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Ultrasound Biomicroscopy & Glaucoma Care

Visualizing angle closure and its mechanisms from screening to post-surgical assessment improves treatment outcomes.

By Ike K. Ahmed, MD, FRCSC

Many of us have utilized optical and ultrasonic imaging technologies for both the anterior and the posterior segment, so we have a good idea of where the strengths and weaknesses lie for these technologies. Training in Toronto where Chuck Pavlin, MD, and Stephen Foster, MD, FACS, invented ultrasound biomicroscope (UBM) technology, I have seen its iterations over the years. Today, it is a very practical, efficient, comfortable and high-yield tool — a fact that perhaps is a little surprising to those who haven't yet used the latest device.

UBM and anterior segment imaging play an integral role in how I screen for glaucoma, choose and assess the efficacy of treatment and improve surgical outcomes. Specifically, its anterior segment imaging capabilities are now an essential component of my workup for glaucoma patients, particularly those with questionable mechanisms of glaucoma/IOP elevation, narrow angle or angle closure.

Imaging Choices

For anterior segment imaging, our options are Scheimpflug imaging, UBM, traditional OCT and spectral domain OCT. In patients with glaucoma, Scheimpflug imaging has high reflectivity in the angle recess, which makes it very hard to assess what's happening in the angle. We can assess central anterior chamber depth, but we don't have the resolution and clarity necessary for the angle.

UBM is very clean, comfortable and easy to use, and it gives us the visualization we need in seconds. I use the Aviso (Quantel), with the ClearScan probe cover (ESI), a monumental step forward in the utilization of UBM that makes it a fast, clean, "sit down and go" procedure.

Let's look at the advantages of UBM for glaucoma alongside OCT. The resolution is quite good with OCT, but because it uses optical waves, the big limitation is its ability to visualize what's happening behind the iris pigment epithelium. UBM's acoustic waves enable us to see behind the iris to get a complete anterior segment picture.

When we compare UBM and OCT for lesions of the iris and ciliary body, UBM gives us the ability to see the posterior borders of these lesions (iris nevi and iris cysts). We can visualize cyst walls and ciliary body cysts much better with the UBM. OCT certainly delivers very good corneal and anterior chamber angle imaging, but UBM goes deeper (**Figure 1**).

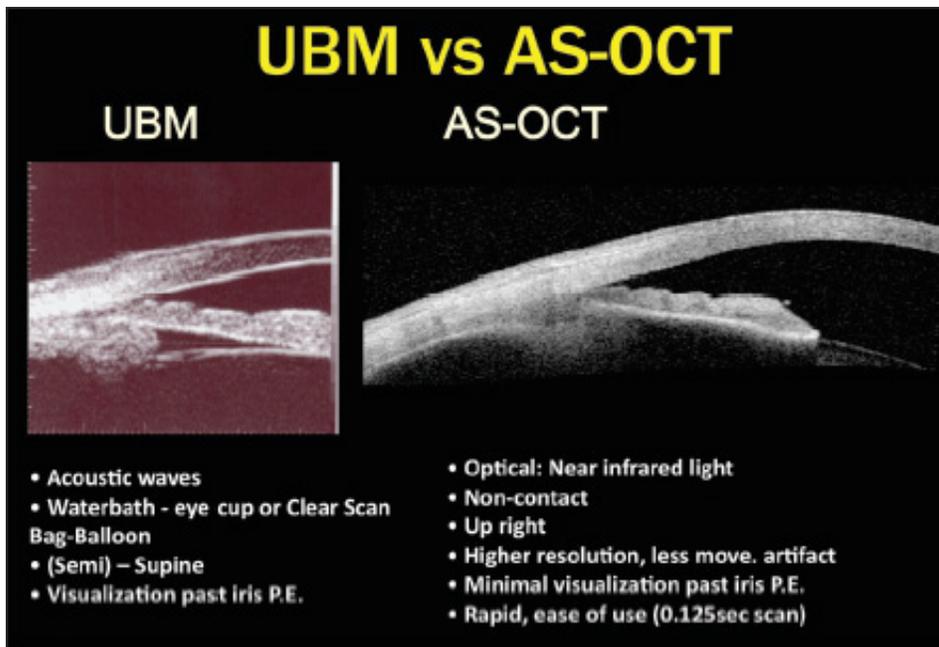


Figure 1. Comparison of UBM and OCT technologies.

Emphasis on Angle Closure

When I mention “angle closure,” colleagues often say, “I don't think I see that very much. It's not going to be an issue in my patient population.” But we're all aware that angle closure glaucoma typically presents as chronic or intermittent angle closure.

Most cases of angle closure are not acute, and they often masquerade as open-angle glaucoma. Every week, I see patients who are referred with open-angle glaucoma, but gonioscopy and imaging show that in fact, the patient has an angle-closure mechanism. Of course, it would have been preferable to identify this earlier.

Depending on the population, in up to 10% of cases I see narrow or occludable angles, which put patients at particularly high risk for angle closure. Although it's especially important to evaluate their angles, we really need to assess the angles in all patients with glaucoma and assess the suspects that concern us. We want to identify the different stages of angle closure:

- Primary angle closure suspects have anatomically narrow angles (180° vs. 270°).
- Primary angle closure occurs with narrow angles, raised IOP and/or peripheral anterior synechia (PAS).
- Primary angle closure glaucoma exhibits all of the above, plus disk and visual field changes. More blindness occurs from primary angle closure than from primary open-angle glaucoma.

Key to understanding angle closure is an awareness of the multiple mechanisms of angle closure and angle narrowing, as well as the effects of surgery. We need a clear picture of the angle and how it occurs.

Gonioscopy and Imaging

Clinically, gonioscopy is the gold standard in terms of our clinical observation, and we typically use an angle classification system such as the Schaffer Classification. Using this system, Grade 2 angle (20° or less) is considered narrow and at risk for angle closure.

Gonioscopy also has its drawbacks, such as the artifact from indentation, artifact from light and the inability to document. It is also difficult and therefore a significant technical skill for the clinician. Imaging, on the other hand, really allows us to have a non-contact, comfortable, objective dark room physiologic assessment of the angle. I look at the tests as adjunctive. Gonioscopy is mandatory in these situations, but imaging adds a lot more value. It enables us to assess, for example, anterior chamber depth, corneal thickness, angle opening distance and the irido-corneal angle. And we can document and follow patients as needed.

Imaging often can be quite revealing when we examine a patient. If we're not quite sure whether the patient has a real narrowing or not, imaging confirms what's going on. In this way, imaging has changed the way that we manage glaucoma. The role of imaging for the disk and retinal nerve fiber layer is often discussed in preferred practice patterns. In our practice, anterior segment imaging has become essential for assessment of the angle.

PI and Post-surgical Imaging

If we follow primary angle closure suspects (patients with narrow angles), we find that almost 20% progress to primary angle closure glaucoma in 2 weeks to 5 years – 30% over 7 years.¹ If we overlook these patients, there is a significant risk of either acute or chronic angle closure, both of which can be more problematic if they aren't addressed quickly. When I talk to my patients with narrow angles about the role of a peripheral iridotomy (PI), I tell them that treatment is important because there is a 20-30% risk of angle closure.

Peripheral iridotomies are the clear choice, but they're not enough. One common mistake is not doing a proper assessment after PI. Studying UBM in our group, we saw that 35% of patients did not have significant opening of their angle after PI.² After PI, 28% of patients may still go on to develop angle closure.³

Why isn't PI always effective? The pupil block mechanism treated by laser iridotomy is the cause of closure for most patients, but other mechanisms are at play in a significant number of patients. Plateau iris and lens-related iris rotation (not so exaggerated as phacomorphia) are two other common conditions. Less common conditions, such as uveal effusion and malignant glaucoma, can cause angle closure as well.

Imaging has enormous value in showing us the mechanisms of the disease as well as the angle. For example, post-surgical evaluation with UBM may reveal plateau iris. If we fail to identify the problem, we might fail to prevent angle closure. Thus, we can't eliminate a patient's risk for angle closure after PI; we need to determine the other mechanisms at play.

Visualizing Closure Mechanisms

If pupil block isn't the problem, which mechanism is causing persistent closure? We look to two other common causes, plateau iris and lens-related iris rotation. We start by distinguishing between the high plateau and the high lens rise, both of which we can assess clinically by looking at the anterior chamber depth and gonioscopy.

Gonioscopy shows normal or shallow anterior chamber depth with a “double hump” or sinusoidal picture for plateau, while high lens rise has a very shallow anterior chamber depth and a “volcano” sign. However, high plateau and high lens rise are often difficult to assess using gonioscopy, but UBM technology allows us to differentiate these mechanisms more easily. And that differentiation is what directly informs our treatment decisions – lens removal versus iridoplasty, for example (Figure 2).

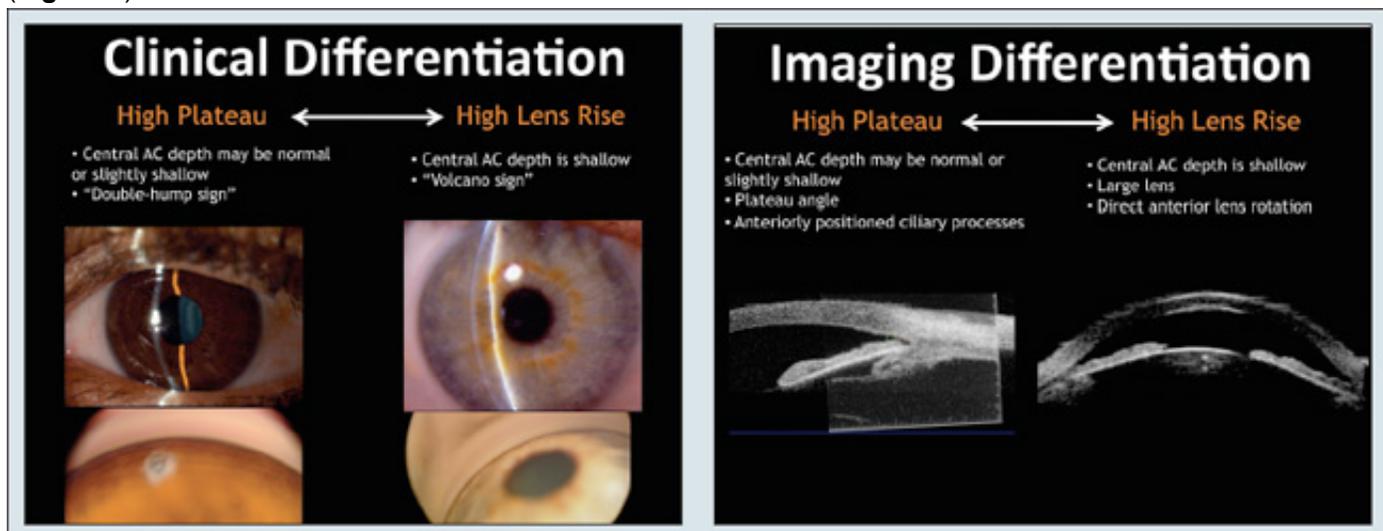


Figure 2. Differentiating high plateau from high lens rise.

If the patient has plateau iris, we can generate a more specific diagnosis. Plateau iris configuration describes the narrow

angle or closure due to plateau iris, but plateau iris syndrome combines configuration with elevated IOP and/or progressive PAS. Plateau iris glaucoma is the syndrome with disk or visual field damage. There are different ways we can treat these problems, and the detail we get from UBM imaging helps guide our choices for therapy.

Removing the crystalline lens can be quite definitive in treating angle closure or angle narrowing caused by the mechanism of lens-related rotation. Endocycloplasty can be used to shrink the ciliary processes – a very good treatment for plateau iris. The treated ciliary processes move to the posterior chamber, allowing opening of the angle. By using UBM imaging to assess patients after PI, we can identify the 35% of patients whose angle closure is not caused by pupil block, identify the mechanism that is at work, choose the appropriate treatment and see that treatment is working.

Beyond the Gold Standard

I hope we all understand the importance of angle assessment. Gonioscopy is still considered the gold standard, but UBM is a very valuable adjunct for determining the angle and its closure mechanism. I don't move forward with my treatment, whether it's screening or PI or post-PI, without proper imaging, and this enhanced modality allows this to be done quickly and easily.

We can visualize not only the outcomes of surgical treatment for angle closure, but also the path of anterior chamber tubes that we've placed in the interscleral passage and the anterior chamber. Even posterior chamber tubes, which are sometimes hard to visualize clinically, are clear with the UBM. In addition, we can assess bleb sizes with UBM to evaluate treatment outcomes.

By using UBM for these purposes, as well as to visualize the mechanisms at work in angle closure from screening to post-surgical assessment, we introduce more detailed practical information into diagnosis and treatment decisions, and we know whether treatment is effective or more therapy is required.

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Maximizing IOL Outcomes with UBM Technology

UBM offers a complete image of the sulcus, adding key information for IOL implantation.

By David R. Hardten, MD, FACS

When my colleagues and I started using UBM several years ago, we were very confident in our ability to visualize IOLs, the natural lens, and the iris using a slit lamp. We didn't feel a strong need to supplement our direct observational findings. But we quickly saw from the perspective of a corneal and lens-based anterior segment surgical practice that UBM technology has many advantages. Added to the other technologies we use, including the slit lamp, Scheimpflug imaging and OCT testing, UBM improves decision-making and follow-up for IOL implantation surgery.

Phakic IOL Screening – Old and New Methods

Because patients with very high myopia often come into my practice, 3 to 5% of my refractive surgeries are phakic IOLs.

Original clinical trials for approval of these lenses only suggested that we use central anterior chamber depth, white-to-white length and slit lamp angle assessment to screen for phakic IOL eligibility. However, even though these original criteria typically were good enough for most patients, some patients experienced complications based on issues related to anterior chamber characteristics.

The white-to-white length does not fully discover the sulcus-to-sulcus dimensions. When choosing the length of a posterior chamber phakic IOL such as the STAAR Visian implant, if the sulcus dimensions are different than the typical relationship between the white to white and the sulcus, an implant that is too long or too short for the eye may be suggested. If for example, the implant is too long for the eye, this can result in plateau iris, angle closure, endothelial cell loss and high IOP. I now follow a patient with a Visian implant who had a very shallow anterior chamber post-operatively and despite anterior chamber taps, viscoelastic deepening and multiple peripheral iridotomies, developed iris ischemia, a subtle anterior subcapsular cataract, as well as endothelial cell loss (**Figure 1**).

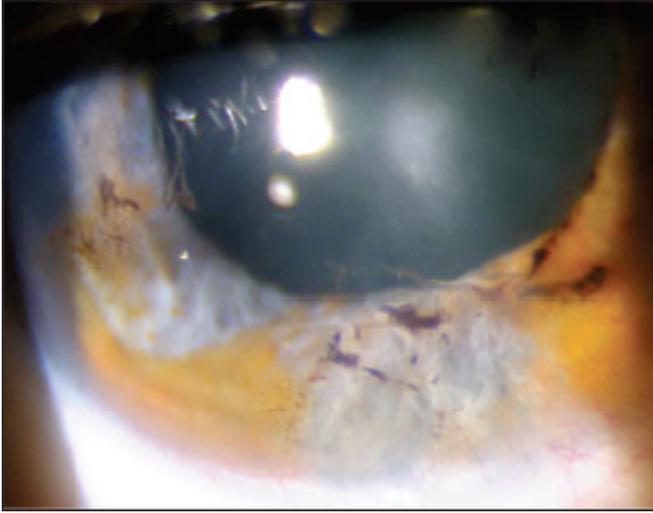


Figure 1. The implant in this patient was too long, resulting in plateau iris, angle closure, endothelial cell loss and high IOP. Despite anterior chamber taps, viscoelastic deepening and multiple peripheral iridotomies, the patient developed iris ischemia, a subtle anterior subcapsular cataract, as well as endothelial cell loss.

Even if the anterior chamber is deep enough for placement of a phakic IOL, it is possible for the iris configuration to be such that an anterior chamber phakic IOL can be problematic. I followed a patient with a Verisyse implant (AMO). Although he fit the parameters used for the clinical trial, he had a high crystalline lens/iris rise combined with a very tight inclination that pushed the Verisyse implant down onto the iris and caused posterior synechia (**Figure 2**).

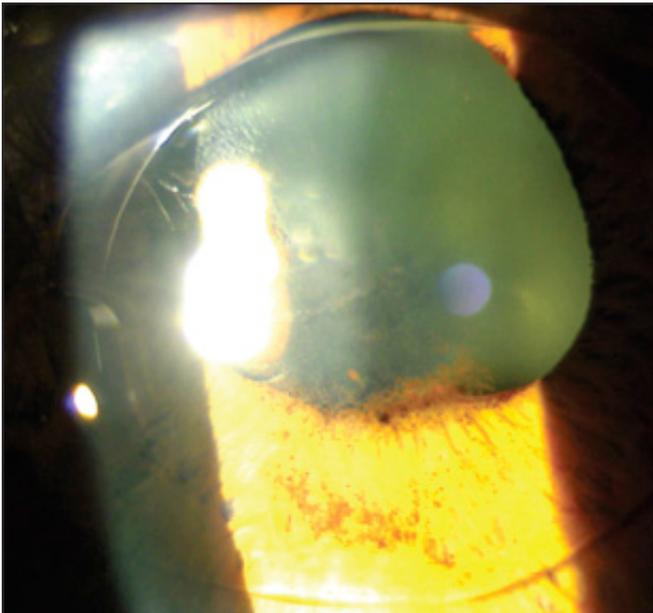


Figure 2. This patient has a fairly high crystalline lens rise combined with a very tight enclavation that pushes the implant down onto the iris and causes posterior synechia.

With a third phakic IOL likely to be approved in the United States next year and a toric version of the Visian near approval in the United States, it is clear that we need to use more advanced clinical tools to guide the use of phakic IOLs.

Planning for “Safety Distance”

With anterior chamber angle-fixated phakic IOLs, we want to create a safety distance of at least 1.5 mm between the edge of the implant and the endothelium. Many anterior chamber angle-fixated IOLs were removed from the market in Europe because they were associated with high levels of progressive endothelial cell loss. Keeping a larger distance between the IOL and the endothelium reduces the chances of endothelial cell loss over time. Screening based only on central anterior chamber depth that doesn't look at the mid-peripheral iris or the distance from the implant to the endothelium is less likely to identify irregularities in some patients.

When we implant a phakic IOL in the posterior chamber without adequate space, it doesn't touch the endothelium, but it does push the iris forward. We want to ensure that if it does, we still have the appropriate safety distance. And the lens does move forward about 20 microns per year, so we also have to plan for the future when we're preparing for surgery.

In the past, we used a variety of different imaging techniques for Verisyse and Visian planning. OCT or Scheimpflug imaging is very useful for placing anterior chamber angle-fixated IOLs because we can see all of the important structures. But right now, most of the phakic IOLs used in the United States are posterior chamber implants. OCT isn't as helpful for these implants because it doesn't provide you with an accurate sulcus image for length or presence or absence of iris cysts.

Scheimpflug imaging shows us the angle and anterior chamber depth. Both OCT and Scheimpflug can show us if a narrow angle configuration would make it impractical to implant the IOL because it would be close to the endothelium or move the iris too close. Neither of these imaging techniques provides enough information about the sulcus, which is helpful in phakic IOL planning, especially for posterior chamber implants.

The Phakic IOL Workup

In my practice, the current phakic IOL workup for Visian and Verisyse lenses includes UBM imaging.

For the Visian lens, we assess the central anterior chamber depth using Scheimpflug imaging, A-scan ultrasound and high-resolution B-scan ultrasound. We measure mid-peripheral anterior chamber depth with Scheimpflug imaging and high-resolution B-scan ultrasound. We still measure the white-to-white distance and compare that to the sulcus-to-sulcus measurement from the high-resolution anterior segment ultrasound.

For Verisyse patients, we also utilize the Verisyse planning software on the Pentacam Scheimpflug camera (Oculus) because it provides a 360° scan of mid-peripheral dimensions. We verify these same mid-peripheral distances with the high-resolution B-scan ultrasound.

We have found that standardizing the image scans improves reproducibility with any IOL scan. Our technicians follow this standardized protocol for using the UBM for any IOL screening or postoperative exam:

- Full scan vertically (right to left)
- Full scan horizontally (superior to inferior)
- Find the longest scans horizontally and vertically
- Save scans
- Measure anterior chamber depth
- Measure iris to endothelium at a 6 mm OZ at a 45-degree angle
- Measure sulcus to sulcus
- Evaluate the scans for cysts or other abnormalities
- Print the scans and their measurements for the horizontal and vertical scans

We still use white-to-white as our primary method of determining the length of the Visian, but we verify it with the more accurate sulcus-to-sulcus dimension on the UBM. If the sulcus-to-sulcus dimensions on ultrasound are 0.4 millimeters or more different than the white-to-white, then we adjust the number that we put into the Visian formula by 0.5. For example, if the white-to-white is 11 mm and the ultrasound measures 11.6 mm, then we adjust the number entered into the Visian

planning software to 11.5 mm (or do the reverse if the ultrasound measurement is lower).

Additionally, the evaluation for iris cysts is very important. Iris cysts are common, and can cause some segmental elevation of the iris in different areas, so we need to be aware of these when we're planning. We really can't image these with the other commonly used technologies of Scheimpflug, OCT or slit lamp evaluation. If there are a few cysts in one meridian, we can rotate the implant to avoid those cysts. If many large cysts are present, then we avoid posterior chamber phakic IOL implantation in that patient.

By utilizing both UBM and Scheimpflug imaging, we can improve the accuracy of our measurements to increase the ability to allow adequate clearance of the IOL to the endothelium when implanting an IOL. The goal is to leave 1.5 mm of long-term clearance, so we typically leave an initial 1.8 mm clearance to allow some room for aging.

More Applications for IOLs

In my practice, I use UBM for many IOL complications that have occurred in the anterior and posterior segment, as well as for preoperative planning. We see patients with IOLs that are displaced or where the IOLs are not easily visualized before corneal transplants. Without UBM, it may not be possible to determine whether the implant is stable in the sulcus or in the capsular bag.

With one-piece IOLs, if the haptic is touching the iris or ciliary body, it may cause pigment dispersion or inflammation. The IOL may vault forward with misplaced haptics, or from asymmetric capsular contraction. UBM helps me plan for keratoplasty or anterior segment reconstruction with clear images of the structures so the proper procedure can be determined.

UBM is very useful for practices that have patients with corneal, glaucoma or anterior segment problems.

Complications despite using standard parameters

Even using the preoperative parameters used in phakic IOL clinical trials, such as anterior chamber depth and slit lamp examination, you can have complications. The addition of UBM technology for sulcus imaging can reduce the chances of these problems.

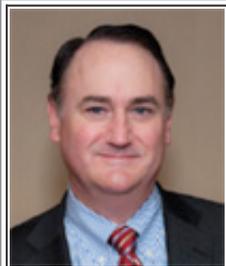
UBM: Clean and Easy

In the past, the problem with using traditional ultrasound in our practice was "the mess." The old water bath technology limited ultrasound in most practical scenarios. Our technicians found it technically challenging, were very concerned about an open shell with a moving nub and they were not able to directly visualize where the corneal surface was located. They were worried about sterility, too, and of course the shell was uncomfortable for the patient.



The ClearScan probe cover changed all that. Now a plastic bag that sits and is moved around directly on the

cornea protects the moving nub. The patient is more comfortable, and the technician is more confident about safety and doesn't have to worry about the probe touching the eye. The process is much more sterile as well, and delivers images that are equivalent to what you get with the shell. The ClearScan cover makes UBM clean and easy as well as effective.



Dr. Hardten is a founding partner of Minnesota Eye Consultants and director of its Clinical Research Department.

When Nothing But UBM Will Do

Utilizing a powerful tool in the diagnosis and management of ocular disease of the anterior segment.

By Roxana Ursea, MD

Ocular pathology affecting the anterior segment can involve structures that are not easily directly visualized by routine examination methods such as the slit lamp exam. That's where imaging technologies play a big role.

My colleagues and I use three instruments – high-resolution ultra-sonography, anterior segment OCT and high frequency ultrasound, or UBM – to evaluate the anterior segment. The UBM provides advantages in many applications.

UBM Advantages

The greater depth of penetration that the UBM allows makes an enormous difference when viewed alongside other technologies. It enables us to visualize the normal anatomy, including anterior chamber structures, and the posterior iris or ciliary body (a unique capability of UBM technology). We can also use it to assess IOL position, and assist us in preoperative assessments and planning in eyes with hypotony or trauma, avoiding surprises in the operating room.

UBM can visualize the whole cornea, iris and iridocorneal angle. We can perform angle-to-angle and sulcus-to-sulcus measurement, essential when placing implantable contact lenses. It is the finest instrument for accurate planning for those types of lenses.

UBM is key in diagnosing the mechanism of a patient's glaucoma. In fact, I think the UBM is the gold standard for several pathological conditions, such as plateau iris, as well as the retroiridal processes. When assessing the iridocorneal angle, the UBM offers a more objective view than gonioscopy. Visualizing the ciliary body is a major advantage as well. The UBM's capabilities help us diagnose and follow various ocular pathology cases.

Anterior Chamber Pathologies

The UBM delineates anatomic relationships and pathology in the anterior segment, even in eyes with opaque media. We can scan 360°, visualizing, for example, the positioning and sizes of different cysts in the anterior chamber, and then assess the angle affected by these cysts.

One patient was referred to us with an almost imperceptible iris bulging on the slit lamp exam in the left eye. The UBM showed an iris cyst, but because many patients have multiple cysts, we scanned both eyes. Although the slit lamp didn't show any iris bowing, we did find a few cysts in the right eye as well, which were not evident on the slit lamp.

An older gentleman showed nothing striking on the slit lamp exam, but a dilated exam showed an iris pigmented epithelium bulging that turned out to be an iris cyst on the UBM. However, an anterior segment OCT image did not give us the diagnosis. The resolution of the cornea and the visualization of the angle were very good, but the OCT didn't allow complete visualization. The posterior wall of the cyst was not visible. So we couldn't tell exactly how big it was or what was behind it. The UBM's depth of penetration offers complete visualization of different iris pathologic conditions, as well as the

IOL and haptics placement (**Figure 1**).

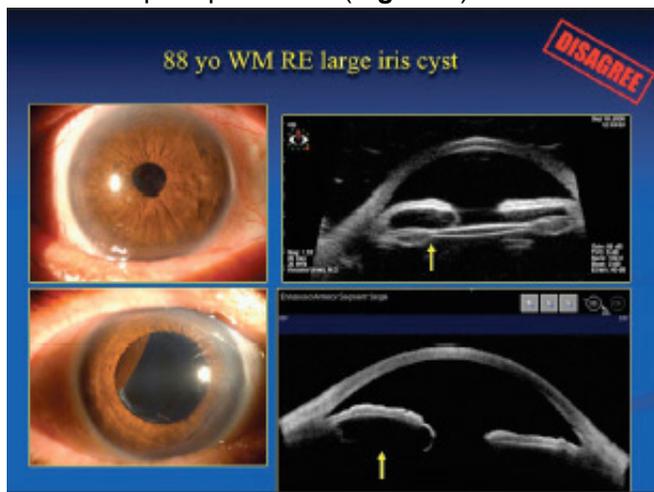


Figure 1. This 88-year-old patient has a large iris cyst. The dilated exam shows a bulging of the iris. The anterior segment OCT image does not give us the diagnosis. However, the UBM's depth of penetration allows imaging of this large iris cyst, as well as the intraocular lens and haptic placement.

When a young patient presented with an iris-pigmented lesion, we wondered if it was a nevus. It looked flat on the slit lamp, and we needed to see what was behind it. The UBM showed that the ciliary body was involved and enlarged in one quadrant. OCT could not diagnose this type of lesion.

If your practice involves numerous cases of anterior segment and especially iris pathology, the UBM is a better choice than other imaging technologies because of its deeper penetration.

Trauma

Many times, when my colleagues and I have trauma cases, we find UBM to be very useful. Before we had the UBM and the ClearScan cover, we used a rubber glove in which we placed balanced saline solution and the transducer to avoid any pressure and to be gentle on the eye. Now it's much easier to assess trauma cases due to the new technology, with no pressure on the eye.

For example, one trauma patient with a persistent rise in IOP had clogged blood in the angle on the UBM. We proceeded with anterior chamber washout which normalized the pressure.

The UBM was also helpful in a trauma patient with iris bowing and induced traumatic cataract, pushed quite far anteriorly almost touching the endothelium. The UBM allowed a 360° visualization, which identified the cataract location in every single position before the patient was taken to the OR. We knew exactly what to expect, and the surgery was successful (**Figure 2**).

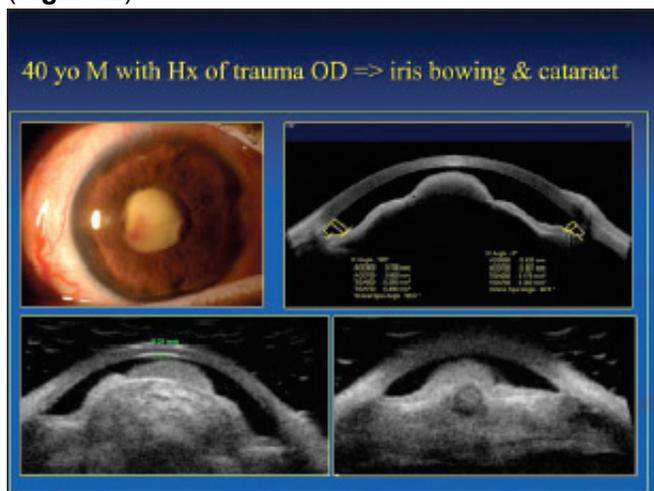


Figure 2. This 40-year-old patient has iris bowing and induced traumatic cataract. The anterior segment OCT

provides limited information for surgery, but the UBM offers 360° visualization, which identified the location and extent of the cataract.

Masses

Masses are a very important part of the ocular pathology cases encountered. It's important to communicate an accurate diagnosis and prognosis to the patient. If these lesions are limited to the iris, then the prognosis is better than when lesions affect the ciliary body.

One older man came in with a pigmented iris lesion at the 5 o'clock position that could have been missed quite easily on slit lamp examination. We detected it on dilation, and then UBM and gonioscopy confirmed our suspicion of angle involvement. We used the UBM to image posterior to the iris and to image the ciliary body, and measure the lesion using calipers. The UBM allowed us to rescan the exact same angle and quadrant, and to watch for any progression over the course of 3 or 4 months.

Finally, a patient with a very subtle, easily missed iris lesion on the slit lamp exam was imaged with the UBM. The iris was not quite involved and the angle was open, but the ciliary body was enlarged in that particular quadrant. The patient had some intralesional cysts in the ciliary body, and an iris and ciliary body melanoma.

Transformational Imaging

UBM technology helps us visualize a number of other problems. For example, the UBM is the test of choice to visualize a posterior chamber intraocular lens. Why? The emitted ultrasound waves readily pass through the iris in such a way that it can show you both the optic and the haptics.

The UBM helps us visualize anterior segment IOLs as well, including one patient's ACIOL whose haptic was pushed against the iris and into the angle. Convex iris and pupillary block are clearly identified with the UBM. Other pathologies suitable for UBM diagnosis include cyclodialysis clefts and anterior suprachoroidal effusions. Gonioscopy cannot always diagnose the clefts, but UBM can confirm the diagnosis and show the extent of the involvement.

The UBM has made a tremendous difference in my practice. It enables us to manage anterior segment pathology for diagnosis and treatment purposes. Imaging is simple and safe, and it gives us opportunities for understanding and planning that just weren't possible in the past.



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