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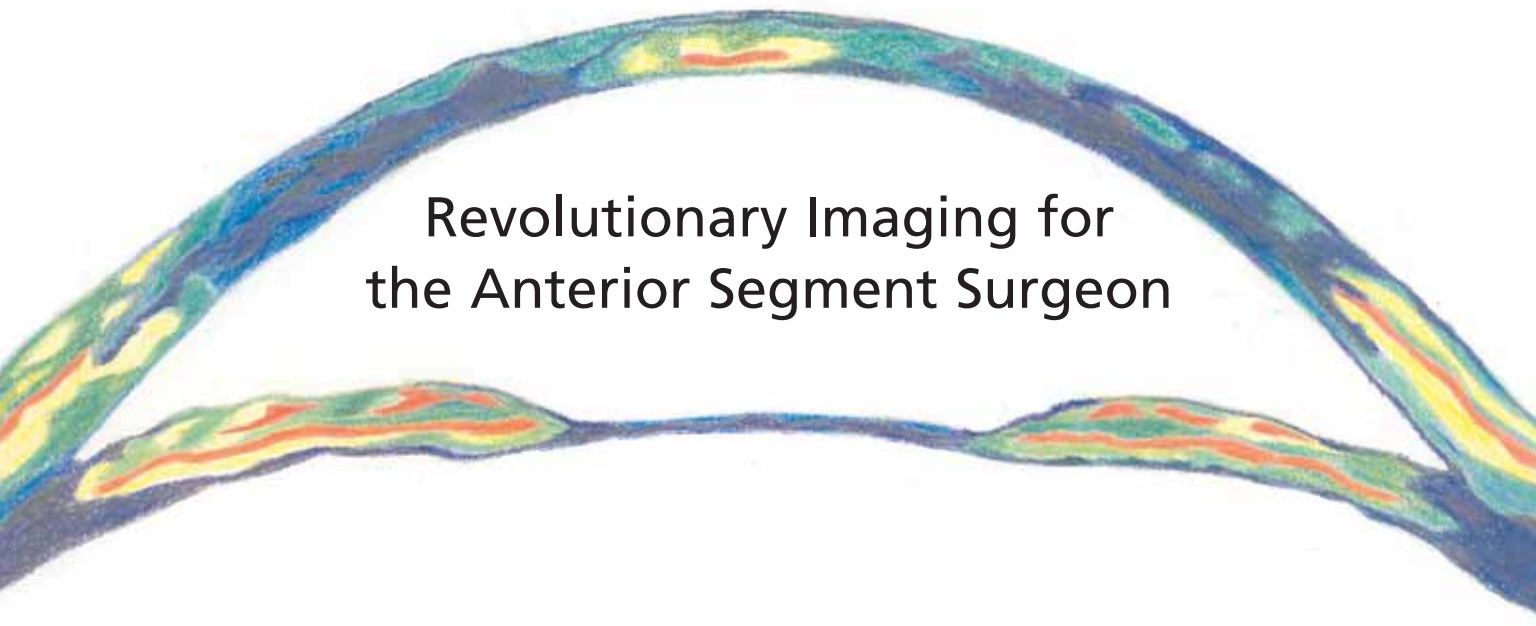
Visante OCT

Revolutionary Imaging for the Anterior Segment Surgeon



Visante OCT: Revolutionary Imaging for the Anterior Segment Surgeon

Visante OCT technology (Carl Zeiss Meditec, Inc, Dublin, CA) is not necessarily new to those familiar with the company's Stratus OCT, which offers comprehensive glaucoma and retinal imaging and analysis. The Visante performs anterior segment imaging and biometry. Its operation is very similar to A- and B-scanning. This device looks at the time of flight of delay of light as it travels through ocular tissue. As the light is absorbed and scattered, the Visante measures it against a reference light beam. Whereas the Stratus uses an 820-nm wavelength, the Visante uses a 1,310-nm wavelength for a variety of important reasons. Its increased water absorption allows the physician to use higher energy and 20 times faster scanning speed at the same signal-to-noise ratio—quite an advantage for anterior segment imaging. This wavelength also increases penetration, therefore improving the resolution when looking at anterior segment tissue.

Figure 1. This image illustrates the quality of imaging of which the Visante OCT is capable.

The Visante OCT creates images in both high- and low-resolution modes. The low-resolution mode performs 256 A-scans in 0.125 seconds. The high-resolution scan produces 512 scans in 250 milliseconds in a transverse fashion. A classic Visante image in a normal patient shows exquisite imaging of the cornea, including the corneal epithelium, the anterior chamber's dimensions, the iris' profile, the spur, and even the anterior capsule of the lens (Figure 1). Lenticular opacities are also visible with the Visante. When using this device to study glaucoma, its high-resolution scan shows the angle and whether it is open or closed. Certainly, the versatility of this instrument is becoming clear in terms of looking at the angle, pachymetry assessments, glaucoma surgery evaluation, examining the iris, crystalline lens, and IOLs, and looking deeper into the sclera and superchoroidal space.

—Iqbal Ike K. Ahmed, MD, FRCSC

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Note: Video presentations from this symposium are available at http://www.meditec.zeiss.com.

Novel Applications for the Corneal and Anterior Segment Specialist

The Visante OCT images everything from corneal implants to corneal transplant interfaces.

BY ROGER F. STEINERT, MD

The new Visante OCT (Carl Zeiss Meditec, Inc, Dublin, CA) is an imaging device so innovative and versatile that not a day goes by that my staff and I do not find some new and better use for it. Following are some of the ways we have used this new technology recently.

LASIK FLAPS

The Visante OCT provides wonderful images of LASIK flaps. Figure 1 shows a 4-year-old flap made with a Hansatome microkeratome (Bausch & Lomb, Rochester, NY). The interface is easy to see. This image and others we took of Hansatome flaps confirm that this microkeratome produces meniscus-shaped flaps, as does the Moria microkeratome (Moria, Antony, France) (Figure 2). The Visante features a device called the *flap tool* that measures the flap and stromal thickness after LASIK. This tool allows up to seven measurements per image. Figure 1 shows that the central flap thickness of 121µm increases to 178µm in the periphery. In Figure 2, the paracentral thickness of 141µm increases to 173µm. If the surgeon is planning an enhancement, the flap tool pinpoints how much stromal bed is available. Knowing the thickness of the residual stromal bed is critical in avoiding the complication of ectasia. With the Visante, guessing at the stromal bed by assuming an average typical flap thickness is no longer necessary.

> *"With the Visante, guessing at the stromal bed by assuming an average typical flap thickness is no longer necessary."*

Figure 3 shows a flap made with the Intralase FS laser (Intralase Corp., Irvine, CA). The laser delivers an inherently

Figure 1. A 4-year-old LASIK flap made with a Hansatome.

Figure 2. A Moria-made flap with the meniscus shape.

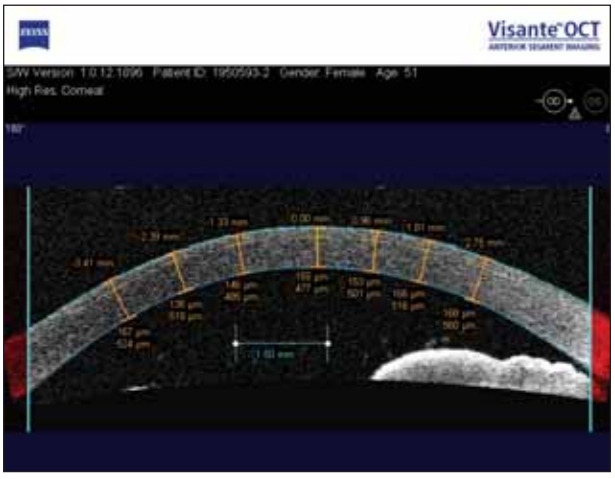

Figure 3. A flap made with an Intralase FS laser is of uniform thickness.

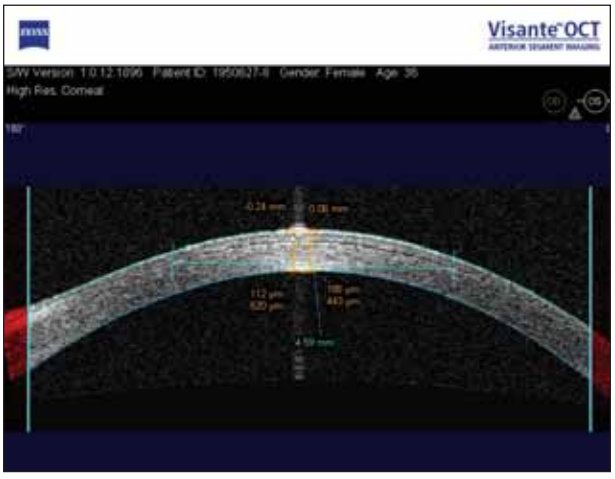

Figure 4. An intracorneal implant from Revision Optics is easily seen with the Visante OCT.

planar applanation and makes a relatively flat flap that my staff and I were able to view with the Visante without any ambiguity. The flap's thickness was fairly uniform, with a variation of no more than 21µm. Also evident is the addition of the caliper tool, shown in blue, which was included as a dimensional reference for calibration in this image.

CORNEAL IMPLANTS

My staff and I have imaged some intracorneal implants with the Visante OCT. One we were able to examine was a 5-mm intracorneal implant from Revision Optics (Lake Forest, CA; formerly known as Anamed) (Figure 4). This device is made of hydrogel material that appears clear in the images, and we were able to measure its diameter with the Visante's built-in caliper tool. Two flap tool measurements at the two interfaces allow a measurement of the implant's thickness (186 - 112 = 74µm), and the caliper tool shows the diameter (4.59mm) in this particular cross-section.

We also used the Visante to image a 2-mm presbyopic implant from Revision Optics, designed to create a multifocal effect in the center of the cornea. It was so thin we could barely image it, even with the Visante (Figure 5). Although still under investigation, this device has the potential for implantation under a post-LASIK flap to correct presbyopia.

CORNEAL TRANSPLANTS

We are pursuing the application of the Intralase FS laser as a cutting device to improve corneal transplantation. The original shape we studied for this application has been called a *top hat*, named for a configuration that looks vaguely like the side profile of a top hat (Figure 6). In the eye shown, we made the initial circular cut from the anterior chamber up into the stroma at a diameter of 8mm. When we reached a depth of 400µm from the anterior surface, a

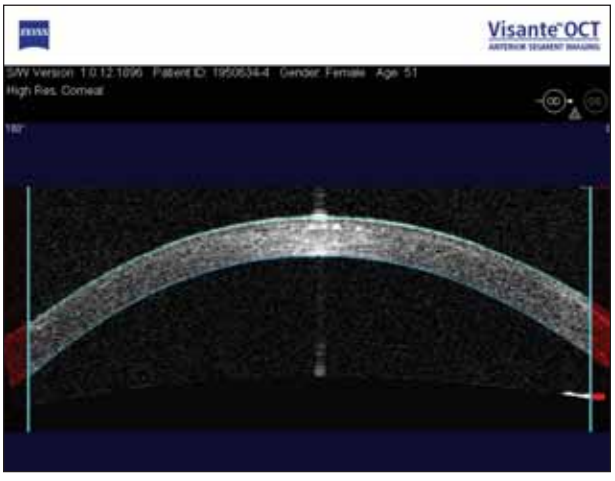

Figure 5. The Visante was able to image an extremely thin presbyopic implant from Revision Optics.

Figure 6. The top hat configuration in a corneal transplant using the Intralse FS laser.

Figure 7. The zigzag cutting pattern for corneal transplantation as seen with the Visante OCT.

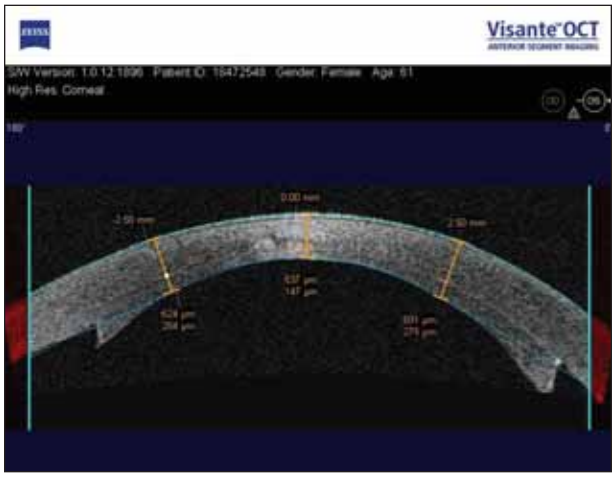

Figure 8. The Visante imaged a particularly pronounced meniscus shape in a DSEK patient.

lamellar incision pattern created a ring from 8mm down to 7mm. At this junction, the laser resumed a circular cut that progressed up to the anterior surface. The wound's configuration is best seen on the left side of this image.

We rapidly realized that the top hat shape had biomechanical and surgical deficiencies. As a result, we developed a "zigzag" pattern, which we have now used on 10 patients with excellent results (Figure 7). The pattern has a high degree of resistance to leakage. As a result, sutures do not have to be as tight as in conventional transplants, and patients consequently see better faster. Our typical amount of induced astigmatism is between 0.50 and 3.00D within 1 week postoperatively, with no suture adjustment. We also expect that the increased surface area of the incision and the healing stimulus of the photodisruptive process of the laser will accelerate wound healing, with greater incisional strength and possibly earlier suture removal. Figure 7, taken at 3 months postoperatively, shows the enhanced signal from the easily seen zigzag incision, which indicates wound healing. Also notable is the smooth contour of the periphery, with no evidence of suture compression, and the presence of the normal prolate contour of the peripheral cornea.

The rapid development of this exciting advance in corneal transplantation was only possible because of the Visante OCT. This technology allowed us to see cross-sections of the corneal incisions and make assessments of our results that cannot be obtained in any other manner.

ANGLE CLOSURE

Gonioscopy is sometimes impossible due to corneal optics, and the ability to assess the anterior chamber is limited to visible areas. In Figure 6, this corneal transplant eye had longstanding peripheral anterior synechiae that are readily seen as bridging tissue up to the back side of the cornea. What is even more intriguing, however, is that the Visante is able to image a small space in the periphery between the iris and the zone of the trabecular meshwork. This patient had already undergone the implantation of a glaucoma shunt. However, had the Visante been available, the identification of the space peripheral to the anterior synechiae might have led to an effort to release the adhesions and reconstruct the angle.

DSEK

The Visante helps in viewing Descemet's stripping endothelial keratoplasty (DSEK). The surgeon can see the interface and use the flap tool to document its depth. In one case, we imaged a particularly pronounced meniscus shape that may explain the observation of a number of clinicians that a hyperopic shift of 1.00 to 2.00D occurs in some DSEK patients (Figure 8). The Visante has also taught us that DSEK-implanted material continues to thin for an average of

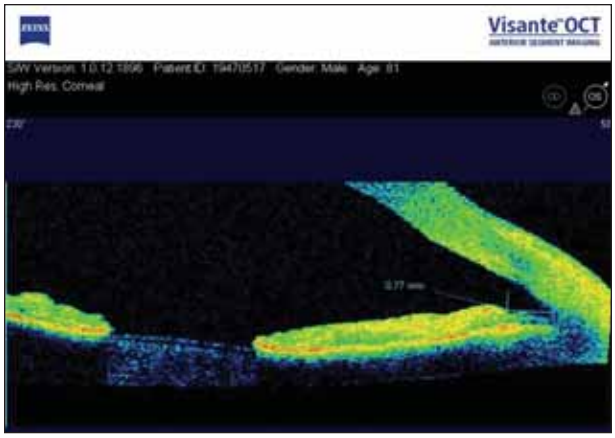

Figure 9. The Visante OCT can show the status of a lesion for tracking purposes.

3 months postoperatively, which is indicative of the corneal physiology's progressive, slow restoration over a considerable period of time.

PIGMENTED IRIS LESION

One very helpful application of Visante has been the ability to document and follow a patient with a pigmented iris lesion near the angle. In Figure 9, the lesion has the potential to be a melanoma, but excision is not indicated unless it expands and threatens to invade the angle or the ciliary body. The image indicates that there is no expansion posteriorly. The caliper tool allows a precise determination of the remaining space between the tumor and the angle. I have now seen the patient and measured his eyes 3 months apart, and I have absolute confidence that the tumor is currently stable, thanks to the Visante's images.

FINAL THOUGHTS

The applications described herein illustrate the versatility of Visante OCT technology. OCT has revolutionized retinal diagnostics and treatment, and now it is becoming a major tool for anterior segment surgeons. Its range of applications continues to expand rapidly as we have the opportunity to visualize the eye in a manner previously unobtainable. ✪

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VISANTE OCT IN THE REFRACTIVE SURGERY CENTER: HOW THIS DEVICE HAS ENHANCED OUR SURGICAL PLANNING

By Captain Steven C. Schallhorn, MD

My clinical team and I have had the Visante OCT (Carl Zeiss Meditec, Inc, Dublin, CA) for a little less than 1 year. There were two broad reasons behind our decision to buy it. First, we were seeking better ways to image the anterior portion of the eye. Better imaging is particularly important for working with phakic IOLs. Second, we desired better ways to analyze the corneal structure, specifically for use before and after keratorefractive surgery.

HOW WE USE IT

So far, my colleagues and I have found the Visante to be an excellent tool and relatively easy to use. The device produces a cross-section of the cornea that shows the anatomy and quality of the tissue in a degree of detail that was previously unavailable. No other device can create an image of the corneal bed, interface, and flap comparable to the quality of the Visante. One very useful feature of the device is a cursor that the user can place over an area of interest for precise depth measurement. We now use it routinely to image LASIK flap interfaces, especially in retreatments, and very accurate calculations of the residual bed can be made for this purpose. These calculations are particularly useful when there is no documentation of the flap's thickness or the excimer laser ablation depth. As such, the Visante is a valuable tool in our effort to prevent ectasia. Another great application of this device is to aid in the diagnosis, documentation, and surgical planning of certain types of corneal pathology, such as a Salzmann's nodule.

MEASUREMENT ACCURACY

In a preliminary evaluation, measurements of central corneal thickness were similar between the Visante OCT, the Pentacam (Oculus, Inc., Lynnwood, Washington), and an ultrasonic pachymeter. This finding is very reassuring. No adjustment or correlating factors are needed between these tools.

APPLICATIONS WITH PHAKIC IOLs

With phakic IOLs, the Visante's ability to accurately image the anterior chamber is very useful. For instance, we have been able to precisely document the vault between an implanted Visian ICL (STAAR Surgical Company, Monrovia, CA) and the anterior lens capsule. The Visante can be used to measure the anterior chamber's width and depth with great precision. There is no question that the device could be used to more accurately size a phakic IOL.

SURGICAL FLOW

At this time, my colleagues and I are selective about which patients undergo imaging with the Visante. We currently use it for surgical planning in LASIK retreatments, pre- and postoperative phakic IOL patients, and patients with corneal pathology. The amount of time required for imaging is negligible compared with the degree to which the device enhances our ability to plan a treatment. In short, the Visante is a very useful tool for imaging select patients.

Captain Steven C. Schallhorn, MD, is Director of Cornea Services at the Naval Medical Center in San Diego. He is not a paid consultant for Carl Zeiss Meditec, Inc, and acknowledged no financial interest in the company or its products. Dr. Schallhorn may be reached at (619) 532-6702; scschallhorn@nmcsd.med.navy.mil.

Advanced Imaging for LASIK Surgery

The Visante OCT provides surgical information that was previously unavailable.

BY ERIC D. DONNENFELD, MD

Here, I describe advanced LASIK applications with the Visante OCT (Carl Zeiss Meditec, Inc, Dublin, CA). Initially, I did not think I needed this device. After having the Visante in my office for 2 weeks, however, I could not believe that I had worked without it, given its many applications.

ECTASIA

Probably the most feared complication of LASIK is the development of ectasia, and I think that trying to keep it from occurring will be an instrumental application for the Visante OCT. I was involved in a white paper on keratoconus and corneal ectasia after LASIK that was published last November.[1,2] In this paper, my colleagues and I commented that the prevention of post-LASIK ectasia can be aided by improving the evaluation of (1) postoperative variations in corneal thickness, (2) flap thickness, and (3) the residual stromal bed. If a technology exists that can give us better ophthalmic information, it is the Visante OCT.

We know that LASIK flap measurements can vary widely. Kerry Solomon, MD, of the Medical University of South Carolina published an article[3] that showed flap thickness can differ by more than 100µm. A common finding among pathologic specimens from patients who have undergone LASIK and developed ectasia is abnormally thick flaps of which the surgeon may not have been aware.

The Visante OCT truly shines when the surgeon is planning an enhancement and is uncertain or has no previous documentation of the flap's thickness. The device's pachymetry readings allow the doctor to determine if the patient is a refractive candidate based on his corneal thickness and irregularities. The Visante easily calculates flap thickness even years following a corneal procedure. It also confirms ocular pathology and analyzes the anterior segment. The Visante's pachymetry maps show areas of thinning as well as hot spots, and they provide the low, high, and mean corneal thicknesses for multiple locations. These are simple applications that all refractive surgeons may easily implement.

> *"The [Visante] allows the doctor to determine if the patient is a refractive candidate based on his corneal thickness and irregularities."*

POSTSURGICAL APPLICATIONS

The Visante OCT is an incredibly valuable tool for examining patients after previous LASIK surgery. It provides visual documentation of flap thickness and irregularity, healing, edema, and the stromal bed, and it lets the surgeon decide if future enhancements are advisable. The Visante involves no guesswork, unlike subtraction pachymetry. In the present medicolegal environment, the Visante's visual documentation is critical and will allow ophthalmologists to make decisions based on information rather than on best guesses.

Insufficient Residual Bed

Figure 1 shows an eye with a thick LASIK flap and a thin residual bed. The surgery was performed 6 years earlier, and still the flap is readily visible with the Visante. Only 228µm of the residual bed is left, and the flap is 185µm. Obviously, the choice is either to perform PRK or leave this eye alone.

Figure 1. The Visante OCT reveals that this eye has an insufficient residual bed for a LASIK enhancement.

Figure 2. The Visante identifies an excessively thin cornea.

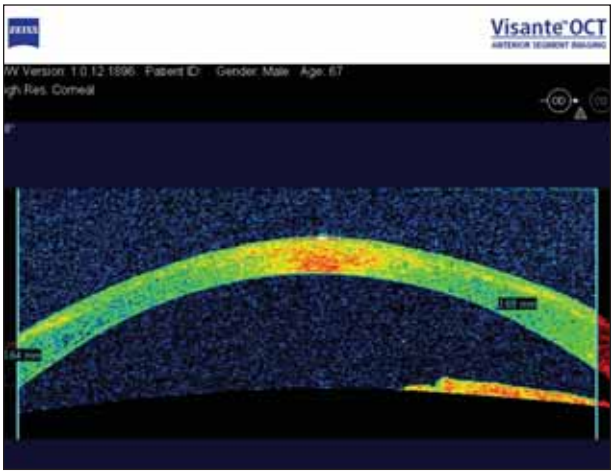

Figure 3. Epithelial ingrowth viewed with the Visante OCT.

CLINICAL EXPERIENCE WITH THE VISANTE OCT

By William W. Culbertson, MD

My colleagues and I at the Bascom Palmer Eye Institute in Miami have been using the Visante OCT (Carl Zeiss Meditec, Inc, Dublin, CA) since we received the instrument in April 2005. Our clinical group, which performs cataract, corneal, and refractive surgery, uses the Visante constantly, I would say approximately 15 times per day.

HOW WE USE IT

The most common ways we use the Visante are (1) imaging through opaque corneas and corneal scars into the anterior segment, (2) determining the thickness of a flap or the residual corneal bed for a LASIK enhancement treatment, (3) assessing past refractive surgeries, and (4) evaluating patients for corneal transplant surgery, lamellar transplant surgery, and anterior lamellar keratoplasties. We also employ it for evaluating the results of our surgeries, such as corneal transplants, to look at the configuration of the interface, the dimensions of the procedure, and the healing response. Finally, we scan for ocular diseases and evaluate the depth of a corneal infection. In our practice, the Visante OCT is largely an additive technology rather than a replacement for another device, although it could supplant intraoperative ultrasound pachymetry for measuring flap thickness and other structures postoperatively.

WHEN WE USE IT

The Visante OCT is particularly valuable because it is noncontact. Our technician can perform almost all of its tests in approximately 5 minutes per eye. Moreover, the instrument does not interfere with any procedure that we have performed or are planning to do.

With the Visante, we pre- and postoperatively evaluate every patient who has either undergone or is scheduled for a refractive procedure. We also use it on a fraction of our cornea patients. Although the device does not have much application for say, blepharitis, it is very practical for detecting keratoconus or other dystrophies. The Visante also has great potential for planning future surgeries.

IMPRESSION AFTER FIRST YEAR

I consider the Visante OCT a very interesting technology that regularly demonstrates usefulness in our cornea and refractive practice. Although perhaps not as important a breakthrough as retinal OCT, I think this device has the potential for providing ophthalmologists with more information than they can get accurately with any other currently available diagnostic modality. For example, postoperative dimensional assessment following refractive surgery is not reliable with the Orbscan (Bausch & Lomb, Rochester, NY), but is with this instrument. Furthermore, as Carl Zeiss Meditec, Inc, becomes able to express the findings of the instrument in terms of power curves of the cornea and lens surfaces, the instrument will have additional utility. Currently, the Visante OCT has wide-ranging utility for our practice's daily activities. Now that we have it, we would feel lost without it.

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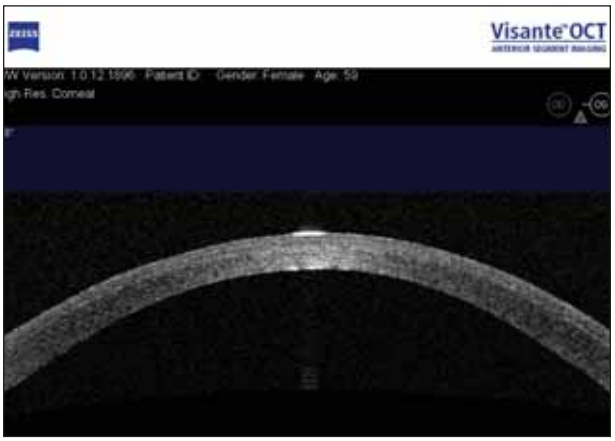

Figure 4. Fluid in the interface increased the IOP in this eye.

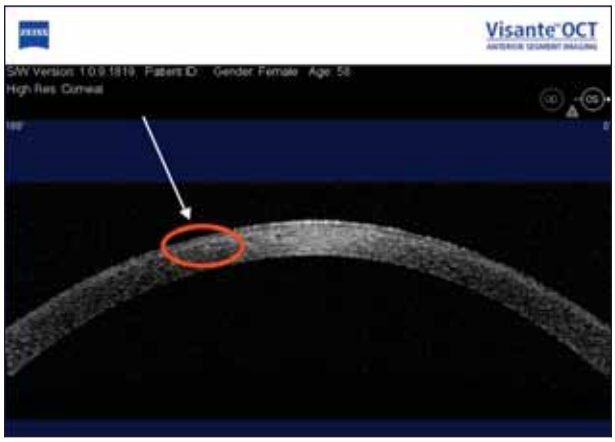

Figure 5. A buttonhole imaged with the Visante OCT.

Thick Flap

A patient came to me for a second opinion regarding additional refractive surgery. She had received a Verisyse phakic IOL (Advanced Medical Optics, Inc., Santa Ana, CA) followed by a LASIK enhancement. The Visante OCT revealed that she had significant stromal bed, but her flap thickness was 224µm (Figure 2). This finding was a complete surprise, and I contacted the original surgeon to see if he was aware that he was creating 224-µm flaps. This information might not have been available without the Visante.

Epithelial Ingrowth

Epithelial ingrowth is a very common problem that all refractive ophthalmologists encounter. Although usually readily visible, there are occasions when this complication may be difficult to detect, and I have used the Visante to outline it. The device shows and documents exactly how far epithelial ingrowth has moved into the eye (Figure 3). After the surgeon performs a scraping, he can again use the Visante to document that he removed all the ingrowth. Because this device is noncontact, he can reevaluate the patient's cornea immediately after the procedure.

Shallow Ablation

I used the Visante OCT to evaluate a post-LASIK patient who presented to me complaining of decreased visual acuity. The device produced an ablation difference map result for the entire cornea that was much less than would be expected: there was only approximately 23µm of ablation, whereas the patient should have had a 70-µm ablation. The Visante image further showed a fluid wave in the interface. Increased IOP was causing fluid interface changes so that the pressure read low, but the actual IOP was in the 40s (Figure 4). By lowering the pressure, the fluid resolved, the patient's vision returned to normal, and the subtraction map showed an expected ablation difference.

OTHER APPLICATIONS

Buttonholes are one of the more feared complications of LASIK surgery, and the Visante's images may help the physician determine the defect's depth and decide the best course of treatment (Figure 5). I prefer to manage superficial buttonholes with PTK. I often treat those that are significantly deeper in the stroma with lamellar keratectomy or lamellar keratoplasty.

Finally, the Visante will show the depth of corneal haze, which is a problem seen with PRK. The surgeon may then decide whether the eye needs PTK or simply a superficial corneal scraping performed in the office.

IN SUMMARY

The OCT allows us to calculate and document flap thickness and irregularity, judge how our keratome is working, evaluate and document postoperative healing, quantify stromal bed thickness, evaluate LASIK complications, and retain medicolegal documentation. In addition, the Visante provides valuable information about the anterior segment, which will have important applications for phakic IOLS. The Visante OCT provides the additional information necessary for the refractive surgeon to make an educated recommendation for the refractive surgery patient. ✪

Eric D. Donnenfeld, MD, is a partner in Ophthalmic Consultants of Long Island and is Co-Chairman of Corneal and External Disease at the Manhattan Eye, Ear, and Throat Hospital in New York. He acknowledged no direct financial interest in the company or products mentioned herein. Dr. Donnenfeld may be reached at (516) 766-2519; eddoph@aol.com.

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Refractive Applications of Visante OCT

This device increases the accuracy of phakic IOLs.

BY JOHN A. VUKICH, MD

I have been working with the Visante OCT (Carl Zeiss Meditec, Inc, Dublin, CA) for a little over half a year. I was one of the original investigators examining the device's feasibility for its original 510(k) approval, and I have continued to find new uses for it.

I wish to describe what I believe the Visante does well and also how it operates, because I think the latter is a critical variable. One of the things about which I am most impressed is that the Visante is a noncontact device. It is technician-run but not necessarily technician-dependent. The device is not messy. It takes only about 15 to 20 seconds to obtain an examination once the patient is situated. The total time to for acquiring an image is approximately the same as for an Orbscan topographer (Bausch & Lomb, Rochester, NY), maybe a little bit more than for an IOLMaster (Carl Zeiss Meditec, Inc), but it is quite suitable for patient flow within an office. It is not a difficult examination to incorporate into a routine screening. This fact is especially appealing to my glaucoma colleagues who are now using the Visante fairly routinely to document their patients' angles. I am very excited about these applications and others yet undiscovered for this machine.

> *"I will stop short of saying that the Visante OCT is the device for measuring the ICL, although I am quite positive that there is going to be some use for it in this regard."*

ACCURACY

Ultimately, the Visante OCT is a measuring device, and we want to know how accurate it is. Table 1 illustrates some of the internal analyses of the device's accuracy data from its original FDA study. The Visante was accurate to within 52µm for anterior chamber depth, 170µm for angle-to-angle measurements, and 1º for calculations of the anterior chamber angle. These are very good levels of accuracy and reproducibility. Importantly, the machine also achieved 95% sensitivity for flap visualization at 6 months, and the other authors in this monograph have described seeing clear images of flaps as old as 6 years. I think this imaging ability will be increasingly important as more patients seek their second or even third LASIK enhancements. Surgeons are starting to make difficult decisions about safety parameters for

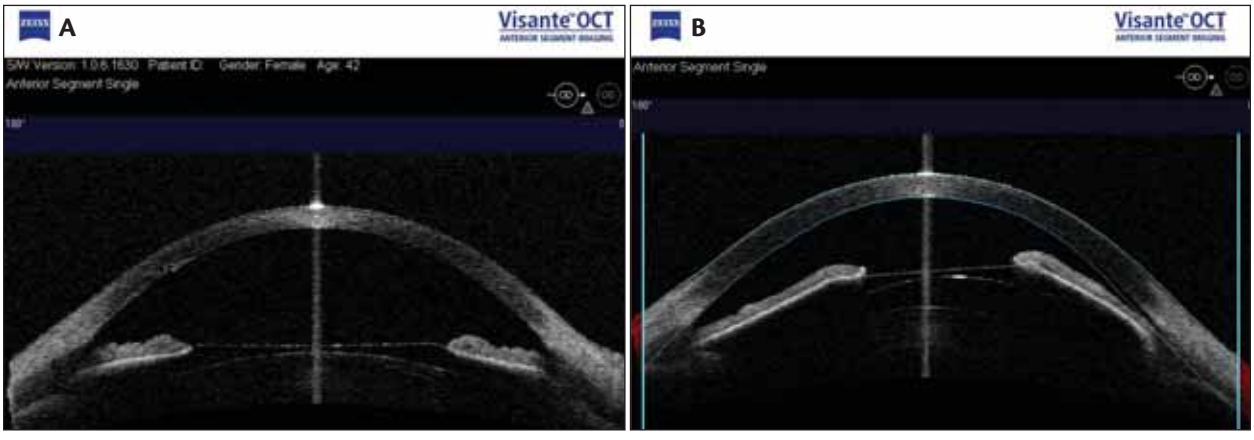

Figure 1. A myopic Visian ICL with minimal vault (A), and excessive vault (B).

enhancements, and many do not have accurate information about flap thickness.

The Visante measures corneal thickness, which is a useful routine application. We investigators found that different devices give different measurements of corneal thickness. We first realized with the Orbscan that when we applied optical imaging, the measurement did not always match that of ultrasound. The same is true between the Orbscan and the Visante—the Visante measures approximately 22µm thinner centrally. This discrepancy probably is related to the fact that the OCT device measures on the optical axis or the visual axis, whereas the Orbscan measures along the visual axis only.

TABLE 1. INTERNAL ANALYSIS VISANTE MEASUREMENTS

Measurement	Accuracy	Repeatability
Anterior Chamber Depth (ACD)	52µm	± 8µm
Angle-to-Angle (A2A)	173µm	± 52µm
Anterior Chamber Angle	1°	± 0.3°
Central Corneal Thickness (CCT)		± 7µm
Peripheral Corneal Thickness		± 14µm
LASIK Flap Visualization	95% sensitivity at 6 months	
Resolution	**Axial**	**Transverse**
	18µm	60µm

PHAKIC IOLs

One of my areas of special interest has been phakic IOLs. I continue to look at the Visante with a great deal of optimism regarding its potential to guide the sizing of IOLs (phakic IOLs, specifically) and thereby improve our ability to choose the right lens for the patient. My colleagues and I have just finished a study (and in fact are still continuing enrollment based on our initial feasibility) of 22 eyes that received the Visian ICL (STAAR Surgical Company; Monrovia, CA), all of which are at least 5 and up to 7 years out. We are examining the safety issues and data that would potentially influence our choice of IOL size. We are measuring anterior chamber depth, endothelial cell count, distance or dome of the cornea to the implant, pupil size, angle, and white-to-white distance. The Visante OCT will not usually image to the ciliary sulcus; its power tends to be absorbed by the iris pigment epithelium. It will sometimes obtain a clear image of the sulcus in very light-colored eyes, but not routinely. When we compared the Visante's anterior chamber measurements to those of the IOLMaster, the Visante's were slightly deeper, so we will have to determine exactly what that means in terms of the decisions we make for distance. The measurement between the corneal endothelium and lens epithelium also differed greatly between the Orbscan and the Visante. Our clinical impression is that the Visante seems more accurate, because at the slit lamp, we will get a different clinical sense of the chamber's depth compared with what the Orbscan reads.

The ICL's sizing remains a challenge; "white-to-white is imperfect" may be an understatement. However, we have been able to use ultrasound to a practical advantage. Ultrasound measurements are technician-dependent, not always easily reproducible, and are fairly hard to perform on a routine basis because ultrasound is a very special application that requires at least 20 minutes. Luckily, the ICL has a fairly large range of acceptable vaulting, anywhere from 50 to 1,500µm, probably due to poor sizing information.

THE SULCUS

Based on ultrasound biomicroscopy (UBM) studies, we know that relative to the limbus, the sulcus is on average

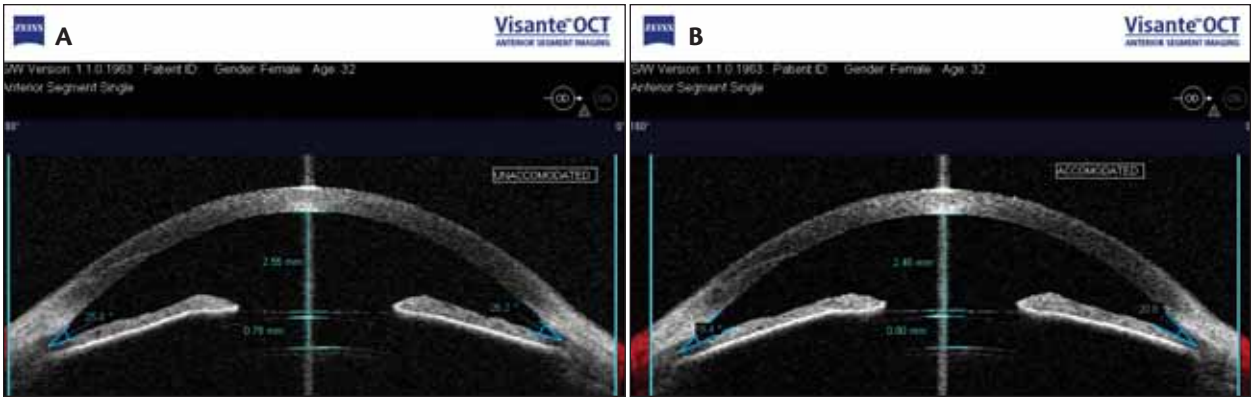

Figure 2. Nonaccommodation (A) versus accommodation (B) imaged with the Visante. The endothelial safety clearance was 2.55mm for the nonaccommodated eye versus 2.45mm for the accommodated one. The vault was 0.78mm for the nonaccommodated eye and 0.80mm for the accommodated eye.

0.21mm more peripheral from one side to the other, or about 0.42mm longer than a white-to-white measurement. In reality, the sulcus is highly variable in a given eye. Even just a few degrees away, it undulates in anatomy, and sometimes determining its location is difficult. These factors play no small part in the reason why ophthalmic surgeons have had difficulty making good correlations.

The ICL is designed to sit in the ciliary sulcus, although it does not always find the structure's recess. Measurements that would be helpful to know when implanting these lenses include the angle-to-angle distance, the clearance involved, the chamber depth, and what is preserved as the angle once this implant has been placed. A typical corneal vault would be 200µm or a 40% to 50% vault. Minimal vaulting (Figure 1A) would leave very little appositional difference between the implant and the crystalline lens. With excessive vaulting (Figure 1B), the angles would be unnecessarily narrowed, and the vault itself would be somewhat skewed and would tend to induce aberrations. Our study found that angle-to-angle and white-to-white measurements have a very poor correlation of approximately .39. So, when surgeons use the white-to-white measurement, they do not have a great deal of confidence that the angle-to-angle measurement will be the same. The question, then, is whether the angle-to-angle measurement is better for ICL sizing. Although we are still collecting data, I will say that in terms of correlations, we see great promise. I will stop short of saying that the Visante OCT is the device for measuring the ICL, although I am quite positive that there is going to be some use for it in this regard.

ACCOMMODATION

My colleagues and I have also studied accommodation with the Visante. What happens to accommodation with lens size? We had always felt that UBM was somewhat unreliable, considering the water baths and getting the patient to accommodate. The Visante has an accommodative target that measures lens movement, and with the ICL, there is a relative plane against which to measure. In the nonaccommodated versus the accommodated eye, we found that accommodation increases or at least does not change the relative distance between the ICL and the crystalline lens (Figure 2). We were reassured to know that there was a very slim chance that we were losing space. Before the Visante, we had not previously had the opportunity to validate that hypothesis strongly. Then, when we compared the mean estimated vault by slit lamp to the mean estimated vault by the Visante, the difference was only 27µm, which is not significant. As a result, we are now confident that clinicians can successfully estimate lens vaulting at the slit lamp.

Figure 3. Convex iris anatomy.

OTHER PHAKIC APPLICATIONS

My colleagues and I next thought that Visante OCT could be valuable in other phakic IOL applications. The Artisan lens (Ophtec BV, Groningen, the Netherlands), for example, has been available for some time and has gained some popularity. However, there are patients in whom it may be contraindicated, according to the Visante. As Antonio Marinho, MD, has described,[1] convex iris anatomy might be a contraindication in terms of maintaining enclavation on the iris, keeping the anterior segment relatively quiet, and avoiding inflammation or chafing. The Visante demonstrates that when the implant has an anterior vaulting configuration (Figure 3), unusual bunching of the iris may result and could lead to conditions that would cause either disenclavation or inflammation. Such screening is another application of the Visante that is gaining acceptance.

Revisiting the poor correlation between angle-to-angle and white-to-white measurements, the discrepancy will almost certainly have some direct implication for anterior chamber angle-supported IOLs. The accurate measurement of the angle-to-angle distance is very important for these lenses, and the Visante will be a key tool for fitting and sizing them.

IN CLOSING

Worldwide experience with phakic IOLs continues to grow, and our outcomes with them can only improve with better imaging technology. I am enthusiastic about the Visante OCT as a tool that will help achieve this goal. ✪

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1. Marinho A, Pinto MC, Vaz F. Phakic intraocular lenses: which to choose. *Curr Opin Ophthalmol.* 2000;11:4:280-288.

Exploring the Anterior Segment With Visante OCT

Versatility is the hallmark of this imaging device.

BY IQBAL IKE K. AHMED, MD, FRCSC

Here I discuss versatile applications with the Visante OCT (Carl Zeiss Meditec, Inc, Dublin, CA) in various specialties. Clearly, the refractive possibilities for the Visante are quite impressive, but it is also proving valuable in glaucoma, cataract assessment, and with pseudophakic IOLs.

GLAUCOMA

Gonioscopy

Gonioscopy, for those of us who perform it on a regular basis, can become almost second nature. However, physicians who do not practice it routinely can have difficulty ascertaining a confirmed diagnosis, such as with an open angle versus a narrow angle. The Visante OCT clearly images pigment to Schwabe's line, the trabecular meshwork, scleral spur, and the ciliary body band. When using the device to examine the angle, the user will focus away from the cornea a bit for a view of these features. The Visante's approach to imaging is noncontact and much less technically demanding than gonioscopy. Furthermore, the infrared light source does not stimulate pupil miosis and therefore does not change angle anatomy. Thus, I think its application for glaucoma has great potential.

Angle Closures

It is important to distinguish between oppositional versus synechial closure, as the prognosis and management may differ between these types of problems. Figure 1A shows a very obvious case of synechiae where there is an alteration of the peripheral iris architecture. Figure 1B shows a more subtle case of synechial closure in an eye with a plateau iris. To make these determinations with the Visante, the surgeon uses evaluations much as those attempted with ultrasound biomicroscopy (UBM), such as angle measures that include the angle opening distance and angle recess area, to properly quantify and objectify the angle measurements.

> *"This instrument is exquisite in its ability to see significant deepening of the peripheral angle."*

Laser Iridotomy

Figures 2A and B show an eye before and after undergoing laser iridotomy. The angle appears very tight preoperatively, but postoperatively you see that the iridotmoy increased the angle's width. The Visante's high-resolution scan shows appositional closure, and immediately after the iridotomy, cells in the anterior chamber were visible. This instrument is exquisite in its ability to see significant deepening of the peripheral angle.

Plateau Iris

Plateau iris is typically diagnosed by looking at the ciliary body's position with an absence of sulcus. The condition must be indirectly assessed in these particular situations, and I am currently involved in a study to test

Figure 1. The Visante images both obvious (A) and subtle (B) cases of synechiae.

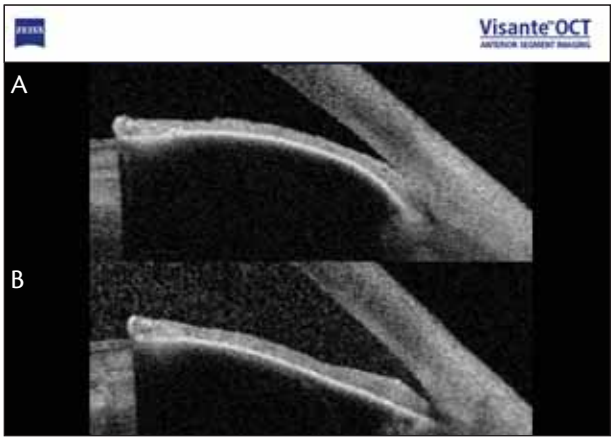

Figure 2. An angle before (A) and after (B) laser iridotomy.

this assessment by changing the angle architecture. My colleagues and I are examining angle recess areas and looking at the thickness of the iris as indirect measures of a plateau iris configuration. Because plateau iris is very hard to diagnose clinically, having an instrument that can discern this particular entity may be of some advantage.

Other Applications

For patients with narrow angle, the surgeon, by identifying the scleral spur, can determine whether the patient is at risk for angle closure and therefore requires an iridotomy.

Figure 3A shows a case of spherophakia—direct lens-related iris rotation. The Visante OCT shows how angulated the iris is, the depth of the anterior chamber (1.18mm), and how the iris has rotated anteriorly. This is not an iris bombe configuration or a plateau configuration, but direct iris rotation forward. It is important to diagnose this condition appropriately and manage this eye with a lensectomy. Figure 3B shows the lensectomy with a capsular tension ring. Note the significant deepening of the angle and the resolution of this patient's glaucoma.

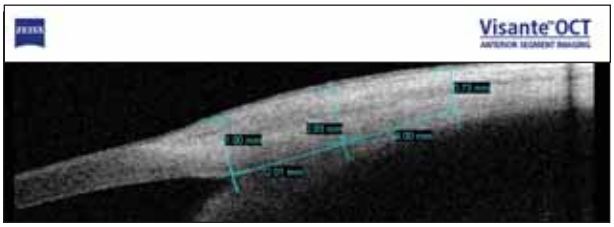

Figure 4. The Visante allows for scleral and uveal measurements of the anterior chamber in preparation for placement of a suprachoroidal microshunt .

Iris lesions, posterior pigment epithelial cysts, and conjunctival blebs are additional pathologies that the Visante can view, measure, and allow the surgeon to follow over time in different dimensions to assess for any change. Finally, this device has a built-in optometer to stimulate accommodation.

Preoperative Planning

Preoperative planning is very important with newer glaucoma instruments and devices, including internal shunts, as is the ability to measure the scleral thickness to properly evaluate how deep dissections should be. Figure 4 shows scleral and uveal measurements in a patient for which a suprachoroidal shunt is being planned. Postoperatively, the Visante is able to image scleral and suprachoroidal shunts along with subconjunctival, superchoroidal, and superciliary fluid.

CATARACT SURGERY

I think there will be a lot of interest in the Visante's abilities in working with cataract and IOL patient groups. The device clearly images the crystalline lens within the pupillary space. Also, the Visante's ability to measure lens thickness and cataract density and location seems to have potential value.

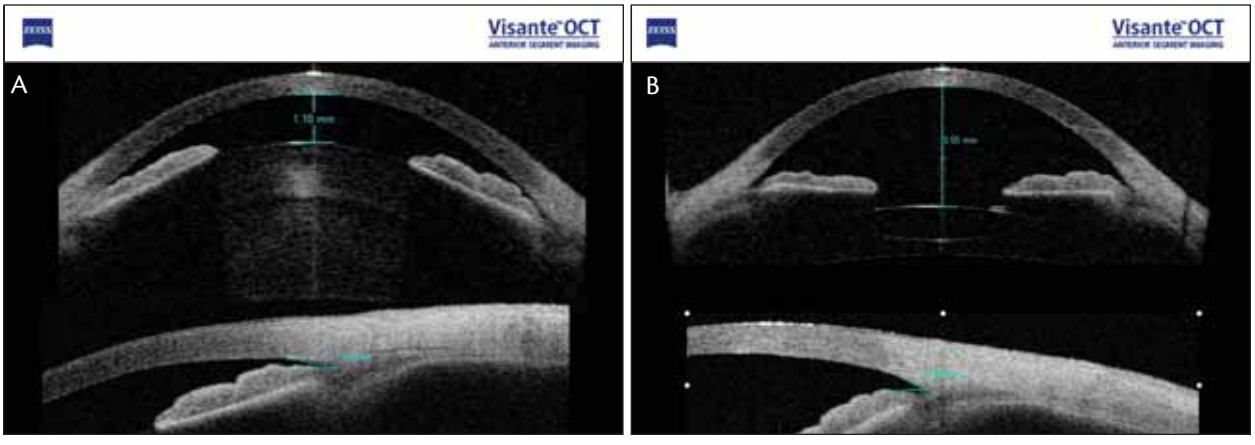

Figure 3. The Visante shows direct lens-related angle closure spherophakia (A). After treatment with a lensectomy and insertion of a capsular tension ring, the angle deepened and the eye's glaucoma resolved (B).

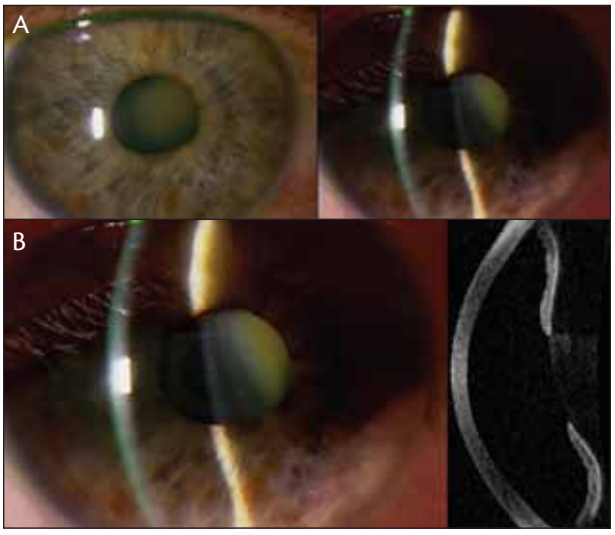

Figure 5. A cataractous eye showed peculiarities such as a dynamic difference between the superior and inferior angles.

There will be some densities that the Visante has difficulty imaging, such as 5+ brunescence. However, I was able to view a 3+ nuclear sclerotic cataract as well as hypermature cataracts far enough back to see the posterior capsule. In all, I have been impressed with the instrument's ability to image through an opaque cornea or lens.

The Visante proved quite useful in a particular case of a patient who presented with a cataract yet showed some peculiarities (Figure 5). The device revealed a dynamic difference between the superior and inferior angles. This patient had a loss of inferior zonules that resulted in the superior subluxation of the lens. The appropriate surgical management of such a case relies on an accurate diagnosis.

My team and I also imaged an eye with aniridia. In this case, the Visante allowed easy documentation and visualization of the anterior multiple equatorial and even the posterior zonules.

Again, the Visante's ability to define anatomical layers in the cataract is quite impressive. Posterior polar cataracts represent a unique challenge. Often, these patients have a very thin if not nonexistent posterior capsule. The Visante clearly images the posterior polar opacity (Figure 6). Such imaging allows the surgeon to proceed with a bit more confidence that the posterior capsule will remain intact during the surgical procedure.

IOLs AND CORNEAL INCISIONS

As previously described, the Visante is useful when sizing and placing IOLs. For example, I have imaged the anterior capsule curling slightly around an Acrysof IOL (Alcon Laboratories, Inc., Fort Worth, TX). The device will measure the anterior chamber's depth. Also, my colleagues

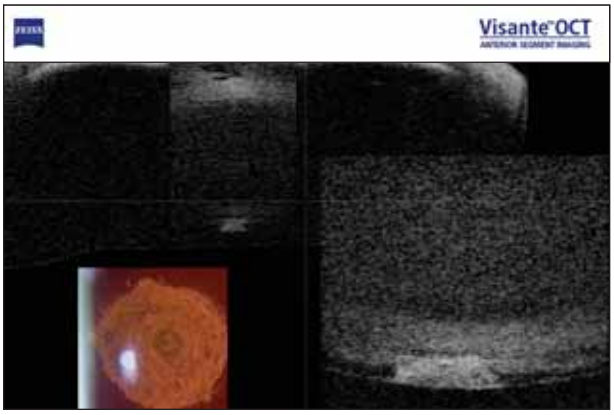

Figure 6. The Visante OCT confirms that this posterior polar cataract has an intact posterior capsule.

and I are currently working on algorithms to look at IOL tilt. We are using a sulcus-to-sulcus linear line and comparing that to the optic of a particular patient. We can actually measure the degrees of tilt as well as the decentration of the IOL. As new generations of IOLs continue to deliver improved visual quality, obtaining perfect centration and minimal tilt is critical. The Visante appears to be able to assess these patients for potential visual complaints.

Accommodative IOLs are certainly generating a lot of interest. I am currently involved in the FDA study of the Synchrony dual-optic IOL (Visiogen, Inc., Irvine, CA). The ability of the lens' optics to move farther or closer apart depending on the accommodative stimulus is something the Visante can dynamically assess, thereby proving or disproving whether these lenses move in the eye. Also, with corneal incisions, especially concerning bimanual versus coaxial, we can examine wound architecture for localized corneal trauma. Descemet's detachment is also easily evaluated in the postoperative situation. Further, we can image through the sclera and look for superchoroidal or supercilliary occlusion.

SUMMARY

As I have described herein, there are myriad ways to use the Visante OCT in ophthalmic surgery. It is a versatile imaging device for both refractive and anterior segment surgeons. I am excited to use the Visante to continue exploring the internal eye.

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