

Newest and oldest, anterior segment imaging tools offer value to refractive surgeons

Cheryl Guttman
in Paris

USING a growing arsenal of anterior segment imaging tools, refractive surgeons are finding the various technologies to be invaluable for diagnosis, monitoring, and establishing indications and contraindications for surgery.

At a symposium on imaging techniques of the anterior segment held during the XXII Congress of the ESCRS, Italian ophthalmologist Giorgio Marchini MD discussed the refractive surgery applications of the oldest available anterior segment imaging instrument - analogue very high frequency ultrasound scanning technology (ultrasound biomicroscopy, UBM). French ophthalmologist, Georges Baikoff MD, reviewed his experience with a prototype of anterior chamber optical coherence tomography (AC-OCT; Visante, Carl Zeiss Meditec), the newest tool.

UBM is a B-scan ultrasonic immersion procedure with a linear scanning mode providing quantitative and qualitative information about structures of the anterior segment. Prof Marchini noted its specifications can be summarised with the "rule of 5s" - it operates at a 50 MHz frequency, has a 5-mm beam focus, 50 microns of axial and lateral resolution, a 50-micron focal distance, and a 5-mm exploration depth.

"The advantage of this technology (UBM) is that it offers good resolution to produce high-definition images." *Giorgio Marchini MD*

"The advantage of this technology (UBM) is that it offers good resolution to produce high-definition images. However, high impedance and high frequency limit its tissue penetration and so its exploration field is only 5x5 mm," he said.

Therefore, while UBM has some important biometry functions and other applications, it cannot be used to measure the angle-to-angle or sulcus-to-sulcus



Giorgio Marchini



Georges Baikoff

distances, and it cannot image the nuclear and posterior portions of the crystalline lens or provide corneal pachymetric topography maps.

However, UBM can be used to obtain qualitative information about a variety of corneal defects related to refractive surgery, including stromal scarring, the depth and reflectivity of severe haze, and the depth and possible perforation of keratotomies. In addition, it is useful for detecting the lamellar interfaces.

Safety tool for phakic IOLs

It can also be applied to determine relationships between phakic implants and intraocular anatomical structures, such as safety distances between the optic and the endothelium or crystalline lens, and to analyse the position of phakic IOL haptics and IOL centration.

Prof Marchini said UBM also has a role in the evaluation of accommodative IOLs as it can be used to characterise movement of the ciliary process and the implant, both of which are parameters that can be used to determine the amplitude of

accommodation. Displacement of the ciliary process is determined by using UBM to measure changes in the scleral-ciliary process angle between the relaxed and accommodated states while the anterior displacement of the IOL optic is calculated using the change in the endothelium to optic plate distance.

Using that technique to evaluate eyes implanted with the AT-45 and ICU accommodative IOLs, Prof Marchini and colleagues reported measuring early accommodation that decreased over time such that by one year postoperatively, there was a maximum accommodation amplitude of only 0.5 to 0.75 D.

"The reduction in IOL movement over time was quite surprising to us, but we expect that it might be explained by capsular fibrosis," Prof. Marchini said.

Studies performed in eyes with non-accommodating monofocal IOLs also detected IOL movement, but the distance of displacement was too short to justify any significant accommodative effect.

Anterior chamber OCT

AC-OCT has just become commercially available, but Dr Baikoff had the opportunity to use a prototype over the last two years. That experience led him to conclude that AC-OCT is a user- and patient-friendly device for anterior segment imaging.

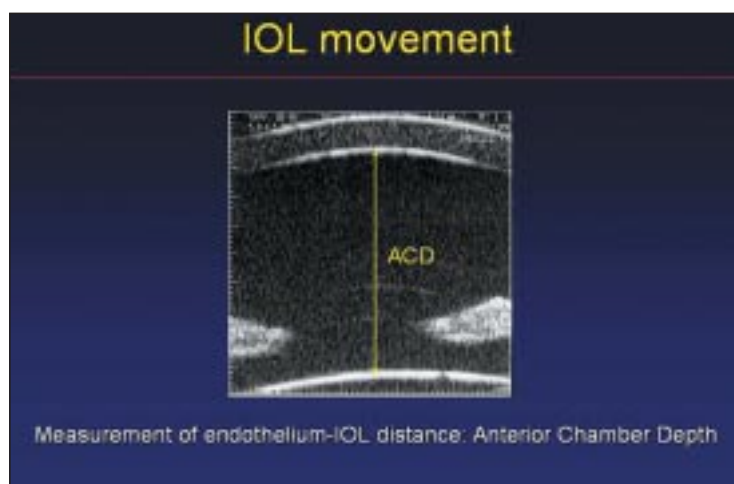
"This is a non-contact procedure and the scan is as easy to perform as topography so there is no need for a highly skilled technician," Dr Baikoff said.

His studies with the AC-OCT prototype involved large numbers of eyes implanted with angle-supported and iris-fixated phakic IOLs and a smaller group of eyes with posterior chamber phakic implants. Based on the information obtained in those evaluations, Dr Baikoff suggested a need for reassessing some existing inclusion/exclusion criteria.

"I strongly believe these advanced anterior segment imaging devices will be mandatory for defining new guidelines that will improve the safety of our surgical procedures, and that AC-OCT or similar equipment will become a necessity when performing phakic IOL implantation just as topography is for corneal refractive surgery," Dr Baikoff said.



UBM allows a very precise evaluation of the different structures of the anterior segment.



The IOL movement during accommodation is confirmed by the reduction of the anterior chamber depth.

ACD recommendations for phakic IOLs in need of review

Based on studies of eyes implanted with angle-supported phakic IOLs, he concluded that the anterior chamber depth safety criteria for candidate selection should be modified to be based on the chamber's internal dimension - the distance from the anterior pole of the crystalline lens to the endothelium - rather than the distance to the cornea's anterior surface.

"Our main concern is the clearance between the IOL and the endothelium, not the distance between it and the epithelium," he explained.

His experience also showed AC-OCT was useful for precisely measuring the internal anterior chamber diameter preoperatively, which he expects will be important for reducing the risk of pupil ovalisation with angle-supported phakic IOLs. In those studies, Dr Baikoff also found that the anterior chamber is not circular, but rather is usually an oval. An evaluation of approximately 100 eyes revealed that the vertical internal diameter

exceeded the horizontal length in about three-fourths of the eyes with an average difference of about 300 microns.

"The difference between the vertical and horizontal distances is quite significant and it has important clinical implications because it means that the key to avoiding rotation and pupil stretching with an angle-supported lens will be to fit the lens exactly to the larger axis of the anterior chamber. In the future, this new AC-OCT device will have the capability to scan eight different axes, and the refractive surgeon can use the largest of those values for IOL sizing," Dr Baikoff said.

Other studies using the AC-OCT device speak to the importance of taking into account the forward movement of the crystalline lens that occurs due to age-related thickening and with accommodation. Dr Baikoff explained that calculations in hundreds of eyes show the anterior pole of the crystalline lens moves forward by 20 microns per year. In addition, comparing images obtained with AC-OCT

when patients were in accommodated and relaxed states showed accommodation was associated with significant anterior movement of the crystalline lens. “These findings suggest there is a risk for contact between the crystalline lens and an angle-

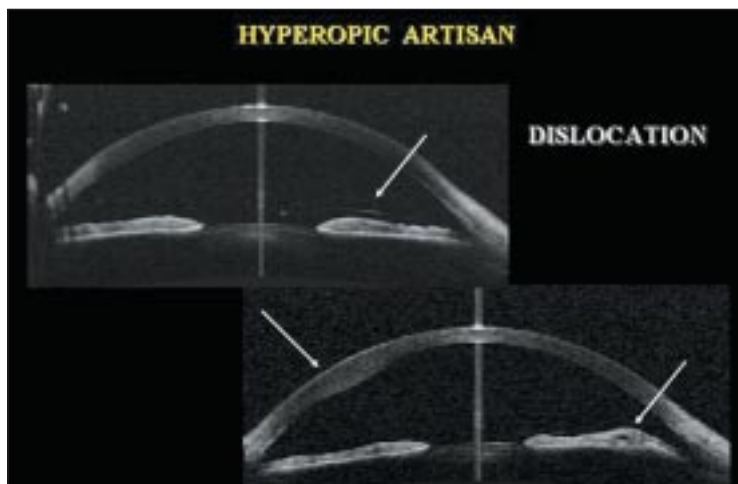
supported implant that may increase over time with crystalline lens thickening. In addition, as the crystalline lens bulges forward, there is also a potential for contact with the posterior surface of the iris-fixated phakic IOL. Although the risk for lens touch is

less with that style implant, it seems the screen of the iris does not guarantee protection,” Dr Baikoff said. Using AC-OCT, Dr Baikoff also documented contact between the PRL and crystalline lens during accommodation, refuting the claim that the implant “floats” in the posterior chamber and avoids lens touch.

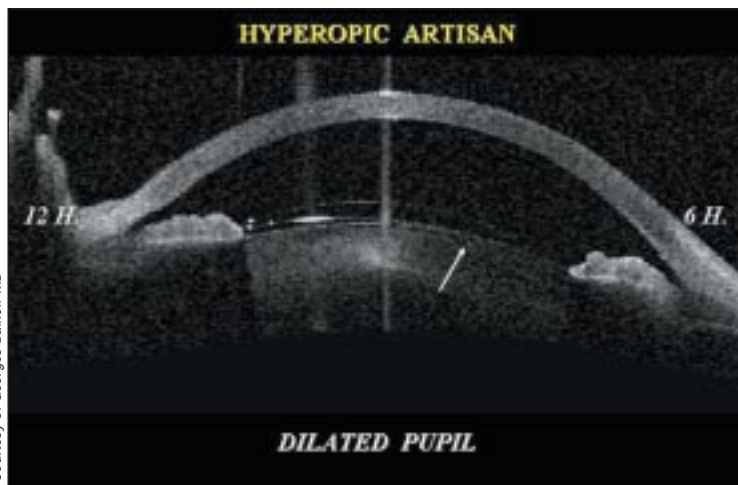
IOL, even if the crystalline lens rise seems to be safe at the time of insertion, surgeons need to take into account that the lens shifts forward by 20 microns per year. Therefore, after 5, 10, or 20 years, the crystalline lens rise may reach a limit that would necessitate phakic IOL explantation,” Dr Baikoff said. AC-OCT cannot be used to

to sulcus) is larger than the horizontal one. Dr Werner used very high frequency digital ultrasound (Artemis) to study the geometry of the anterior chamber and ciliary sulcus in cadaver eyes. “Just as the discovery that the anterior chamber is an oval has implications for sizing anterior chamber phakic IOLs, this information from Dr Werner’s studies should be considered for better sizing of posterior chamber phakic implants,” Dr Baikoff said.

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Hyperopic ARTISAN – dilated pupil. Vertical view of anterior segment of hyperopic ARTISAN after dilation. A tilt of the implant on its horizontal axis can be noted and the lower part of the implant comes into contact with the crystalline lens as the iris no longer acts as a screen between the crystalline lens and the implant.



Hyperope (+13D) with a PRL implant. It can be noted that during natural accommodation, the crystalline lens comes into contact with the PRL's posterior face.

“Our main concern is the clearance between the IOL and the endothelium, not the distance between it and the epithelium.”

Georges Baikoff MD

Pigment dispersion syndrome

Dr Baikoff also used AC-OCT to compare the anterior chamber dimensions of patients with and without pigment dispersion syndrome, a complication that he has observed in approximately 6% of 200 eyes implanted with the hyperopic iris-fixated phakic IOL and in a single myopic eye with that style of implant.

Those evaluations showed patients with pigment dispersion syndrome all had a crystalline lens rise >600 microns. Crystalline lens rise is defined as the distance between the crystalline lens anterior pole and the horizontal line that represents the anterior chamber’s horizontal internal diameter (ie, the line joining the summit of the opposing angles on the 3 o’clock and 9 o’clock meridians).

“When implanting an iris-fixated or other anterior chamber phakic

visualise behind the pigmented iris. However, Dr Baikoff had the opportunity to study an albino patient. Analyses from images obtained in that individual demonstrated the ciliary sulcus decreased by about 1.0 mm in association with 10.0 D of accommodation.

He added that the dynamic measurements in that patient focused only on determining the horizontal diameter since he was not aware at the time that there was a difference between the vertical and horizontal diameters of the anterior chamber.

Interestingly, in studies performed at the John A. Moran Eye Center, University of Utah, Liliana Werner, MD, PhD, has confirmed that the anterior chamber’s internal vertical diameter is larger than the horizontal distance and that the posterior chamber’s vertical diameter (sulcus