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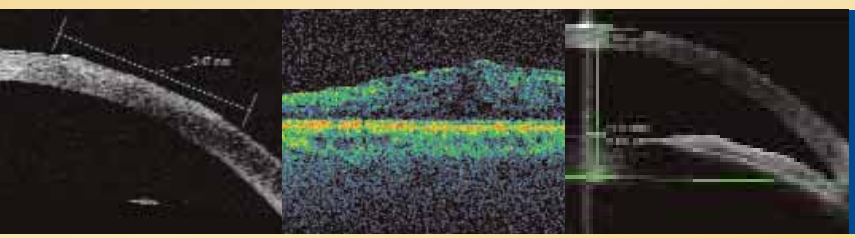
Advanced Diagnostics for Surgeons



New applications and expert advice for the IOLMaster, Stratus OCT, and Visante OCT.

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On Friday, April 27, 2007, at the annual ASCRS meeting, Carl Zeiss Meditec, Inc. (Dublin, CA), sponsored an evening symposium produced by *Cataract & Refractive Surgery Today* to educate physicians about new upgrades to the IOLMaster, Stratus OCT, and Visante OCT. This monograph features the print version of the presentations given that evening (video of the actual presentations is available at www.meditec.zeiss.com). Following is a summary.

VISANTE OCT

The Visante OCT has new application software featuring refractive and iridocorneal tools, advanced pachymetry, and enhanced image quality. Also, a new, unique feature is a template for the Verisyse phakic IOL (Advanced Medical Optics, Inc., Santa Ana, CA) that overlays an image of the lens into an eye's anterior chamber to assist the user in preoperatively judging its fit and placement. This feature includes adjustable safety lines for the residual stromal bed.

For glaucoma, the Visante OCT's improved image quality provides a more detailed view of the angle and the scleral spur, thus potentially replacing gonioscopy. Also, its pachymetry software gives multiple pachymetric readings, including the minimum, maximum, and mean corneal thickness at multiple locations, for incredibly accurate numbers.

STRATUS OCT

I use the Stratus OCT with every cataract surgery to diagnose preexisting retinal pathology, including epiretinal membranes, lamellar macular holes, and cystoid macular edema, which would not be easily visible on funduscopic examination. It helps me decide what type of lens will best suit a patient, and its images let me set realistic surgical expectations for patients.

IOLMASTER

The IOLMaster has also received new advanced-technology upgrades. For working with refractive, multifocal, accommodating, and toric IOLs, I consider the IOLMaster the state of the art. It has become the standard of care in my practice for cataract surgery. The device's new upgrades allow it to image through thicker cataracts, provide enhanced analyses, and improve the quality of surgical outcomes overall.

READ ON ...

The IOL Master, Visante OCT, and Stratus OCT are improving patient safety, outcomes and satisfaction. These exciting new technologies are enhancing ophthalmologists' level of care through their advanced imaging and diagnostic capabilities. Compared with previous technologies, they are more accurate and provide information that was often unavailable to the clinician. The most important reason to use these technologies is that they ultimately benefit the most important part of our practices … our patients. ■

—Eric D. Donnenfeld, MD

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OCT's Applications for the Cataract Surgeon

New tools for evaluating the angle with the Visante OCT.

BY IQBAL IKE K. AHMED, MD, FRCSC, AND JOSHUA C. TEICHMAN, MD


One of the most important things we as ophthalmologists can do to preserve patients' vision is guard against glaucoma. New applications on the Visante OCT (Carl Zeiss Meditec, Inc., Dublin, CA) are allowing us advanced screening capabilities to aid in this objective. After 3 years of using the Visante, this device has become an indispensable part of our group practice.

THE IMPORTANCE OF EXAMINING THE ANGLE

Angle-closure glaucoma can affect all patient populations and members of every race. Its diagnosis is not foolproof; many of us have examined a patient who was diagnosed as having progressive open-angle, normal-tension glaucoma but in fact had a narrow angle or an angle-closure component. Furthermore, there are different mechanisms of angle closure—pupillary block, plateau iris, and lens-related mechanisms—that require identification.

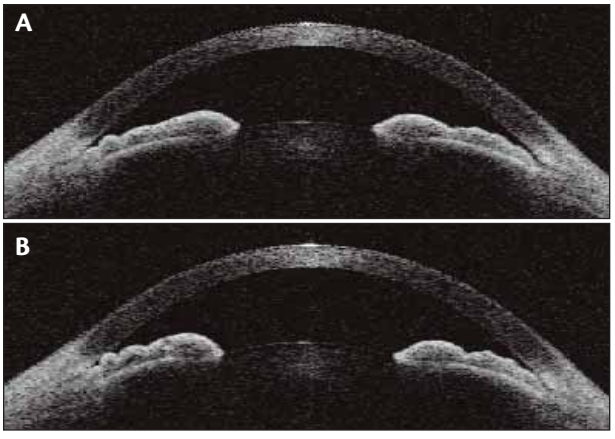

Figure 1. The angle opened in response to a light being directed into the iris (A), and closed in the absence of the light (B).

Because a closed anterior chamber angle is one of the most common causes of glaucoma-related visual loss, it is important to make sure that a patient's angles are adequately evaluated. Although the gonioscopy lens has been our specialty's gold standard for assessing angles, it suffers from artifacts due to light and indentation, even among clinicians who use the lens routinely. To demonstrate how gonioscopy can be unreliable, my colleagues and I performed a Visante scan while shining a light on the iris, as is done in a gonioscopic examination. We attempted to avoid reaching the pupil with the light. We found, based on Visante imaging, that even shining light into the angle and the iris resulted in the angle's opening compared with a dark state (Figure 1A and B). For some patients with borderline angles, the light artifact inducing miosis during clinical gonioscopy may result in the misdiagnosis of an angle closure mechanism such as open-angle glaucoma.

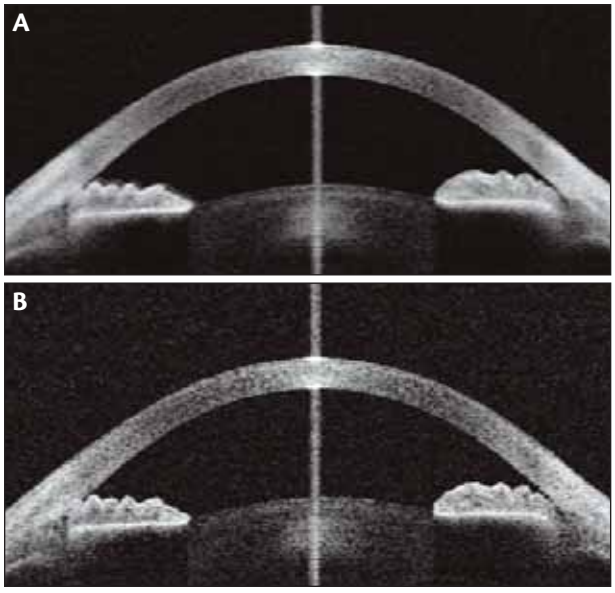

Figure 2. An enhanced-scan Visante OCT image (A) shows more intraocular detail than a single-scan image (B).

TABLE 1. CORRELATION OF VISANTE ANGLE MEASUREMENTS WITH GONIOSCOPY (SHAFFER CLASSIFICATION)

GONIO	VAN HERICK				
Grade	TIA°	AOD 500 (µm)	Grade	ACD (mm)	TISA 500 (µm^2)
4	37 ± 15 (13-59)	424 ± 243 (127-880)	3.4 ± 0.7 (2-4)	3.20 ± 0.55 (2.35-3.98)	137 ± 43 (79-218)
3	23 ± 9 (13-34)	208 ± 88 (121-330)	2.5 ± 0.8 (2-4)	2.69 ± 0.22 (2.33-3.04)	77 ± 42 (22-138)
2	15 ± 3 (10-18)	129 ± 28 (80-160)	1.2 ± 0.7 (1-3)	2.23 ± 0.20 (1.90-2.47)	40 ± 24 (12-70)
1	2 ± 4 (0-8)	15 ± 25 (0-61)	1.1 ± 0.4 (1-2)	2.09 ± 0.44 (1.75-3.06)	4 ± 7 (0-20)
0	2 ± 4 (0-9)	22 ± 36 (0-87)	1.2 ± 0.4 (1-2)	1.93 ± 0.16 (1.75-2.04)	4 ± 6 (0-14)

The Visante OCT's advanced capabilities and ease of use may make the gonioscopic mirror obsolete. The unit's wavelength does not create pupillary constriction and therefore eliminates the light reflex that a slit lamp produces. The Visante OCT has exceptional clarity on both high and low resolution, and one of its most recent improvements is the ability to enhance these images. An enhanced-scan image, which utilizes averaging among consecutive scans, has more definition than a single-scan image (Figure 2). Such clarity is particularly important when trying to identify the scleral spur for an accurate angle assessment. The Visante's images correlate well with the scleral spur, which is the most identifiable part of an image and on which assessments are based. By locating the scleral spur, we can indirectly measure the trabecular meshwork's distance, see the ciliary body's curve, and view the depth of the anterior chamber.

CORRELATING THE VISANTE WITH GONIOSCOPY

If the Visante OCT is going to replace gonioscopy, the two must correlate. Our group and others have attempted to equate the Visante's measurements with the standard Schaffer classification and assess how sensitive and specific the device is for occludable angles. Correlations have been strong with all grades of angles. Furthermore, as clinicians, we need to differentiate between peripheral anterior synechia and appositional closure. Assessing the iris profile into the angle on the Visante permits a differentiation of synechial and appositional closure, which is important in regard to appropriate management.

ASSESSING ANGLE CLOSURE

Although measuring the angle may be helpful, it is not the best way to assess a patient's risk of angle closure. It is more important to know the dynamic and physiologic proximity of the distance between the iris and the trabecular meshwork as well as the potential area within the area of the trabecular-iris space. We could never glean these measurements from a clinical examination, but the Visante's latest software upgrade can produce them easily. The surgeon places the angle tool on the image of the eye and positions the red dot on the scleral spur. Then, the machine will automatically adjust itself to locate the trabecular meshwork and the iris surface, thereby calculating the angle opening distance. This distance appears to have good correlation with traditional clinical gonioscopic angle grading.

Figure 3 shows an occludable angle with an opening distance of 205 µm. The Visante OCT can measure the area, but most of the device's utility is in assessing the opening distance. With the Visante's tools, we hope to move away from only assessing the angle and begin evaluating additional important measurements. After all, if a slit-lamp gonioscopic examination determines that a patient has a 10° or 20° angle, how accurate is that measurement, and more importantly, are there not other factors that affect an angle's potential to occlude? The Visante's overlay, which is accurately and easily obtained in the high-resolution scans, provides objective angle tools including angle, angle opening distance, and the area of the trabecular-iris space.

Table 1 shows our group's preliminary correlation findings

Figure 3. This occludable angle (left side) has an opening distance of 205 µm.

between Visante measurements and clinical angle grading. Carl Zeiss Meditec, Inc., plans to design a printout feature on the Visante OCT that will include these angle parameters.

It is also important to identify eyes that need an iridotomy. Figure 4A and B shows an eye before and after undergoing this procedure. The images show a dramatic change in the pupillary block. Many eyes with occludable angles or angle closure have a dramatic improvement in the angle; these patients have a prominent pupillary-block mechanism. However, there are some patients whose angles do not seem to improve much after an iridotomy. These patients have primarily a non-pupil block mechanism, typically either plateau iris or lens-related anterior rotation of the iris.

Furthermore, it is possible to confirm plateau iris syndrome with the Visante OCT without actually seeing the ciliary processes (Figure 5). Although the iris pigment epithelium inhibits some visualization of the ciliary processes, we can indirectly assess for a plateau iris, as the iris has a characteristic configuration and thick profile. We think this entity is quite underreported and underdiagnosed.

POTENTIAL FOR TREATMENT PLANNING

Lens rise, the distance that the crystalline lens "rises" above an arbitrary line drawn from one end of the angle recess to the other, is something George Baikoff, MD, has talked about[1] for assessing the potential and risk of vaulting in phakic IOLs, and my colleagues and I are examining it for glaucoma. The eye in Figure 6 has a lens rise of 1 mm with an anterior chamber depth of 2 mm—almost one half of the anterior chamber. Note the resultant anterior rotation of the iris that is crowding the angle. This patient would clearly benefit from the lens' removal. Lenticular removal in these situations creates a large change in the anterior chamber's volume and decreases or eliminates the anterior iris' rotation and angle closure. The Visante OCT's ability to tell us what effect a lens' extraction may have is remarkable.

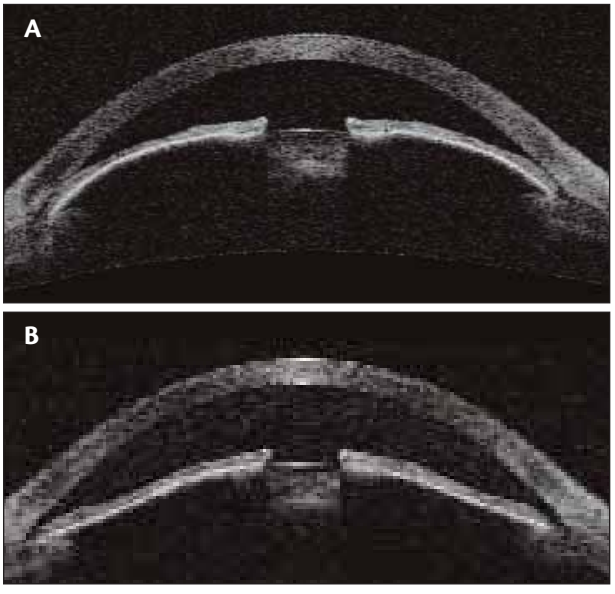

Figure 4. An eye before (A) and after (B) undergoing an iridotomy. Note the dramatic change in the pupillary block.

Figure 5. Plateau iris syndrome as imaged with the Visante OCT.

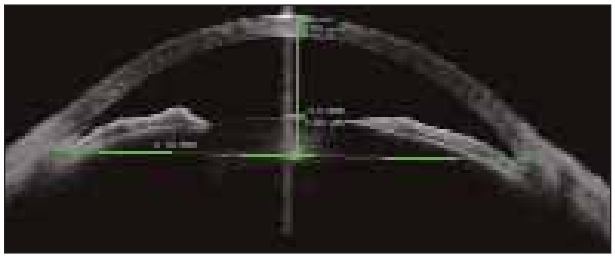

Figure 6. The lens rise in this eye is almost one half of the height of the anterior chamber.

CLOSING THOUGHTS

Assessing the angle is critical for all patients, including those with glaucoma. Just as retinal/posterior segment imaging has become commonplace, we believe objective assessment and documentation with advanced anterior segment imaging will take angle management to the next level. ■

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1. Baikoff G, Bourgeon G, Jodai HJ, et al. Pigment dispersion and Artisan phakic intraocular lenses: crystalline lens rise as a safety criterion. *J Cataract Refract Surg.* 2005;31:4:674-680.

Clinical Advantages of Advanced Imaging

Novel applications in the anterior segment with the Visante OCT.

BY ROGER F. STEINERT, MD, AND MARJAN FARID, MD


The Cornea, Refractive Surgery, and Anterior Segment Surgery Service at the University of California, Irvine, has had the Visante OCT (Carl Zeiss Meditec, Inc., Dublin, CA) for approximately 2 years. During that time, our colleagues and we have come to rely on the device for a wide range of applications, including refining our surgical treatments and designing advanced incisions for corneal transplantation. Following is a review of a few of the clinical benefits afforded us by the Visante OCT.

THE ZIGZAG INCISION FOR CORNEAL TRANSPLANTS

Developing an improved incision for corneal transplantation has been a project of high priority for the past 3 years. The Visante OCT's advanced imaging capabilities played an integral role in this incision's evolution by allowing us to view its construction, healing characteristics, and stability in three dimensions in every eye. Thus, we were able to rapidly design an incisional pattern that enhanced the graft's biomechanical stability.

The zigzag incision provides a smooth anterior surface transition from donor to host. High magnification shows its angled anterior side cut. The original "top hat" incision configuration was not internally stable—we were surprised to find that its flange dropped down. The Visante's images allowed us to vary parameters with each succeeding case until we identified the zigzag pattern as inherently the most stable, both at the internal and external interfaces (Figure 1).

When we viewed the zigzag incision with the Visante OCT at 1 and 3 months postoperatively, we could see its shape much more distinctly by the third month. We hypothesized that this was a reflection of wound healing (scar tissue) that was giving a higher signal return. In addition, we could see that our suture depth was only 50%, yet

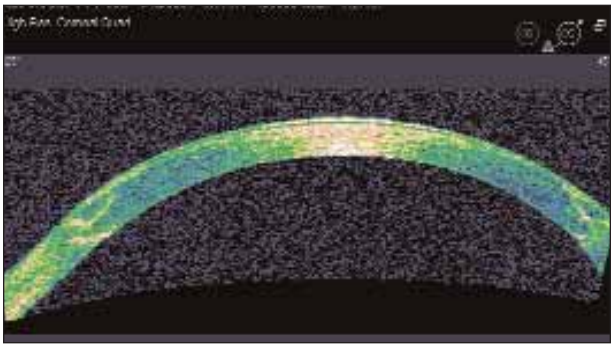

Figure 1. The zigzag incision imaged with the Visante OCT.

Figure 2. Corneal ulcer in relation to the anterior segment.

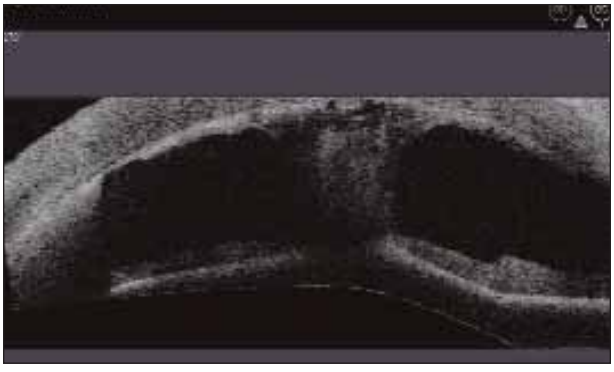

Figure 3. Vertical orientation of the same corneal ulcer.

Figure 4. A *Pseudomonas* ulcer was occupying approximately 75% of the anterior segment.

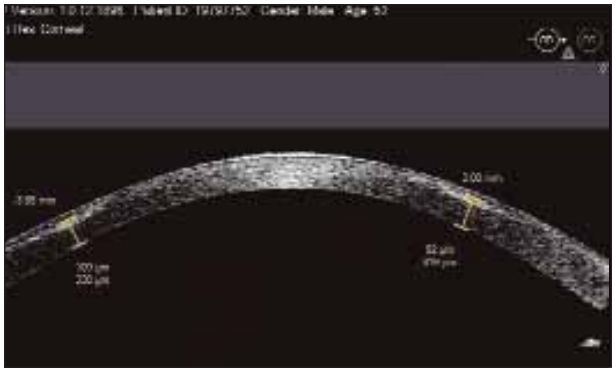

Figure 5. A peripheral epithelial ingrowth under a LASIK flap did not require immediate treatment.

this was adequate to align the deep internal layer of the incision, a further indicator of biomechanical stability. This finding encouraged us to explore this incision configuration in a larger series of eyes.

CLINICAL DIAGNOSES AND TREATMENTS

Acute Fungal Keratitis

Figures 2 and 3 show the most remarkable images we have ever seen of a corneal ulcer. If we looked at the same eye through a slit lamp, we would have seen infiltrate and hypopyon, but not the ulcer's relationship to the anterior segment. Figure 2 shows a horizontally oriented anterior segment image of a funnel of fiber pouring off the backside of the endothelium and down toward the lens. In high resolution, the OCT image shows what looks like a tornado cloud of fibrin coming out of the pupil, up to the back of the cornea. By increasing the image's resolution and orienting the optical cut vertically, we could see the inferior collection, the hypopyon of inflammatory cells, as well as inflammatory material on the back of the cornea (Figure 3).

The confocal microscopy on this eye showed 45° branching structures consistent with *Fusarium* keratitis. The patient had inadvertently stored his contact lenses in a bottle of pure, nonpreserved saline infected with the fungus, which was then transferred to his cornea. Although we feared he would lose the eye, the inflammation began to improve after about 2 weeks. He has recently undergone penetrating keratoplasty because his central cornea was scarred after the infection resolved.

Bacterial Ulcer

In this case of a female patient who had a *Pseudomonas* ulcer, the Visante OCT proved its value in guiding management. Figure 4 shows the hypopyon, which was occupying about 75% of the anterior chamber. What was more interesting, however, was its thickness. At the slit lamp, we thought her cornea was close to perforation. If we had relied on that image exclusively, we would have been pressured to take her to the OR while the eye was still actively infected, because her cornea looked paper-thin. This would have been a high-risk procedure, increasing the potential of infectious endophthalmitis as well as rejection due to the intense inflammation. When we evaluated her eye with the Visante OCT, however, we discovered that her residual cornea was 270 µm thick. This finding gave us courage to delay treatment. Within 2 months, her corneal thickness had increased to 530 µm. She overcame the inflammation and infection, and she underwent a corneal transplant 6 months later under much more favorable circumstances. We were able to perform a simultaneous cataract and IOL surgery, and the graft has remained clear.

Epithelial Ingrowth Under LASIK Flaps

Not all epithelial ingrowths need treatment, and the Visante OCT has helped us differentiate between critical and noncritical cases. The Visante OCT has a flap tool that measures the thickness of the epithelium and a LASIK flap. One eye that we imaged had 109 µm of epithelium under the flap. We decided to monitor rather than immediately treat this eye, because the ingrowth looked fairly peripheral and the corneal center was uninvolved (Figure 5).

Another case of epithelial ingrowth did not look serious on slit-lamp examination. The Visante OCT, however, revealed that it was much bigger than it appeared (Figures 6 and 7). In addition, this eye's flap was thinning toward the corneal center. When we took this patient into the OR and lifted the flap, the epithelial ingrowth was even more extensive than it looked at the slit lamp, confirming the OCT findings. The central flap thickness outside of that area was 201 µm, but the flap had thinned to 89 µm in the area of the ingrowth, and the ingrowth itself extended to 3.21 mm in width.

Iris Melanoma

A patient presented with an iris melanoma (Figure 8), and we were undecided about the best treatment course. We

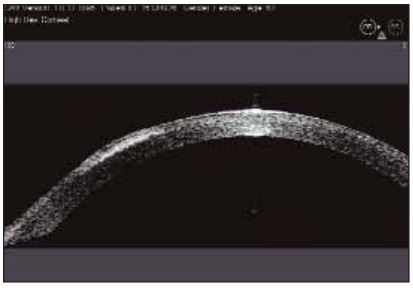

Figure 6. This epithelial ingrowth was larger than it appeared at the slit lamp.

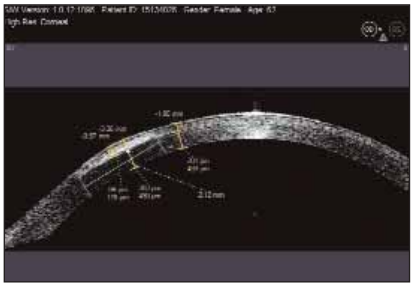

Figure 7. The same ingrowth measuring 3.1 mm wide and under an 89-µm flap.

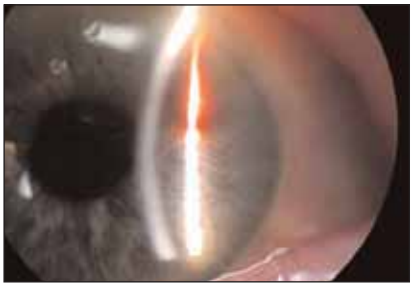

Figure 8. A slit-lamp image of an iris melanoma.

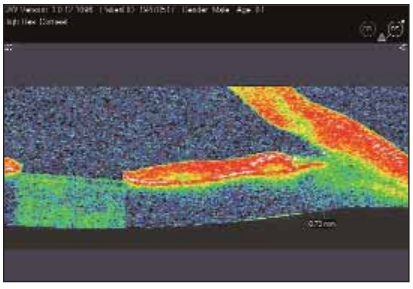

Figure 9. An iris melanoma viewed with the Visante's color scale.

Figure 10. The Visante imaged a haptic in the ciliary sulcus.

Figure 11. Water trapped under a LASIK flap gives no signal return.

have been monitoring him with the Visante's caliper tool every 4 to 6 months. Although we usually use the machine's gray-scale setting for most cornea analyses, its color scale is excellent for imaging the iris. The high signal return in Figure 9 indicates the pigmented areas as red. The normal iris pigment epithelium on the backside of the iris and the same density of pigment in the tumor are clearly visible. Therefore, we can monitor this tumor quantitatively with this tool, where we use the caliper tool to measure the distance of the tumor from the angle. If the melanoma gets much larger, it will threaten his ciliary body and we will have to remove his iris. For now, however, we can monitor it with confidence, and the patient understands what we are doing.

Iritis

It is possible for the Visante OCT to penetrate the iris, depending on its thickness. In this case, we suspected that the IOL might not be in its proper position within the capsular bag, but the pupil could not be dilated adequately to confirm this suspicion. The Visante OCT image allowed preoperative confirmation that a haptic was in the sulcus rather than the capsular bag. As seen in Figure 10, the clear area underneath the iris is the haptic of a single-piece AcrySof IOL (Alcon Laboratories, Inc., Forth Worth, TX) in the ciliary sulcus (a placement that is contraindicated). We exchanged the IOL, and the iritis resolved.

Unusual Cases Resolved

Figure 11 shows water trapped under a LASIK flap. Because water does not cause a signal return, the water space looks empty on OCT, and the water-filled cleft has taken a perfect meniscus shape in the interface under the flap. This patient underwent LASIK in the presence of Fuch's corneal dystrophy several years ago. More recently, she had cataract surgery, and the endothelium decompensated. This phenomenon of water accumulation in the flap interface is also seen in eyes with high IOP, where the water cleft gives a falsely low IOP reading. The Visante OCT can be invaluable in diagnosing this dangerous situation.

SUMMARY

We feel that we cannot practice ophthalmology adequately without the Visante OCT because it images every part of the eye that relates to our specialty, from the cornea to the angles to iris legions. The optical cross-section gives unique information that is not available through any other modality, providing critical guidance in everyday patient care. ■

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New IOLMaster Advanced Technology Software

Clinical findings and revolutionary product enhancements.

BY WARREN E. HILL, MD, FACS

When the engineers at Carl Zeiss Meditec AG (Jena, Germany) first described the capabilities of the new IOLMaster Advanced Technology version 5 software, I doubted that it could possibly perform as described. I now admit that I seriously underestimated its capabilities, which practically transform the IOLMaster into a new instrument. Thanks to Carl Zeiss Meditec AG, the measurement of axial length will never be the same.

NOTABLE IMPROVEMENTS

The new IOLMaster version 5 software dramatically enhances the accuracy and reproducibility of axial length measurements by automatically analyzing them individually and as a series. Instead of reporting an average of all of the measurements taken, the IOLMaster instead uses digital-signal processing technology to generate an extremely accurate composite measurement (Figure 1) from all those that meet validation criteria. The most exciting advance of this new software is its ability to extract meaningful measurements through dense nuclear and posterior subcapsular cataracts. The end result is an extremely precise measurement of axial length in clinical settings that would have been impossible until now.

In the past, operator skill determined whether or not the IOLMaster could accurately capture axial length measurements through dense nuclear and posterior subcapsular cataracts. A signal-to-noise ratio of less than 1.8 was generally considered unusable. With a correct-appearing axial length display, signal-to-noise ratios of 2.0 to 2.5 were generally considered good, and those above 3.0 were generally considered very good to excellent. By comparison, with the Advanced Technology version 5 software, for 2+ nuclear cataracts, we are now commonly seeing signal-to-noise ratios of over 100. This improvement places axial length measurements in a completely different realm.

CASE EXAMPLE

My practice was the first in North America to receive and evaluate this newest software feature of the IOLMaster. I became convinced of its amazing capabilities almost immediately after my staff and I began using it. One of the very first patients whom we evaluated was referred to my practice by a retinal surgeon requesting that this patient's hand movements, darkly brunescent cataract be removed so that he could "see the macula." Again, I doubted that the IOLMaster could accurately measure the axial length through so dense a cataract.

As expected, most of the measurements for this eye were just above the baseline. By selecting the composite axial length feature, the software determined that the axial length was 26.16 mm. Doubting the validity of this reading, I performed a standard immersion A-scan on

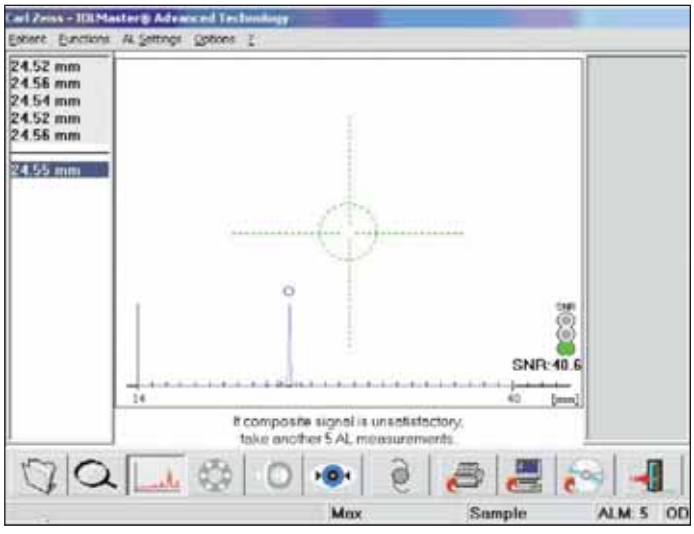

Figure 1. This image is an example of a composite axial length generated by the IOLMaster.

this eye, and it differed from the IOLMaster's composite determination by only 0.01 mm.

USING THE SOFTWARE

With the new software, the operator takes five measurements. If there is enough information to generate an adequate composite axial length, the fifth measurement stays red for about 1 second, and then a blue composite axial length measurement is automatically generated and appears on the screen. In the lower right-hand corner of the screen, there will also appear a green traffic light with the composite "enhanced" signal-to-noise ratio displayed.

Because so much of the process is now automated, the software is so easy to use that even inexperienced technicians operate it successfully.

AUTOKERATOMETRY FEATURE

For the past 20 years, I used a Javal-Schiötz keratometer to measure the central corneal power of every eye prior to cataract surgery. Since I received the IOLMaster with the version 5 software, this old and trusted friend has remained under a cover. We now use the IOLMaster's keratometry readings for every preoperative measurement. This is quite a change for someone who previously did not like this instrument's keratometry function.

One of the primary complaints about the original autokeratometry feature of the IOLMaster was that its acquisition time was relatively slow. If the ocular surface became dry between measurements, the operator would have to take more measurements in an attempt to meet the validation criteria of three measurements taken within 0.25 D in each of the principal meridians. The new version 5 software is extremely fast. The autokeratometry feature generates three measurements in about 1 second, with astounding reproducibility. Validation criteria are met within the instrument itself, and it is a simple exercise for the patient and the operator.

The autokeratometry feature includes the adjustment aid in the form of a traffic light indicator: a red light appears if the system is out of focus for keratometry, a yellow light appears if it is near the best focus position, and a green light appears when the system is ready to take measurements.

STUDY

In January 2007, our office conducted a formal study of the version 5 software in our practice. We measured 54 eyes of 36 subjects in four different ways.

First, we used the standard method of taking five consecutive measurements, calculating the mean, and gauging the validity of the result. For the second method, we took five measurements and let the machine analyze the data by generating a composite measurement. The third approach used a method that our office developed for Carl Zeiss Meditec, Inc. (Dublin, CA), years ago, in which the operator takes multiple readings around the measurement reticule, looking to find the location that returns the best axial-length display. All 20 measurements are taken, the best axial-length display is identified, and then all measurements greater than 0.02 mm on either side of this ideal measurement are discarded. For the last method, we took 20 measurements and let the machine analyze them without any input from the operator.

A slightly greater number of the patients were male, their mean age was 75 years, and 61% had vision that was between 20/40 and 20/200. All pseudophakic eyes were excluded. Eleven percent of the eyes had vision of less than 20/200, and more than 9% had finger counting or light-perception cataracts. All cataracts were graded by the Lens Opacities Classification System III as described in the *Archives of Ophthalmology* in June 1993.[1] The final results were then stratified by lens color and other criteria.

The standard method of taking five measurements and calculating the arithmetic mean produced the results we expected: not great. A little more than half of the eyes could be measured. When we gave the machine five consecutive measurements and allowed the IOLMaster to arrive at a composite value, more than 92% of patients were successfully measured. When we used our usual method of sampling multiple areas, combined with deleting outliers, 94% of patients could be successfully measured. Finally, when we took 20 measurements and simply allowed the IOLMaster software to arrive at its own conclusions, more than 96% of eyes were successfully measured. It is helpful to keep in mind that more than 9% of these eyes had count-fingers or light-perception visual acuity.

IMPLICATIONS FOR THE PRACTICE

The IOLMaster's new Advanced Technology version 5 software opens up an entirely new patient population to treatment. Its measurements are very reproducible, incredibly accurate, and require minimal operator intervention. Because of its ease of use, technicians with various skill levels can achieve the same outcomes. As far as office efficiency, patients move through this process very quickly. Everybody in my office absolutely loves our "transformed" IOLMaster. ■

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1. Chylack LT Jr, Wolfe JK, Singer DM, et al. The Lens Opacities Classification System III. The Longitudinal Study of Cataract Study Group. *Arch Ophthalmol.* 1993;111:831-836.

The Versatility of the Visante OCT

How this device makes itself invaluable in all aspects of a busy corneal practice.

BY AMIN ASHRAFZADEH, MD

My ophthalmic surgical practice in northern California is composed of approximately 60% anterior segment, 30% refractive, and 10% purely classic corneal surgery. The Visante OCT (Carl Zeiss Meditec, Inc., Dublin, CA) has come to play an important role in each area, as the following case examples illustrate.

TERRIEN'S MARGINAL DEGENERATION

A 15-year-old Hispanic male with an 8-year history of superior corneal thinning presented with Terrien's marginal degeneration across most of his superior cornea. I had difficulty deciding how to treat this patient. His corneal topography showed inferior flattening where the cornea was sagging down. On the Visante OCT, I could clearly see the area of thinning and was able to map it (Figure 1). A high-resolution Visante image allowed me to measure the cornea and determine that it was of normal thickness on the anterior and posterior edges. Thus, I confirmed that the cornea could withstand transplantation.

LATE-ONSET ENDOPHTHALMITIS

A 75-year-old white female presented with a history of late-onset endophthalmitis. She had undergone two vitrectomies and an IOL explantation, and subsequently she had developed pseudophakic bullous keratopathy. I performed deep lamellar endothelial keratoplasty and implanted an ACIOL. The patient has seen well since, with a UCVA of 20/60. The ACIOL is clearly visible in the Visante OCT image; note the fair amount of distance between the ACIOL and the endothelium (Figure 2). The high-resolution image shows the thickness of the deep lamellar endothelial keratoplasty button (Figure 3).

DENDRITIC ULCER

A 69-year-old white female presented with a classic dendritic ulcer (Figure 4). Her condition resolved after

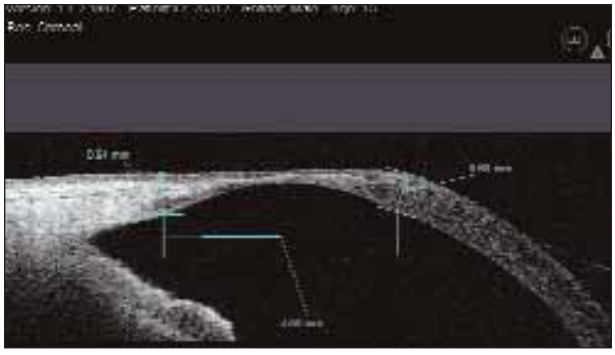

Figure 1. Terrien's marginal degeneration.

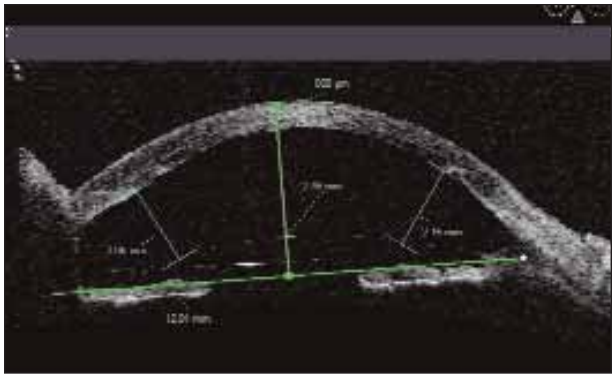

Figure 2. Late-onset endophthalmitis.

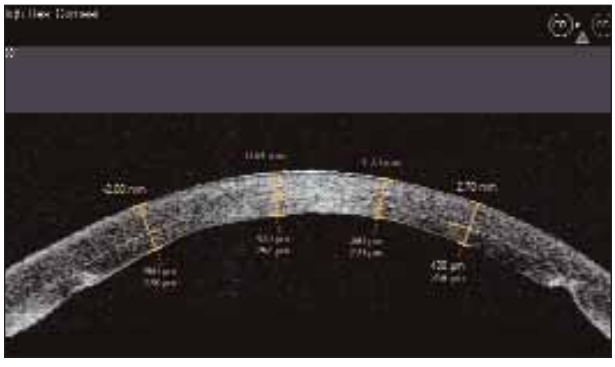

Figure 3. Deep lamellar endothelial keratoplasty button.

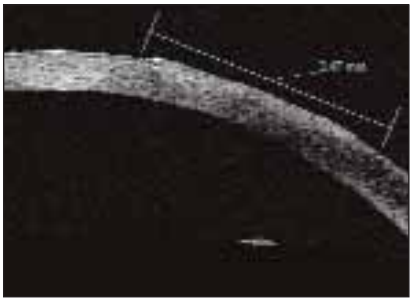

Figure 4. A classic dendritic ulcer thoroughly imaged with the Visante OCT.

Figure 5. A dendritic ulcer that tested positive for *Acanthamoeba*.

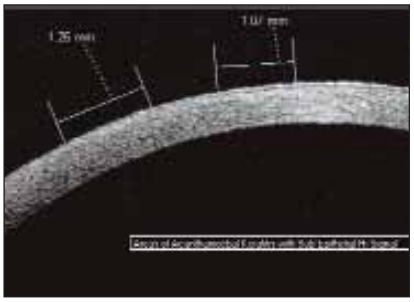

Figure 6. The *Acanthamoeba* did not affect Bowman's membrane.

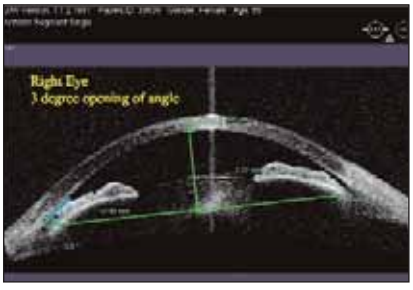

Figure 7. Hyperopic right eye with an angle opening of 3º.

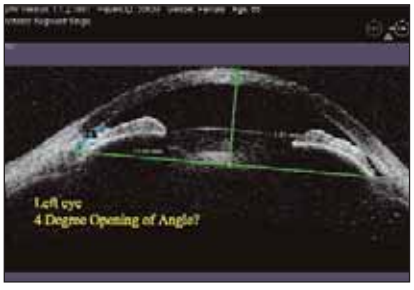

Figure 8. Left eye with 4º angle opening and iridocorneal touch.

Figure 9. Nuclear sclerosis seen in the left eye of the same patient.

treatment with Viroptic (Catalytica Pharmaceuticals, Inc., Greenville, NC). Interestingly, the Visante OCT showed the entire area of epitheliopathy, as well as some changes inside and underneath Bowman's membrane, into the stroma.

I also treated a 22-year-old contact lens user, who developed a dendriform corneal ulcer in her right eye (Figure 5). She was very photophobic and teared profusely such that it was impossible to keep fluorescein in the eye to take a picture. Her eye was very irritated and uncomfortable, and it tested positive for *Acanthamoeba* on corneal culture. Please note the difference in quality of keratitis and how Bowman's membrane is unaffected in the *Acanthamoeba* case (Figure 6).

NARROW ANGLES

Carl Zeiss Meditec, Inc., has produced some new tools to measure the anterior chamber angle. A 65-year-old white female presented for a routine eye examination, during which I discovered that her right eye had very narrow angles. Upon questioning, she mentioned that she experienced some frontal headaches at night and some multicolored halos around lights. The Visante OCT showed that her right eye had a very shallow anterior chamber and angle openings of approximately 3º. Also, she was a +3 hyperope (Figure 7). Her left eye had an angle opening of about 4º (Figure 8), but it also had iridocorneal touch. Nuclear sclerotic cataract could be noted in both eyes (Figure 9).

We discussed her treatment options at length, and I offered her either a peripheral iridotomy or cataract surgery with possible implantation of multifocal IOLs. She chose a multifocal IOL. She is thrilled with the result and is no longer at risk for angle closure. As a clinician, I appreciate being able to present patients with a picture of their condition so that they understand it better and may make informed decisions about their treatment.

A 56-year-old white female presented for a LASIK evaluation; she was a +2 hyperope and had angles of approximately 9º in both eyes. Again, I performed a peripheral iridotomy, which opened her angles by about 6º (Figure 10). Another benefit of the Visante OCT is that immediately after performing a laser ablation, one can check the eye and confirm that an anatomical iridotomy was successful.

TRAUMA-INDUCED HYPHEMA

A 17-year-old white male sustained a BB gun injury to his right eye. He extracted the BB and went to the ER with a small hyphema; he was told to call his doctor in the morning. When he presented to me the next morning, he had choroidal detachment and angle recession (Figure 11). I treated the eye with cycloplegia and topical and systemic steroids. Fourteen days later, the choroid had returned to normal, but there was still a notable recession of the angle (Figure 12). Per classic training, I typically never perform contact gonioscopy so soon after an injury. Instead, I appreciate having the Visante's noncontact gonioscopy

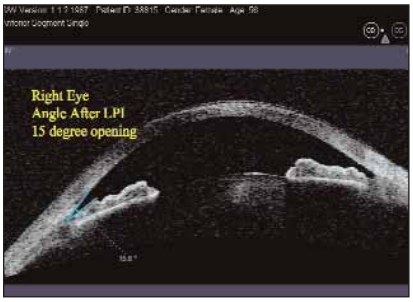

Figure 10. A right eye after angle opening of 6º.

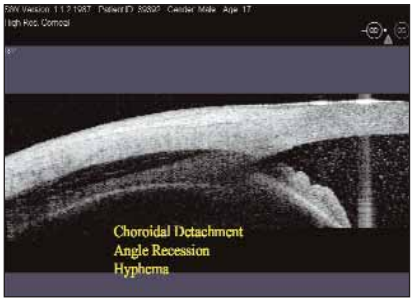

Figure 11. Eye showing trauma after a BB gun accident.

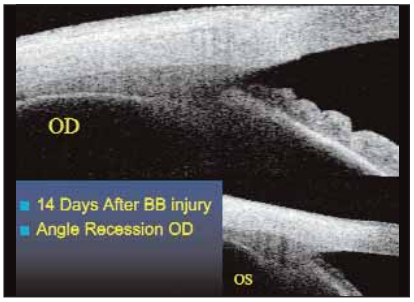

Figure 12. Angle recession OD 14 days after the BB gun injury.

Figure 13. Residual stromal bed was thick enough for a LASIK retreatment.

Figure 14. Minor epithelial ingrowth at 2 months after LASIK retreatment.

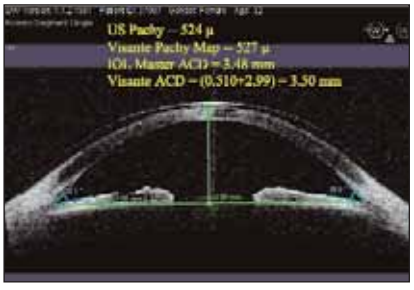

Figure 15. Anterior chamber depth of 3.5 µm on the Visante.

available to assess the angle and discuss the lifetime risk of glaucoma with the patient.

MYOPIC REGRESSION

A 41-year-old male had undergone LASIK 8 years ago at another clinic and was now experiencing myopic regression of approximately -1.25 D. We did not have his history. As a refrigerator mechanic, he was in and out of meat freezers constantly and could not wear glasses because they fogged up, nor did he want to wear contact lenses. With the Visante OCT, I was able to measure his flap and clearly determine whether there was enough residual stromal bed for a retreatment. He had 350 µm (Figure 13), and I performed the enhancement. At the 2-month follow-up, this patient had a little epithelial ingrowth that we imaged on the Visante OCT (Figure 14). He is now 20/15 and thrilled.

PHAKIC IOL EVALUATION

My favorite use for the Visante OCT is evaluating patients for phakic IOLs. A 32-year-old black female with a refraction of -14.50 D in both eyes wanted to consider phakic IOLs. Ultrasound pachymetry measured her cornea at 524 µm, and the Visante's pachymetric map showed 527 µm. Her anterior chamber depth on the IOLMaster (Carl Zeiss Meditec, Inc.) was 348 µm and 350 µm on the Visante (with the Visante, add the thickness of the cornea to the anterior chamber's depth to obtain the equivalent number) (Figure 15). With the new tools, we evaluated her for both a 6-mm and a 5-mm Verisyse phakic IOL (Advanced Medical Optics, Inc., Santa Ana, CA).

The Verisyse's calculator, called VeriCalc (Xaldon Technologies GmbH, Wurzburg, Germany), measured the clearance between the optic and the endothelium at its shortest distance at 1.89 mm. On the Visante, however, this distance was clearly less than 1.5 mm. Even for the 5-mm lens, the VeriCalc measures at 2.15 mm, whereas the model barely reaches 1.5 mm. This apparent discrepancy is being clinically evaluated further with all models of the Verisyse.

CONCLUSIONS

The Visante OCT is very easy to use. I love its real-time, noncontact evaluation and usefulness for patient education. Many patients will pay extra for this technology, and they sometimes ask to see before and after images of their conditions, especially in cases of narrow angles and phakic IOL implantation. As the cases herein have shown, the Visante OCT is an invaluable tool. ■

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Better Care Through Diagnostics

Three invaluable tools for my cataract and refractive practice.

BY ERIC D. DONNENFELD, MD

My colleagues and I at Ophthalmic Consultants of Long Island in New York have become fans of the line of ophthalmic diagnostic products made by Carl Zeiss Meditec, Inc. (Dublin, CA). The Stratus OCT, Visante OCT, and IOLMaster each have improved our diagnostics and surgical planning in our cataract and refractive practices by making available an unprecedented level of ocular data.

The IOLMaster became my standard of care for cataract surgery by improving my IOL accuracy. I also use the Stratus OCT with every cataract patient to help me decide what type of lens to implant, diagnose intraocular pathology, and set realistic surgical expectations for cataract and refractive patients. Finally, the Visante OCT provides information following previous refractive surgery that is not available with any other technology and allows me to make better-informed decisions for my refractive patients. Following is an account of how I use these devices in my practice.

STRATUS OCT

Unless a patient has an overt retinal abnormality, I am not confident in my ability to describe subtle pathologies. Fortunately, the Stratus OCT helps me overcome this shortcoming. This device has become an invaluable tool for diagnosing pathology that I previously could not. It also makes me a more effective clinician by helping me determine if a patient is (or is not) a candidate for refractive surgery or if he needs to be referred to a retinal specialist.

In 2005, Calvin Roberts, MD, of Cornell Medical University in New York City, presented a study[1] at the annual ASCRS meeting that shows the Stratus OCT's clinical value. When he screened 130 patients scheduled for routine cataract surgery with the device, he found that six of them had previously undiagnosed epiretinal membranes. Postoperatively, the patients diagnosed with epiretinal membranes had decreased contrast sensitivity, a higher incidence of visual disturbances such as glare and halos, and were generally unhappy with their vision compared with the patients who had normal retinas preoperatively.

I now use the Stratus OCT preoperatively on all my cataract surgery patients, because I want to know if they have significant pathology that could affect their postoperative vision. Also, I find it particularly useful for examining eyes that have undergone previous refractive surgery. I evaluate their topography for residual astigmatism and rule out any retinal pathology with the Stratus OCT before deciding whether they are good candidates for additional surgery.

CASE EXAMPLE

Recently, I examined a 59-year-old healthy female who had undergone refractive surgery by another surgeon to treat her high myopia. She had received multifocal IOLs bilaterally. The patient's refractive error was -10.00 D in the right eye and -12.00 D in the left, and both eyes had normal, flat corneas. She complained of severe glare and halos as well as decreased visual acuity, and she wanted a second opinion about whether her vision could be improved further.

My staff and I performed all the necessary tests, including a visual field test because she had a history of glaucoma. We found central glaucomatous visual field loss. Her refraction showed that she indeed had suffered decreased vision. When we examined her dilated eyes with the Visante OCT, we were surprised to find two IOLs in the capsular bag of both eyes, an AcrySof Restor IOL (Alcon Laboratories, Inc., Fort Worth, TX) and a Clariflex lens (Advanced Medical Optics, Inc., Santa Ana, CA). Although her IOLs' placement was not contraindicated and they were well covered by the capsular bags, the patient had not been told about the dual implantation.

Using the Stratus OCT, we detected moderate cystoid macular edema with an epiretinal membrane in the patient's right eye that may have been there prior to her original surgery (Figure 1). We also found cystoid macular edema, an epiretinal membrane, and a lamellar retinal hole in her left eye (Figure 2). I was able to diagnose these

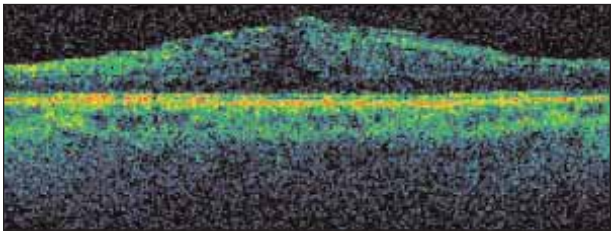

Figure 1. Moderate cystoid macular edema with an epiretinal membrane was imaged in the patient's right eye.

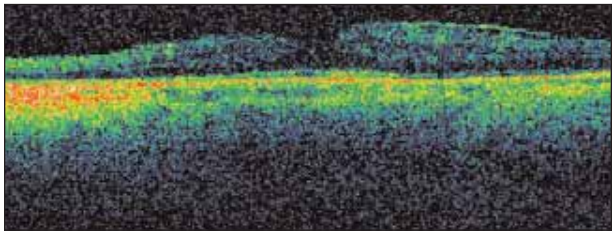

Figure 2. Cystoid macular edema, an epiretinal membrane, and a lamellar retinal hole plagued this patient's left eye.

conditions instantly with the Stratus OCT and thus could discuss a treatment plan with the patient immediately. Had this patient's previous surgeon performed a retinal OCT scan before her cataract surgery, I doubt he would have recommended the implantation of multifocal IOLs, and she may have adjusted her expectations about her postoperative visual acuity.

The lessons learned from this case study apply particularly to refractive IOL surgery: the more chair time we spend with patients preoperatively, the less we need to spend with them postoperatively. Also, discussing a pathological finding with patients before scheduling their surgeries eases their minds and creates a level of expectation about their potential outcomes. For example, if I find an epiretinal membrane during a preoperative evaluation, I will inform the patient and explain that the retinal abnormality increases the risk of developing glare, halos, and retinal swelling after the surgery.

Postoperatively, these patients often ask me about their condition, and I tell them that my staff and I gave them more NSAIDs pre- and postoperatively and that their outcome is great. In this scenario, patients feel good about you as their surgeon. If a patient finds out about an ocular condition postoperatively, he will assume it is a complication you caused, and it puts you on the defensive and changes your relationship with him. Although the surgeon of the patient described herein did not induce her epiretinal membrane during her cataract surgery, she is still very angry that he did not detect it before he operated on her eye.

THE IOLMASTER

Cataract patients are now demanding excellent distance vision after conventional IOL implantation and minimal or no spectacle dependence following multifocal and accommodating IOL surgery. In our practice, the IOLMaster has been critical in achieving these results. It has dramatically improved the accuracy of our IOL calculations, and we have seen a corresponding rise in patient satisfaction and referrals. We have an IOLMaster in each of our seven offices. The device is the single most important piece of equipment for optimizing results in our cataract practices.

THE VISANTE OCT

Like the IOLMaster and Stratus OCT, the Visante OCT has improved the care I give my patients. I find it particularly useful for examining eyes that have undergone previous refractive surgery. The Visante allows me to postoperatively judge their flap thickness and amount of residual stromal bed. This is extremely important in determining whether to lift a flap for an enhancement or to perform a surface ablation.

Another useful feature of the Visante OCT is its ability to superimpose an image of a Verisyse IOL (Advanced Medical Optics, Inc.) into the anterior chamber so that the user can see if implanting the lens will impinge on any part of the cornea. The surgeon can input different clearance levels into the device to judge the IOL's clearance from the cornea—at all points on the IOL, not just its center. Knowing an IOL's clearance in the anterior chamber is important for preventing corneal decompensation and ensuring that a patient is an appropriate candidate for a lens.

OPHTHALMOLOGY TODAY

In response to increasing patient expectations for postoperative visual acuity, we surgeons need to document our clinical findings with more accurate diagnostic tools. We must also improve our patient selection and try to eliminate unexpected postoperative complications. These goals are attainable if we evaluate patients with the right equipment. The Visante OCT, Stratus OCT, and IOLMaster help us deliver the best possible visual results by providing intraocular information that has not been available previously. ■

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1. Roberts CW, Elie ER. Optical coherence tomography for the preoperative evaluation of cataract patients. *Insight.* 2006;31:2:10-12.