Anterior Segment OCT for Glaucoma Clinics

Is the UBM era over?

BY HIROSHI ISHIKAWA, MD

Except for slit-lamp photography, Scheimpflug photography is probably the oldest anterior segment imaging modality that provides various quantitative measurements of the anterior segment anatomy.1-3 Regular B-mode ultrasound could not provide sufficient resolution to perform specific and sophisticated analysis.4 In 1991 (coincidentally, the same year Huang et al published the first article on optical coherence tomography [OCT] in Science5), Pavlin et al introduced a clinical application of high-frequency ultrasound or ultrasound biomicroscopy (UBM).6 By using a higher range of frequency (50-100 MHz) than conventional ultrasound (5-20 MHz), UBM achieves a higher axial resolution (approximately 25 µm). After its introduction, UBM dominated the field of anterior segment imaging until the first commercial anterior segment OCT (AS-OCT) unit was introduced in 2005 (Visante OCT; Carl Zeiss Meditec, Inc., Dublin, CA).7-13 Has AS-OCT replaced UBM?

UBM VERSUS AS-OCT

The UBM scanner requires a coupling medium between the subject’s eye and the probe.14 Conventionally, a water bath technique with a small plastic eye-cup was used to hold the medium.15,16 Later, thin latex caps holding the medium replaced the water bath method to improve patients’ compliance. This change also allows those performing the measurements to scan subjects while they are sitting or prone in addition to supine, which was the only option with an open water bath.17 Although it does not require direct contact, UBM can still be invasive, especially after surgery or trauma.

AS-OCT has several advantages over UBM, including true noncontact scanning, higher axial resolution (18 µm vs 25 µm), and a faster sampling rate (2.0 kHz vs 0.8 kHz).18-21 UBM, however, has a clear advantage over AS-OCT in terms of the depth of penetration (5 mm vs approximately 2 mm). This capability is especially useful for visualizing structures behind the iris and sclera, where the OCT scanning beam cannot reach (Figure 1). In addition, hyphema and other conditions can obstruct the OCT scanning beam.

OCT is therefore useful for corneal imaging and basic assessments of the anterior chamber angle, but it is not
suitable for confirming plateau iris configurations (the ciliary sulcus must be visualized) and ciliary body tumors/cysts. OCT is also useful for evaluating the bleb after filtering surgery because of the technology’s true noncontact scanning. Although UBM provides higher-quality visualization of blebs, this form of imaging can only be performed after the wound has completely healed.

**ALL-IN-ONE OCT**

Anterior and Posterior Imaging

Because AS-OCT is designed and optimized for scanning the anterior segment, it has different optics and uses a longer-wavelength light source than conventional posterior segment OCT units (1.3 µm vs 820-840 nm). For this reason, AS-OCT was first commercialized as a stand-alone, single-purpose unit for the anterior segment application (Figure 2A). There has been a significant demand from general ophthalmologists, however, to combine AS-OCT with posterior segment OCT as a way of saving space and money. Now, two commercial posterior segment spectral domain OCT devices can provide anterior segment imaging. This option allows an all-in-one OCT solution that covers both anterior and posterior segment imaging. Moreover, it brings all the benefits of spectral domain OCT technology to anterior segment imaging: faster scanning (26 kHz) and a higher axial resolution (approximately 5 µm). The latter makes it possible to visualize not only the trabecular meshwork but also Schlemm’s canal.

**The RTVue**

To image the anterior segment, users need to obtain special object lenses that can be attached to the RTVue scanner (Optovue Inc., Fremont, CA). Several types of scans are dedicated to anterior segment imaging for both corneal and glaucoma applications. One provides a signal-averaged image by taking multiple scans at the same location in order to improve the signal-to-noise ratio (Figure 2B). Unlike competing devices, the RTVue’s software offers the most advanced anterior chamber angle quantitative tool, which allows users to measure the trabecular-iris segment area (TISA) and the conventional angle opening distance (AOD) 500 and 750 µm anterior to the scleral spur with assistance from the software.

AOD was first proposed by Pavlin et al for quantitative assessments of the anterior chamber angle using UBM. Later, Ishikawa et al proposed angle recess area (ARA), which is an improved extension of the AOD measurement. The ARA measures an area bounded by a roughly triangular space between the angle recess, the corneal endothelium, the iris’ surface, and a line perpendicular to a point on the corneal endothelium that is 750 µm anterior to the scleral spur. Theoretically, the ARA more accurately quantifies the angle, because it reflects variable undulation of the iris’ surface. Both the AOD and the ARA are well established and widely used for quantitative UBM analysis.

Because it cannot clearly visualize the angle recess and the iris’ surface near the scleral spur, AS-OCT cannot properly measure the ARA. Radhakrishnan et al proposed the TISA method, which does not require clear visualization of the angle recess. It is therefore more suitable for AS-OCT. TISA-X is defined as an area bounded by a roughly trapezoidal shape between the scleral spur, a point on the corneal endothelium X µm

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**Figure 2. AS-OCT images of the anterior chamber angle.** The angle is open angle with relative papillary block (anteriorly bowed iris) as seen with the Visante OCT. Although the ciliary body is visible, the ciliary process is obscured behind the iris (A). A narrow angle is evident with the RTVue. Detailed angle structure is obscured due to the device’s shorter wavelength compared with the Visante OCT, but the former’s higher axial resolution allows visualization of Schlemm’s canal (arrowhead) (B). The Cirrus HD-OCT detects a narrow angle in the same eye seen in Figure 2B. Detailed angle structure is obscured here as with the Visante OCT image, but Schlemm’s canal is visible (arrowhead) (C). Abbreviations: C, cornea; CB, ciliary body; S, sclera. Black and white arrows indicate the scleral spur.
anterior to the scleral spur, and the intersections of the iris’ anterior surface with perpendicular lines drawn from the first two landmarks. The Analysis Tools on the RTVue allow TISA-500 and TISA-750 measurements with the software’s assistance. After locating the scleral spur, the user specifies a point on the corneal endothelium anterior to the scleral spur (distance is automatically locked to either 500 or 750 µm) and two more points on the iris’ surface, where perpendicular lines from the scleral spur and other corneal point intersect. Although these points are entered manually, because the assisting software does not allow divergence from the perpendicular lines, the measurements’ consistency is reasonably maintained.

The Cirrus HD-OCT
For anterior segment imaging, the user must obtain an anterior segment imaging license for the Cirrus HD-OCT system’s software (Carl Zeiss Meditec, Inc.). No hardware modification or additional attachment is needed. The types of scans available are the same as for the device’s retinal counterpart: a series of five high-resolution slices or three-dimensional cube imaging (Figure 2C). Although the Cirrus software does not provide measurement tools specifically for the anterior chamber angle, users can still measure distances and angles as with any other imaging device.

Drawback
All-in-one solutions use an approximately 840-nm light source, which emphasizes the weakness of AS-OCT: the depth of penetration is shorter than 1.3 µm (dedicated UBM). The iris can be fully visualized with the dedicated AS-OCT system, but that is the end point. Visualizing any structure behind the iris can be a real challenge with AS-OCT. For cases requiring clear visualization behind the iris (eg, indo-ciliary cysts, tube implants, and aqueous misdirection), UBM is still the best imaging device to answer important clinical questions.

CONCLUSION
AS-OCT provides quick and patient-friendly imaging of the anterior segment. This modality is useful for distin-

guishing angle closure from open-angle cases as well as for assessing the bleb during the early postoperative period. When structures behind the iris are involved, however, UBM has a clear advantage over AS-OCT. Eye care specialists should therefore use both technologies in a complementary fashion on a case-by-case basis. AS-OCT and UBM are not meant to be competitors.

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