The Role of UBM 
and Anterior Segment OCT in Anterior Segment Imaging

M. Chockalingam DNB FRCS PGDHM
N. V. Arulmozhi Varman MS

Since its development and usage, Ultrasound biomicroscopy (UBM) (Figure 1) has been the gold standard for the objective and quantitative assessment of the anterior chamber especially the angle. The recent introduction of Anterior Segment Optical Coherence Tomography (AS-OCT) (Figure 2) has offered another imaging option and thereby evoked a debate on the pros and cons of each system viz – a – viz the other.

Technological Basis

Introduced by Charles Pavlin and co-workers, Ultrasound Biomicroscope (UBM) incorporates a high frequency ultrasound transducer used with a frequency of 35 – 50 MHz. The most frequently used device carries a polymeric, 50 Mhz transducer with a resolution of 50 microns. This high frequency is needed since the anterior segment has a depth of 4 – 5 mm and the structures are close to each other. The images obtained with the 50 Mhz probe are 5 mm wide but a 35 Mhz version covers the entire anterior segment. The lateral and axial physical resolution of the 50 MHz probe is 50 and 25 microns respectively and the depth of penetration is 4 – 5 mm. This technique can produce eight frames of cross – sectional images per second and since it uses sound waves, can capture images through opaque media. The speed of acquisition of images with UBM is 1-5 seconds.

The patient lies supine and a plastic ring containing saline or gel holds the lids open and allows immersion of the probe. Images are seen through the monitor and the operator conducts the examination holding the probe. UBM reaches specific areas of the eye such as the lens, zonules, ciliary body, pars plana, peripheral retina and superficial vitreous body.

Address for correspondence: Dr. M. Chockalingam, Uma Eye Clinic, Chennai
Anterior Segment Optical Coherence Tomography (AS – OCT) employs light instead of sound to determine tissue depth and relies on the principle that two waves of light in the same phase amplify each other while two waves of light out of phase cancel each other. It is used with the patient seated in the upright position. A Michelson interferometer determines the time required for the reflected light to return to the transducer. Anterior Segment Optical Coherence Tomography (AS – OCT) uses a 1.3 micrometer wavelength super luminescent LED light, which is better suited for imaging of the anterior chamber angle due to certain reasons. At this wavelength, the amount of scattering in tissue is less thereby enabling greater penetration of light through inherently scattering ocular structures such as the sclera and iris. Secondly, since water in the ocular media absorbs the 1.3 micrometer wavelength light, only 10% of the incident light on the cornea reaches the retina. This improved retinal protection allows use of high – powered illumination, which in turns enables high – speed imaging. The speed of acquisition with the AS – OCT is 3.3 seconds. The high speed acquisition of 4000 axial scans / sec eliminates motion artifacts, reduces examination time, allows rapid survey of relatively larger areas and enables imaging of dynamic ocular events. The axial resolution of the 1.3 micrometer light source is 18 microns and the depth of penetration is 6 mm. Like UBM, AS – OCT generates eight frames of cross – sectional images per second, but the limitations of its optical principles makes it suitable only for imaging through clear media.

**Indications for UBM and AS – OCT**

While both UBM and AS – OCT are useful for imaging the anterior segment, the bio – mechanics of each confers particular advantage on imaging certain conditions of the anterior segment which the other may not be able to do with perfection.

The 1.3 micrometer light of AS – OCT is unable to penetrate iris pigments adequately (except in albinos) and thereby cannot image structures and lesions behind the iris plane, namely the ciliary body and peripheral retina. This makes determination of presence of plateau iris configuration impossible. Plateau iris configuration is characterized by closure of the angle at the peripheral recess that is associated with relatively deep central anterior chamber. Plateau iris configuration is caused by anterior rotation of ciliary process and occasionally it may be caused by iridociliary cysts and / or iridociliary tumors neither of which can be visualized by AS – OCT. Since the UBM can penetrate the iris, this imaging modality can show the etiology of plateau iris configuration (Figure 3) Complications involving structures lying behind the iris such as choroidal detachment not clearly shown by the AS – OCT are also best seen by the UBM.

**Figure 2 – Anterior Segment – OCT**

**Figure 3 – UBM of an eye with a complete plateau iris configuration and showing a clear view of the ciliary body. Note the narrow image as captured by the UBM**
While UBM is useful for assessing the bleb’s status in patients with previous filtration surgery\(^9-11\), this approach is risky, can be stressful and not 100% safe. AS – OCT due to its non – contact method of analysis, is useful in assessment of anterior chamber angle and bleb status in eyes with history of trabeculectomy\(^12\). In eyes with positive Siedele’s test due to unhealed incisions and / or conjunctival button holes, where the use of UBM is contraindicated, AS – OCT due to its non – contact mode of examination is safe and a superior choice. Similarly, AS – OCT is safe in evaluating anterior chamber and angle details in eyes with compromised ocular or surface integrity like

(1) Confirmed or suspected globe laceration or perforation
(2) Recent intraocular surgery
(3) Perforated corneal ulcer

In these cases, AS – OCT’s non – contact modality eliminates the risk of mechanical abrasion and further aggravation of the condition that may occur on assessment with UBM.

Pros and cons of UBM

In the UBM the use of open transducer with no covering membrane over the piezoelectric crystal may damage the cornea on direct contact; therefore the use of a water bath is mandatory which is created with an eye cup in a palpebral fissure filled with 1% or 2% methylcellulose solution. The procedure can be performed in any position though it is best comfortably and accurately done with the patient in supine position. The crystal of the transducer should be placed approximately 2 mm from the eye surface. Too closer placement of the probe increases the chances of injury to cornea which though is prevented by software in the instrument. The size of the image in a 50 MHz UBM is relatively small and it takes at least three scans per axis to obtain a complete picture of the anterior segment. The procedure requires some training to be performed and good co – operation on the part of the patient, is at times messy and stressful to the patient, time consuming and causes discomfort to the patients due to placement of the eye cup. It is particularly difficult to perform in eyes with deep socket, in children and uncooperative adults. Due to the contact nature of the procedure it is not 100% safe to do the procedure in eyes with bleb post trabeculectomy and UBM is contra indicated in eyes with compromised structural or surface integrity.

However, the UBM is very useful in evaluating plateau iris configuration and performing a host of dynamic procedures like

(1) Indentation UBM gonioscopy
(2) Changes in anterior segment morphology and angle configuration following Valsalva maneuver like thickening of the ciliary body, increase in iris thickness and narrowing of AC angle recess.

The UBM like AS – OCT is useful for objective analysis of the AC angle. However, due to its cost, size, time required and requirements of patient position and discomfort, UBM is not very useful as a screening tool in angle closure glaucoma.

Unlike the AS – OCT, the UBM can capture images through opaque media. In the UBM penetration of light through inherently scattering ocular structures such as the sclera and iris, enables imaging up to anterior layers of lens, zonules and anterior vitreous.

Pros and cons of AS – OCT

The AS – OCT is non – contact and performed with the patient in the sitting position. Since the AS – OCT does not require contact with the eye; it avoids mechanical distortion of the structures to be examined. The procedure is easy to perform, requires less training and is rapid. It is comfortable to the patient and is easy to perform in perform in eyes with deep socket, in children and in otherwise
uncooperative adults. Since the procedure can be performed in a sitting position, we can study angle dynamics in physiological position. Due to the non-contact nature of the procedure it is 100% safe to do the procedure in eyes with bleb post trabeculectomy and can be used with ease in eyes with compromised structural or surface integrity.

The non-contact mode of evaluation provides a pertinent advantage in the planning wound modulation following surgery. The AS-OCT due its non-contact mode of examination is helpful in evaluating in the following

1. Central corneal thickness of the eye (Figure 4)
2. Evaluation of tear film in individuals with dry eyes and epiphora (Figures 5 and 6)
3. Evaluating the positioning of the implantable contact lens in the eye (Figure 7)

The UBM is not helpful in evaluating any of these three parameters in the eye.

A potential significant advantage of this technology is that it may be used in complete darkness. Any changes in ocular configuration that are induced by ambient lighting are thus eliminated. Therefore, the AS-OCT is useful for dynamic evaluation of angle structures and their study in physiological conditions like

- Light and dark
- Accommodation

Since the AS-OCT is unable to penetrate iris pigments adequately, it cannot image structures posterior to the iris, namely the ciliary body and peripheral retina (Figure 8). There are also reports of difficulties in recognizing the scleral spur in a significant percentage of patients. While performing AS-OCT, the upper and lower lids come in field of view thereby obstructing imaging of the superior and inferior angle. The examiner has to manually lift up the eyelids to get a proper view. The AS-OCT cannot acquire images through opaque media.
Figure 8 – Anterior Segment OCT image with defective outlining of the ciliary body. Note the wide image as imaged by the AS – OCT

Conclusion

Though their indications do not overlap, UBM and AS – OCT have their specific advantages and uniqueness in their role in anterior segment imaging. Ideally both should be used in glaucoma evaluation, though in reality clinicians do not always have the luxury to have both imaging modalities.

The two modalities differ in their ease of use with the UBM, unlike that of AS – OCT necessitating longer training and reasonably good understanding of the anatomy of the anterior segment on the part of the examiner. However, the quality of images captured by the UBM, especially of the peripheral angle recess is slightly better than that of the AS – OCT. UBM provides a detailed view of the structures behind the iris that cannot be viewed with the AS – OCT. On the other hand, the non – contact nature of the AS – OCT provides a very patient friendly modality and makes easy imaging even of vulnerable eyes. Ultimately both modalities are useful for qualitative and quantitative assessment of the anterior chamber and angle of the eye and therefore it is for the individual physicians to choose the platform that suits their preferences and needs.

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>UBM</th>
<th>AS – OCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basis of functioning</td>
<td>High – frequency ultrasound</td>
<td>Coherent light</td>
</tr>
<tr>
<td>Patient position</td>
<td>Supine</td>
<td>Upright and seated</td>
</tr>
<tr>
<td>Contact or non – contact</td>
<td>Contact mode</td>
<td>Non – contact</td>
</tr>
<tr>
<td>Immersion required</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Image size</td>
<td>Narrow</td>
<td>Wide</td>
</tr>
<tr>
<td>View of posterior chamber</td>
<td>Excellent</td>
<td>Poor</td>
</tr>
<tr>
<td>View of ciliary body</td>
<td>Excellent</td>
<td>Poor</td>
</tr>
<tr>
<td>Duration of study</td>
<td>More</td>
<td>Fast</td>
</tr>
<tr>
<td>Patient comfort</td>
<td>Less comfortable</td>
<td>More comfortable</td>
</tr>
</tbody>
</table>
References:


