Ultrasound Biomicroscopy

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The ultrasound biomicroscope works on the principle of an ultrasound but at a higher frequency. The normal B scan probe works at a resolution of 10 to 12 MHz while the UBM probe works at a frequency of 35 - 50 MHz or higher. The basic parts of a UBM are the same as that of a standard ultrasound and consist of a handpiece with transducer, a computer console which has the required hardware and software specific for the purpose, a monitor, a printer and a foot switch (Fig. 1). The UBM software has special measuring features for measuring thickness of tissues or measuring angles. Unlike a B scan probe where the transducer is sealed inside along with its coupling media the UBM probe requires a medium. While the Paradigm UBM uses a PMMA cup with Methyl Cellulose as coupling agent, most of the other machines have a silicon cup with water as the coupling media. The probe sweep can be set for a sweep of 200 or 300. The transducers in the newer machines are threaded on and can easily be interchanged for one of a different frequency (Fig. 2). In the Paradigm machine the transducer is mounted on a gantry while for the Sonomed, OTI Technologies and Appasamy Gantec the transducer is relatively light in weight and can be hand held. The UBM has a low penetration because of high frequency and should be kept at least 11mm from the cornea. The sweep at maximum setting includes 256 A scans coupled to give a B image and consists of an area of pixels. The raw picture can be saved and recalled to make measurements. If necessary the procedure can be recorded in Windows media format as video and played back later. The probe should be oriented perpendicular to the scanning tissue for best pictures.

Room lighting, fixation and accommodation affect anterior segment anatomy and should be taken care of, when doing quantitative assessments or follow up scans.

The Normal Eye

The cornea, anterior chamber, posterior chamber, the angle and ciliary body can be easily seen (Fig. 3). The anterior lens surface also can be visualised. Anatomy of the angle is complicated and the important landmark is the scleral spur. This is constant and located where the trabecular meshwork meets the interface between scleral and ciliary body. The iris has a planar configuration with slight anterior bowing...
Narrow angle glaucoma

UBM is a useful tool in narrow angle glaucoma (Fig.4) where the cause could be abnormal size or position of one of the structures in the angle. Glaucoma can be caused by pupillary block, plateau iris, phacomorphic element or other forces.

Angle closure

With the UBM it is easy to note and confirm the narrow angle. The angle can be measured and if necessary the angle can be measured in bright light where the pupil constricts and in darkness where the angle tends to narrow because of dilatation.

Phacomorphic glaucoma

The subluxated lens may cause a shallowing of the anterior chamber or an already shallow AC maybe compromised by a bulky lens. The subluxated lens on UBM may show in addition to a shallow AC weak zonules.

Malignant glaucoma

In this condition there is pooling of aqueous behind the lens pushing the lens iris diaphragm against the cornea. UBM will confirm a flat anterior chamber with all angle structures being pushed anteriorly with or without fluid in the supraciliary space.

Other causes like tumours, cysts, ciliary body enlargement due to inflammation or tumour and air or gas bubbles after intraocular surgery may present as angle closure. This can all be diagnosed by UBM.

Open Angle Glaucoma

The only type of open angle glaucoma with a characteristic picture on UBM is pigment dispersion syndrome. In this condition there is mechanical friction between the posterior iris and the anterior zonules releasing pigment into the aqueous stream.

UBM findings include a wide open angle, an iris with posterior bowing resulting in a concave iris and increased iridolenticular contact. There is a pressure gradient between the anterior and posterior chambers and laser iridotomy sorts out this problem and the iris gets back its normal configuration.

Abnormalities of the Iris and Ciliary Body

UBM can be used to distinguish solid tumours from cystic lesions and the size of the lesion can be documented. UBM can differentiate traction detachment from dehiscence of the ciliary body.

Pupillary block

This is the commonest cause where there is iridolenticular touch and pooling of the aqueous in the posterior chamber. This leads to angle closure and can be relieved by a YAG laser iridotomy. UBM will show that all other anterior chamber structures are normal in structure and anatomy.

Plateau iris

Here the ciliary body is more anterior in location pushing the iris forward. The iris root may be short and inserted anteriorly on the ciliary body. The iris may be flat or convex and the anterior chamber of medium depth indentation gonioscopy shows a characteristic double humped iris the two humps being at the ciliary body and the lens and the dip being at the space between ciliary body and the lens. This can be confirmed by using an indentation cup made of plastic which depresses the limbus during UBM. It is a variant of indentation gonioscopy.

Fig. 4 Narrow Angle

Fig. 5 A case of scleritis with localised ciliochoroidal effusion
In cases with pars planitis where there is no view of the posterior segment UBM will show dot like opacities in the anterior vitreous and pars plana. There will be exudates in the inferior portion of the ciliary body and the pars plane. UBM may help to better time the surgery.

In scleritis and episcleritis UBM helps to better localise the pathology.

Fig. 5 A case of scleritis with localised ciliochoroidal effusion

**Ocular Trauma**

When view of the anterior segment structures is blocked by hyphaema UBM can be used to assess the structural damage and to localise foreign bodies though this can be extremely difficult. Angle recession can be differentiated from cyclodialysis.

In angle recession the ciliary body face is torn from the iris insertion with a wide angle with no disruption between the ciliary body and sclera. In contrast in cyclodialysis the ciliary body is separated from the sclera resulting in direct access of aqueous into the suprachoroidal space.

Foreign bodies generate echoes depending on the type of material. Wood and concrete create shadowing artefact by absorbing most of the incoming ultrasound. Scleral sutures also show shadowing. Glass and metal foreign bodies generate comet tail echoes by reflecting ultrasound back and forth within the material.

Fig. 7 Foreign body in the angle with comet tail echoes and localised corneal opacity

**Postoperative Evaluation Laser iridotomy details**

UBM is very useful to evaluate the patency of YAG laser iridotomy under different conditions. If patency cannot be studied by the slitlamp, UBM is useful.

**Post trabeculectomy blebs**

UBM also helps us to know the status of a drainage bleb, whether functional or not and if functional if it is diffuse or cystic.

Fig. 8 Functional trabeculectomy with iridectomy

**Sclerostomy sites**

Sclerostomy sites after vitrectomy can be studied to see if the site has healed well, if it has gaped internally or covered by a plaque. It is useful to study vitreous incarceration, fibrovascular proliferation and anterior hyaloid fibrovascular proliferation. Recurrent vitreous bleeds can be due to fibrovascular proliferation.

Fig. 6 Blunt trauma with hyphaema: 1. Angle Recession 2. Subluxated Lens 3. Subconjunctival Haemorrhage
Intraocular lens position

Intraocular lens optics and haptics give foreign body type echoes. The capsular bag cannot be localised and so the position of the haptic is used to identify if the loop is in the sulcus, bag or dislocated.

Presurgical Evaluation
Prekeratoplasty evaluation

Where the cornea is opaque UBM gives a lot of information on the status of all structures in the angle and helps the surgeon to better plan for surgery.

Evaluation for secondary lens implantation

The integrity or absence of the posterior capsule can be studied prior to secondary lens implantation. This is useful especially in cases with nondilating pupils with extensive posterior synechiae. Synechiae can also be picked up on the UBM

Quantitative Measurement

UBM helps in precision measurement and refers to the width and height of a pixel which can be measured by the operator using the screen cursor. The UBM software calculates the distance and area by measuring the number of pixels and multiplying it appropriately. The UBM can resolve measurements greater that 25 micrometer axially and 50 micrometer laterally. The Paradigm is supposed to be slightly better than the OTI Technologies machine in giving better resolution.

Piero et al. compared corneal thickness measurements by UBM, Ultrasonic Pachymeter and Optical Pachymeter. The first two methods had a strong correlation.

Measurement reproducibility

Various studies done by Tello et al. and by Urbak et al. showed strong intraobserver repeatability except for angle opening distance, but weak interobserver reproducibility.


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<thead>
<tr>
<th>Name</th>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>Angle opening distance</td>
<td>AOD</td>
<td>Distance between the trabecular meshwork and the iris at 500 micron</td>
</tr>
<tr>
<td>Trabecular-iris angle</td>
<td>TIA 01</td>
<td>Angle of the angle recess</td>
</tr>
<tr>
<td>Trabecular—cilary process distance</td>
<td>TCPD</td>
<td>Distance between the trabecular meshwork and the ciliary processes 500 micron anterior to the scleral spur</td>
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<tr>
<td>Iris thickness</td>
<td>ID1</td>
<td>Iris thickness at 500 micron anterior to the scleral spur</td>
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<tr>
<td>Iris thickness</td>
<td>ID2</td>
<td>Iris thickness at 2 mm from the iris root</td>
</tr>
<tr>
<td>Iris thickness</td>
<td>ID3</td>
<td>Maximum iris thickness near the pupillary edge</td>
</tr>
<tr>
<td>Iris—cilary process distance</td>
<td>TCPD</td>
<td>Distance between the iris and the ciliary process</td>
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<tr>
<td>Iris-zonule distance</td>
<td>IZD</td>
<td>Distance between the iris and the zonule along the line of TCPD</td>
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<tr>
<td>Iris-lens contact distance</td>
<td>ILCD</td>
<td>Contact distance between the iris and the lens</td>
</tr>
<tr>
<td>Iris-lens angle</td>
<td>ILA 02</td>
<td>Angle between the iris and the lens near the pupillary edge</td>
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Clinical evaluation of Quantitative Biomicroscopy

This measurement can be used to measure infant eyes and follow up changes in angle as they age and also to study differences between normal and narrow angles.

The effect of pilocarpine which opens up narrow angles and at the same time narrows open angles has been studied.

The difference in angle anatomy with YAG iridotomy and throwing a bright light have also been studied.
Collagen implants placed under scleral flaps have been monitored and these disappear over 6 to 9 months. They are found to leave behind a tunnel in the sclera.

The height and area of ciliary body and iris tumour can be studied\(^\text{10}\).

**Future**

As of now UBM is an indispensable tool for anterior segment analysis and with newer and better software and algorithms we will see a lot of the calculation process being automated. What would be interesting to watch is how much of the UBM’s functions will be replaced by Anterior Segment OCT.

1. Ultrasound Biomicroscopy of the Eye by Charles J. Pavlin, F. Stuart Foster

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