Iris Imaging in Primary Angle Closure Glaucoma

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Core Concepts
- Primary angle closure glaucoma (PACG) has a high risk of visual loss.
- The iris (thickness, area and curvature) seems to play an important role in angle closure. Its dynamic response in eyes with angle closure is different from that of normal eyes.
- Optic coherence tomography (OCT) may be used to measure the iris volume.
- Iris volume may increase after pupil dilation in eyes with angle closure.
- Calculating iris volume using a time-domain OCT may not be reliable because only a limited number of B-scans can be acquired at one time.
- A new swept-source anterior segment OCT collects 128 radial B-scans and allows a detailed biometric analysis of the iris with built-in software. Like that the relationship between iris configuration and anterior chamber angle dimensions can be visualized and analyzed.
- Another important measurement derived from this imaging of the iris is the area and extent of involvement of peripheral anterior synchia (PAS).
- The presence and extent of PAS is a defining criterion of primary angle closure (PAC). It has been shown to be associated with the level of intraocular pressure (IOP) and development of PACG.
- Three-dimensional biometric analysis of the iris and anterior chamber angle would provide mechanistic insights into the development and progression of angle closure glaucoma.

The iris and primary angle closure glaucoma

Primary angle closure glaucoma (PACG) has a high risk of visual loss, accounting for 3.9 million people with bilateral blindness worldwide in 2010. While a small anterior chamber depth (ACD), a short axial length, and a thick and anterior lens position are established risk factors for PACG, the iris also contributes to angle closure. With biometric analysis of the iris imaged by the anterior segment optical coherence tomography (OCT), increased iris thickness, iris area and iris curvature have been reported to be independently associated with narrow angles (posterior trabecular meshwork not visible for ≥180°).

In contrast to ultrasound biomicroscopy, the anterior segment OCT allows high speed, non-contact imaging of the anterior segment at specific angle meridians. These features help to track iris dynamics. In fact, two recent studies suggest that the iris behaves differently in eyes with angle closure compared with normal eyes. Using a time-domain anterior segment OCT (Visante® OCT, Carl Zeiss Meditec, USA), Quigley and colleagues compared the change in iris cross-sectional area in 29 subjects with angle closure suspect, primary angle closure (PAC) or PACG and 36 eyes with open-angles and showed that the decrease in iris cross-sectional area after pupil dilation was less in eyes with suspected or definite angle closure. Using the same OCT instrument, Apte and Denis demonstrated that while iris volume (calculated from 4 B-scans captured at the vertical, horizontal and two oblique meridians) decreased by 15% after pupil dilation in eyes with open angles, it increased by 11% after pupil dilation in 30 fellow eyes of 30 patients who had an episode of acute angle closure. Although the disparity in iris response to pupil dilation requires further validation, these studies highlight the value of iris imaging to study angle closure mechanisms and dynamics.

Imaging and measuring the iris with swept-source optical coherence tomography

Limited by a relatively slow scan speed, the time-domain anterior segment OCT cannot image the iris for 360° in one single capture. The Visante® OCT (Carl Zeiss Meditec, USA) takes 0.125s whereas the slit-lamp OCT (Heidelberg Engineering, Germany) takes 1s to capture one B-scan of the anterior chamber. Although the advent of spectral-domain OCT substantially increases scan speed, most commercially available instruments are designed for imaging the macula and the optic disc and may not be optimized for anterior segment imaging. A new swept-source anterior segment OCT (Casia® OCT, Tomey, Nagoya, Japan) facilitates three-dimensional 360° analysis of the iris and anterior chamber angle (Figure 1). Detailed biometric analysis of the anterior chamber angle and the iris including measurement of the angle opening distance, trabecular iris angle, trabecular iris space area, angle recess area, iris curvature, and iris volume can be performed with the aid of built-in software (Figure 2). The iris is a dynamic structure with irregular surfaces. In the swept-source anterior segment OCT, the anterior and posterior boundaries of the...
iris are automatically detected in multiple cross-sectional OCT images and the volume of the iris is then computed. The iris boundaries can be manually adjusted if automated segmentation is considered erroneous. Figure 3 illustrates the dynamic response of the iris in an eye with primary angle closure imaged in room light and after pharmacological dilation. In this eye, the iris volume reduced from 41.9 mm³ to 33.0 mm³ after pupil dilation.

Where are we going with iris imaging?

Volume scan of the iris with the swept-source OCT provides a more reliable and accurate computation of iris volume compared with time-domain OCT. With 360° imaging of the anterior chamber, the relationship between iris configuration and anterior chamber angle dimensions can be visualized and analyzed at different meridians. In addition, the area and the extent of involvement of peripheral anterior synechia (PAS) can be quantified. PAS is a defining criterion of PAC and the extent of PAS (semi-quantitatively measured with gonioscopy in terms of clock hour involvement) has been shown to be associated with the level of IOP and development of PACG. However, quantifying the development and progression of PAS objectively and reproducibly has been problematic with gonioscopy. With the swept-source OCT technology, PAS is measured by detecting the scleral spur and the iris end-point in individual B-scans. A polar plot can then be constructed for measurement of the area (the region bounded between the scleral spur (indicated in red) and the iris end-point (indicated in green)) and the extent of PAS (Figure 4). Tracking the change of the area and degree of PAS involvement would be clinically important to monitor any progression in PAS and development of glaucoma.

The development of high-speed anterior segment OCT imaging devices will enable the study of the structure and dynamics of the iris. With the advent of new software to process high volume OCT data, precise and reliable measurement of various iris parameters is attainable. Three-dimensional biometric analysis of the iris and anterior chamber angle would provide mechanistic insights into the development and progression of angle closure glaucoma.

References