What you should know about OCT assessment

Part 3 - Anterior eye

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OCULAR EXAMINATION

OPTIONS

Dr Rachel Hiscox finishes her look at practical OCT use with a review of anterior eye assessment. Module C39179, one distance learning point for optometrists and IP optometrists

Following from Parts 1 and 2, which reviewed macular and disc scan interpretation, the final article in this OCT series will review the many varied uses of anterior segment OCT. Anterior segment OCT was first described in 1994,[1] offering the ability to rapidly capture non-contact images of the cornea, anterior chamber angle (ACA), iris and anterior lens. Along with posterior segment OCT, most commercially available OCTs now come with the ability to capture anterior segment scans, furthering the diagnostic capacity of an OCT machine.

When to use an anterior OCT scan

There are many varied applications of anterior segment OCT, with different applications requiring different scan protocols. The two main scanning protocols used for anterior segment imaging are radial OCT scans, consisting of 12 B-scans in a radial pattern, and high-resolution single line B-scans. Radial scans are generally used to evaluate the corneal curvature and thickness, with automated output including corneal thickness and curvature values (Figure 1A). A single line B-scan is the protocol of choice when a high quality image of an anterior structure, typically the ACA, is required (Figure 1B). An additional scan protocol that some instruments employ is a 3D anterior cube scan, which is similar to the 3D macular cube scan as discussed in the first article of this series. The 3D anterior cube scan enables imaging of a large area of the anterior segment and is therefore useful when structural information is required over a larger area than the radial scan covers.

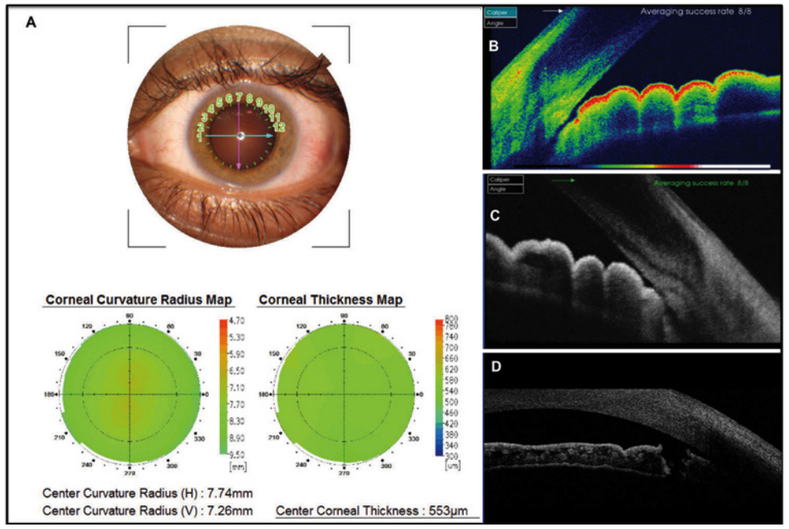

Figure 1 Anterior segment OCT in glaucoma. Radial scan protocols can be used to produce an automated corneal thickness value (A). A single line B-scan protocol can be used to assess the ACA which may appear narrow (B) or closed (C). Post surgery, OCT can be used to determine the patency of an iridotomy (D)

Applications of anterior segment OCT

Glaucoma assessment

As discussed in Part 2 in this series, currently the number of people with glaucoma worldwide is estimated to be 64.3 million, with this number predicted to increase to 76.0 million by 2020.[2] Closed-angle glaucoma has previously been stated to account for only 4-5 per cent of all glaucoma cases,[2] however, a recent large scale study has revealed that 10 per cent of glaucoma cases have closed angles, with 75 per cent of these wrongly diagnosed as primary open-angle glaucoma.[3]

Examination of the ACA is imperative in determining the risk of angle closure. Currently, gonioscopy is the gold standard in ACA evaluation, however, assessment is subjective and highly dependent on the examiner's judgment and experience. Pressure on the eye during examination can change the angle configuration and the use of light to illuminate the angle structures can cause miosis and lead to an incorrect evaluation of ACA.[4] Previous studies have shown that even experienced examiners have only moderate agreement in evaluation of angle width.[5,6] It addition, the contact nature of the technique may not be accepted by all patients.

Anterior segment OCT offers the ability to non-invasively image the ACA (Figure 1 B, C and D). Depending on the scan resolution and the wavelength of light used, anterior segment OCT can also enable visualisation of the angle structures (Figure 2). Anterior segment OCT offers several advantages over gonioscopy; it is non-contact, quick and easy to perform and as less light is required to image the angle with OCT there should be less pupillary miosis.

While simply viewing the B-scan images (Figure 1, B, C and D) can help to determine whether there is suitable space to allow aqueous drainage through the trabecular meshwork, it is sometimes useful to be able to quantify the angle. In order to get a repeatable measurement, a systematic approach must be taken; the angle should be measured from 500µm anterior to the scleral spur, to a point perpendicularly opposite on the iris (Figure 3). Following this technique, ACA measurements with anterior segment OCT have been demonstrated to be reproducible.[4,7] The angle opening distance (AOD) can give further information on the relationship between the iris and cornea and should be calculated as the perpendicular distance measured from 500 µm anterior to the scleral spur to the anterior iris surface (Figure 4).8 In a study of Caucasian eyes, average ACA was found to be 36 degrees and 16.1 degrees in open and closed angles, respectively. While average AOD was found to be 450µm and 170µm in open and closed angles, respectively.[9] Using an AOD cut off value of 190µm was found to be 100 per cent sensitive and 87.5 per cent specific in detecting occludable angles in one study, suggesting an AOD of less than 190µm is occludable.[10]

In addition to being able to assess the ACA with OCT, an automated measurement of central corneal thickness can be obtained, using a radial scan protocol (Figure 1A). The Ocular Hypertension Treatment Study identified a thin cornea as an independent risk factor for the development of primary open-angle glaucoma.[11] In addition, corneal thickness has an effect on the accuracy of IOP measurement, with thinner corneas underestimating IOP, and thicker corneas overestimating IOP. Many algorithms[12] have been developed which allow calculation of an adjusted IOP, but much controversy exists regarding each of the algorithms, with none being proven to be 100 per cent accurate as the relationship between IOP and corneal thickness is highly variable. It is therefore recommended that adjustment scales are used as a guide only.

Measurement of corneal thickness with OCT has been shown to have comparable repeatability to ▶

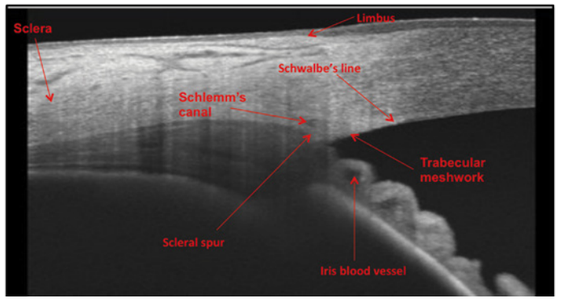

Figure 2 A B-scan of the anterior chamber angle, with angle structures identified

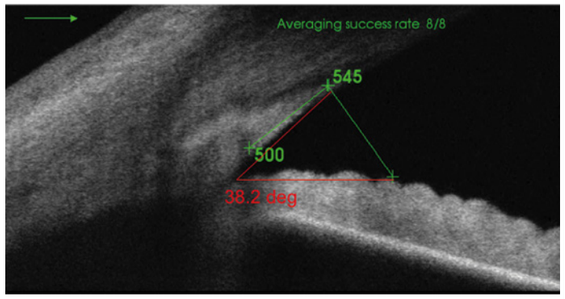

Figure 3 Measurement of the ACA (red lines, 38.2 degrees) from 500µm anterior to the scleral spur, to a point perpendicularly opposite on the iris. Measurement of the AOD (green line between cornea and iris 545µm)

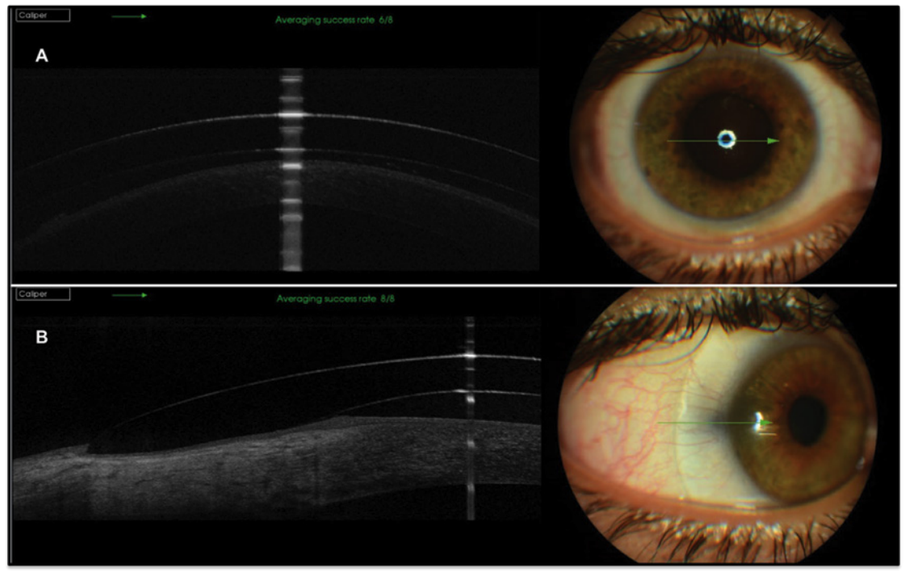

Figure 4 Anterior segment OCT for contact lens fit assessment. OCT scans of a semi-scleral contact lens fit in a keratoconic patient showing central apical clearance (A) and limbal clearance but poor edge alignment with the conjunctiva (B)

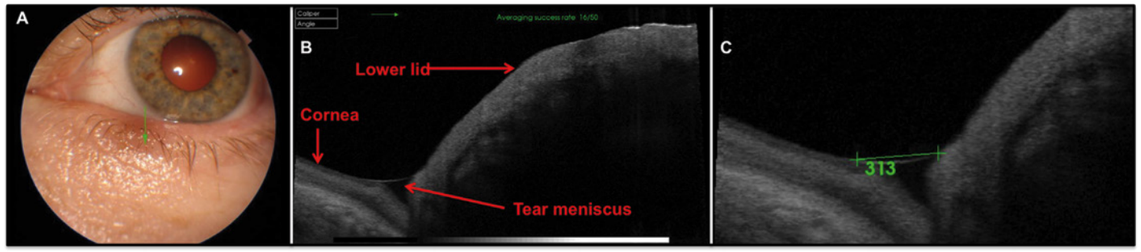

Figure 5 Anterior segment OCT for dry eye assessment. A vertical single line scan should be aligned over the inferior lid margin (A) and focused to obtain an image of the tear meniscus (B). The tear meniscus can then be measured with integrated calipers (C)

ultrasound pachymetry, currently the gold standard in corneal thickness measurement.[13] However, due to differences in the way corneal thickness is measured, OCT assessment of corneal thickness consistently measures 16µm thinner than ultrasound.[13]

Contact lens fitting

Currently, assessment of rigid contact lenses relies upon slit-lamp examination under white light to determine the edge alignment, and observation of fluorescein pattern to determine the relationship between the cornea and the posterior surface of the lens. However, previous research has demonstrated that slit-lamp examination with fluorescein may not always be sufficiently sensitive in determining the lens fit.[14] Anterior segment OCT can aid in the assessment of a contact lens fit, making it possible to accurately assess the edge alignment and the central fit (Figure 4), even enabling measurement of the space between the corneal surface and the contact lens. Use of anterior segment OCT in both small-diameter rigid lenses and larger-diameter scleral lenses has been shown to improve contact lens fitting, resulting in less contact lens intolerance and increased patient satisfaction.[15]

Dry eye assessment

Assessment of tear film quantity is an integral part of a dry eye work up, with an insufficient tear volume resulting in ocular discomfort and compromised ocular surface health.[16] Many of the methods used to determine tear volume are invasive and induce reflex tearing, resulting in an overestimation of basal tear flow and volume. The inferior tear meniscus comprises 75 to 90 per cent of the total tear volume[17] and is a good indicator of overall tear volume.[18] Typically, gross measurement of the tear meniscus in practice has relied upon manipulation of the height of the slit lamp beam.

Anterior segment OCT offers a non-invasive method for the imaging and measurement of tear meniscus height, with good levels of repeatability (Figure 5).[19,20] With more high street optometrists offering extended dry eye examinations, OCT offers an accurate and repeatable way to assess tear volume.

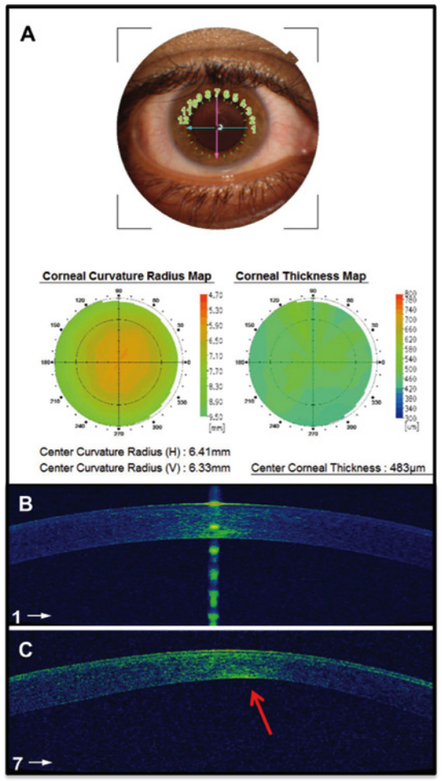

Figure 6 Anterior OCT for keratoconus assessment. (A) Typical radial scan report for a keratoconic patient, showing a thin CCT and a 'cooler' temperature thickness map. (B) Normal corneal B-scan, showing a smooth corneal shape (C) B-scan of a keratoconic cornea, showing a change in the shape of the back surface of the cornea (red arrow)

Keratoconic assessment

Keratoconus is a chronic, non-inflammatory corneal ectasia, characterised by corneal steepening, visual distortion, apical corneal thinning and central corneal scarring. While the incidence of keratoconus worldwide is relatively low at one in 2,000,[21] early detection is key to enable access to treatment with corneal collagen cross-linking, thus preventing the development of corneal scarring and possible need for corneal transplant.

Anterior segment OCT can aid in the detection of keratoconus, with several studies showing keratoconic corneas to have significantly thinner central corneal thickness versus non-keratoconic eyes.[22,23] Radial OCT scan protocols, as already discussed, will automatically calculate the central corneal thickness, along with horizontal and vertical radii of curvature, which will show progressive steepening in keratoconus. While topography maps from dedicated topographers which utilise Placido discs or Scheimpflug imaging undoubtedly produce more detailed topographical maps of the cornea, the corneal thickness and curvature maps produced with OCT can aid in keratoconic detection. Careful observation of the B-scan profile can also reveal keratoconic changes to the cornea (Figure 6).

Summary

With the use of OCT growing in the primary eye care setting, this series of articles have explored the use and interpretation of macular, disc and anterior segment scanning. With OCT technology continuing to develop at a rapid rate, it is important that eye care practitioners utilise all the features of their OCT machines in order to provide the highest level of patient care.

● Look out for a review of results from an anterior eye imaging workshop using OCT early next year.

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