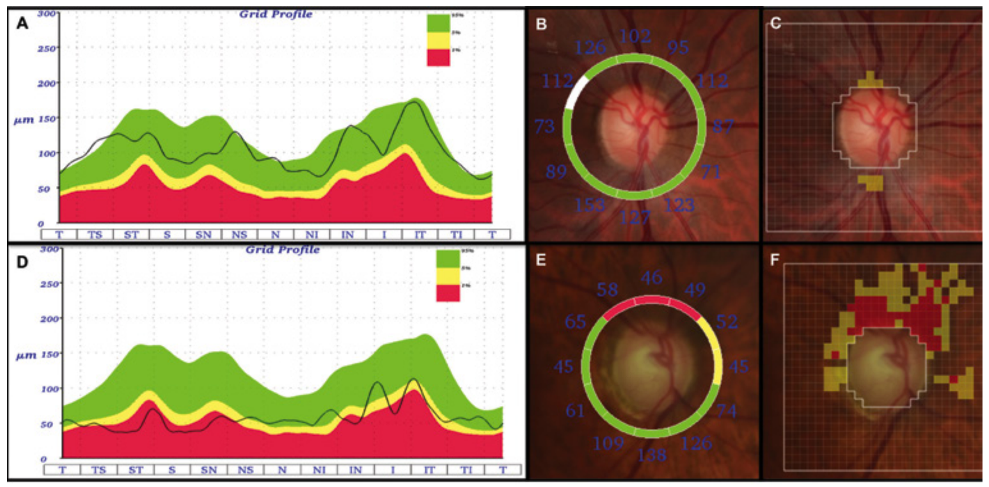

Figure 4 Normative comparisons for a healthy (A-C) and a glaucomatous (D-F) eye. (A) TSNIT graph showing RNFL thickness is within (green) or above (white) normal limits. (B) 3.4mm diameter circle showing RNFL thickness is within or above normal limits. (C) Significance plot showing that RNFL thickness is borderline (yellow) at a few grid locations near the disc, but within normal limits (clear) for all other locations. (D) TSNIT graph showing RNFL thickness is outside normal limits (red) across the superior temporal (ST) to superior nasal (SN) quadrants. (E) 3.4mm circle showing RNFL thickness is borderline or outside normal limits. (F) Significance grid showing the RNFL is borderline or outside normal limits in the superior nasal quadrant, highlighting a possible RNFL arcuate defect

● Normative comparison

All commercially available OCT machines come preloaded with an internal normative database, enabling practitioners to classify a patient's RNFL thickness as 'normal', 'borderline' (within 1-5 per cent of the normal distribution) or 'outside normal limits' (within the bottom 1 per cent of the normal distribution). Normative comparison is often shown in three different ways; on a TSNIT chart, on a 3.4mm ring, and on a significance grid (Figure 4).

While normative comparison provides a useful reference to determine whether RNFL thickness is within normal limits, it must always be interpreted with caution. An area of red (outside normal limits) does not automatically mean the patient has glaucoma, and likewise, a completely green plot does not mean the patient definitely does not have glaucoma. Normative databases are not exhaustive and typically contain less than 500 patients. Additionally, they do not always include a range of ethnicities and refractive errors, both of which affect RNFL thickness. Non-glaucomatous myopic eyes tend to have a thinner RNFL,[10] and will therefore often be falsely classified as 'outside normal limits'. However, these limitations aside, identification of both diffuse and localised RNFL atrophy with normative comparison has been shown to have reasonable levels of sensitivity and specificity, with sensitivity improving with increasing visual field defect.[11,12] Normative comparisons should be used to highlight possible areas of damage, prompting the optometrist to carry out further tests, eg dilated stereoscopic disc examination, extended visual fields, applanation tonometry and corneal thickness calculation. Normative comparisons should never be used in isolation of other tests.

● Disc topography

Evaluation of the optic nerve head is crucial in the detection and monitoring of glaucoma. With advances in technology, this has moved from direct or indirect observation with an ophthalmoscope or slit lamp and written notes, to documentation with fundus photography. With the use of OCT, it is now possible to obtain automated topographical disc measurements, including C:D area ratios and disc diameters (Figure 5). As the disc topography values are automatically determined by segmentation algorithms, they provide repeatable, ▶

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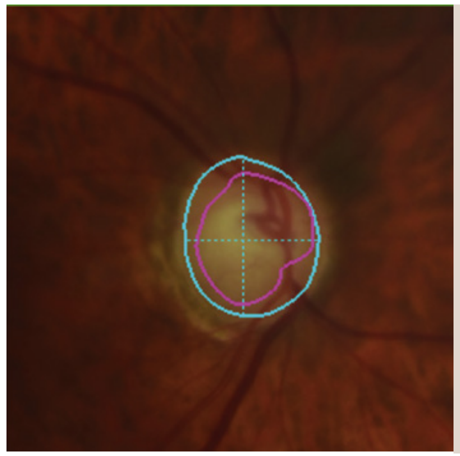

Disc area	(mm^2)	3.00
Cup area	(mm^2)	1.93
Rim area	(mm^2)	1.07
C/D area ratio		0.64
Linear CDR		0.80
Vertical CDR		0.86
Cup volume	(mm^3)	0.33
Rim volume	(mm^3)	0.07
Horizontal DD	(mm)	1.77
Vertical DD	(mm)	2.16

Figure 5 Automatic disc topography parameters. The disc rim is identified by the opening in Bruch's membrane (blue rim), while the cup (pink rim) is identified at a reference height of 120µm above the RPE

objective measurements which can be monitored over time.

Measurement of optic disc size can be useful in determining glaucoma risk, with research showing that large discs are more likely to have large physiological cups.[13] Average disc area has been measured to be $2.8 \pm 0.5mm^2$ with Topcon OCT.[14] Comparing disc topography output between right and left eyes can further aid in the detection of glaucoma, with asymmetry in C:D ratio of 0.2 or more being more prevalent in patients with open-angle glaucoma than healthy patients, particularly when differences in disc size are also taken into account.[15]

● Trend analysis

One of the biggest advantages of using OCT for the assessment of glaucoma, is the ability to monitor for structural changes over time, rather than waiting for a visual field defect to present. Trend analysis detects progression by evaluating the slope of RNFL thickness over time using linear regression analysis, providing the ability to extrapolate for the future rate of progression. Healthy subjects have demonstrated an age-related reduction in RNFL thickness of −0.52 µm/year.[16] However, the rate of structural loss is related to the baseline RNFL thickness, where a higher baseline thickness thins at a higher rate. Along with normal age-related loss, RNFL measurement reproducibility must also be taken into account when analysing OCT disc scans for signs of progression. Commercially available OCTs are typically able to measure RNFL thickness with a reproducibility error of less than 10µm, provided scan quality is high.[17] Therefore, glaucoma progression can be identified by a change of greater than 20µm (based on 2x the reproducibility error).[18]

But what about the ganglion cell layer?

While the 3D disc scan automatically detects and measures the thickness of the RNFL, it does not measure the ganglion cell layer thickness. As glaucoma results from ganglion cell apoptosis, the ganglion cell layer should also be quantified. Ganglion cell layer thickness is best measured over the macular region, where more than 50 per cent of the retina's ganglion cells reside.[19] While the diagnostic capabilities of measuring the ganglion cell layer thickness have been found to be comparable to those of the RNFL,[20,21] it is considered to have higher diagnostic ability in myopic patients where retinal thinning is more exaggerated around the disc,[22,23] leading to false positive results particularly when compared to the normative population. It is therefore recommended that the macular ganglion cell scan is preferentially used in myopic patients. The retinal ganglion cell layer shows the greatest glaucomatous thinning in the inferior retina,[24] as shown in Figure 7. ●

● In the third and final article, we will look at anterior assessment with an OCT.

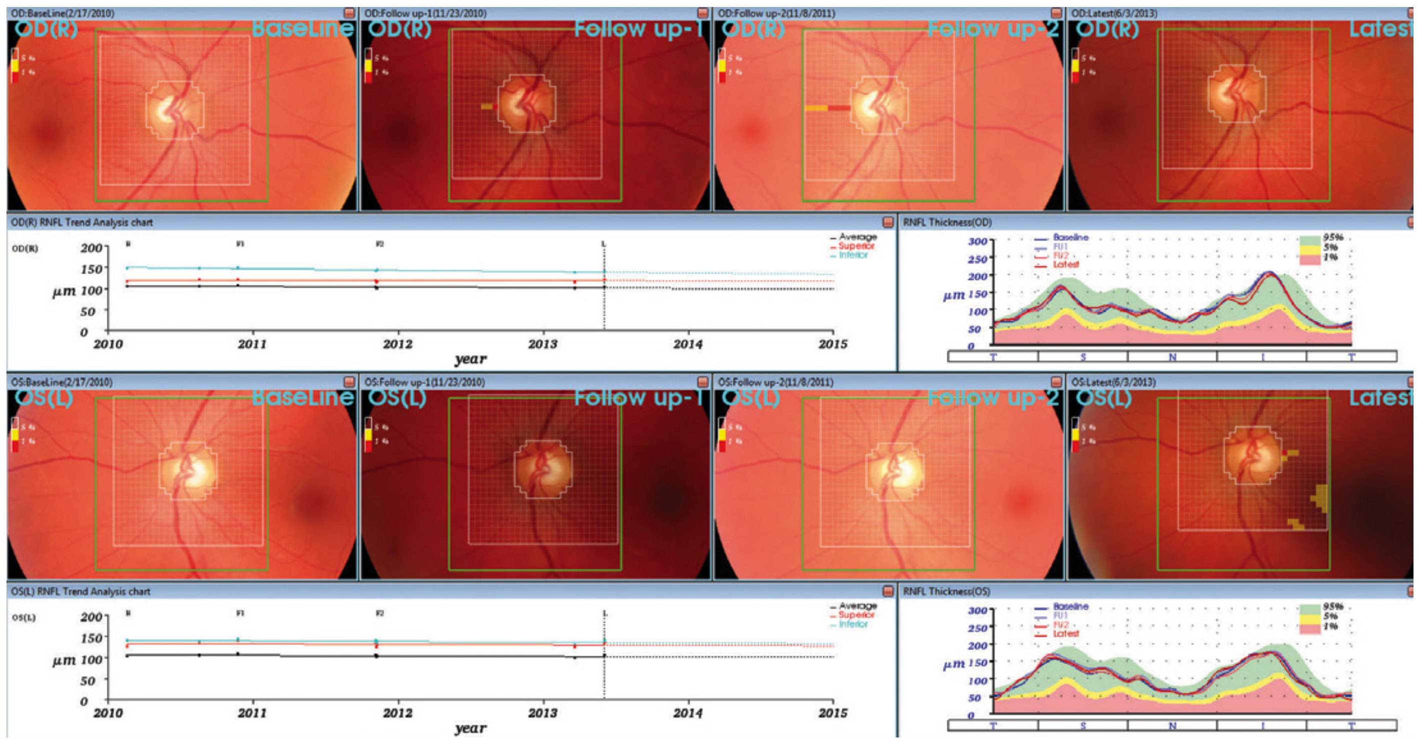

Figure 6 Glaucoma trend analysis function including optic nerve photographs which can be overlaid with temperature thickness plots or normative data, normative TSNIT graphs and linear regression trend analysis graphs

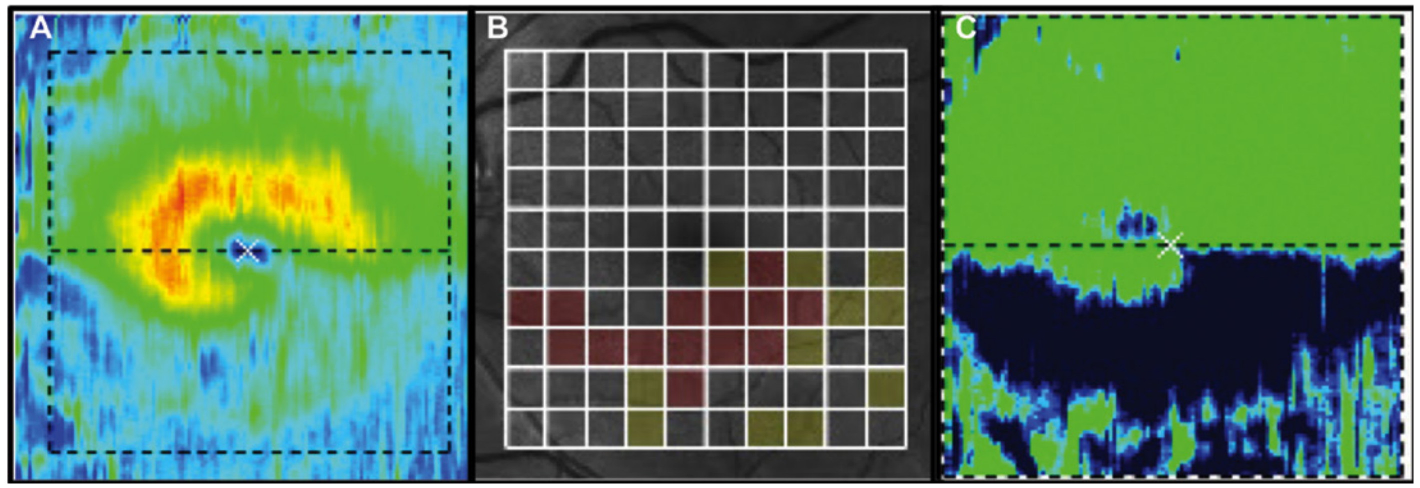

Figure 7 Macular ganglion cell analysis for a left eye. (A) Temperature thickness plot showing thinning inferiorly. (B) Significance graph showing areas of ganglion cell thickness that are 'borderline' or 'outside normal limits' in a wedge pattern. (C) Asymmetry plot showing that the ganglion cell layer is thinner inferiorly relative to the superior retina

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