High-Tech Measurement For Phakic IOLs

Surgeons discuss the advantages and disadvantages of the Pentacam, Visante OCT and Artemis 2.

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WITH THE ADVENT OF PHAKIC intraocular lenses, measuring the anterior chamber accurately has become critical. Many surgeons still rely on tried-and-true technology such as standard ultrasound scans, the IOLMaster (Carl Zeiss Meditec) and the Orbscan II (Bausch & Lomb). However, three more recent instruments are now becoming the focus of attention for this purpose: the Pentacam (Oculus); the Visante OCT (Carl Zeiss Meditec); and the Artemis 2 (Ultralink LLC).

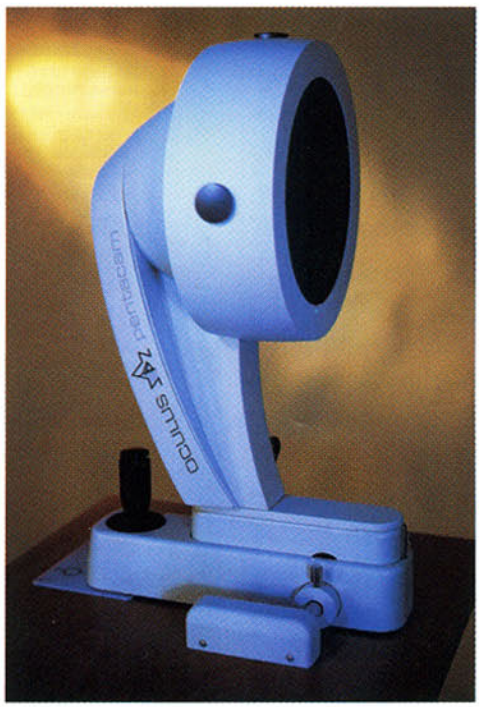
We asked a number of surgeons who have used these new instruments to discuss how the new tools are affecting their ability to get good results when implanting phakic lenses.

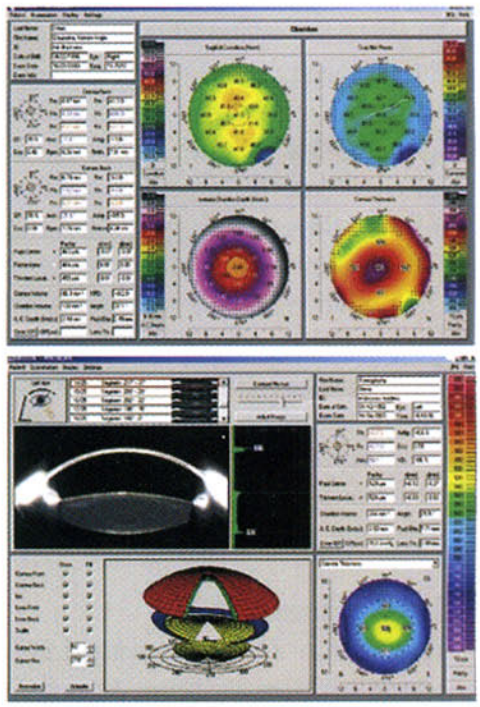
Working with the Pentacam

The Pentacam uses a rotating Scheimpflug camera to take multiple images of the anterior segment; its software then generates three-dimensional images and measurements of the anterior chamber. It provides detailed cross-sectional (or movable 3-D) images from the posterior surface of the crystalline lens to the anterior surface of the cornea, and measures the anterior chamber angle, chamber volume, chamber depth, pupil diameter and corneal characteristics such as eccentricity, central radius and astigmatism. The Pentacam can also provide pachymetry (limbus to limbus), densitometry data for the cornea and the crystalline lens, topography maps of the anterior and posterior surfaces of the cornea, and a "true net power map" showing the refractive value of the cornea at any given point.

Jason E. Stahl, MD, a cataract and refractive surgeon practicing in Overland Park, Kan., says that when measuring for a phakic IOL such as the Verisyse, he relies on both the Pentacam and IOLMaster, plus the refraction and measuring the endothelial cell count. "It's crucial to know the distance from the anterior surface of the lens to the corneal endothelium," he says. "The Pentacam can also look at the angle of the anterior chamber and give us an idea of how open it is, and tell us if there's any significant anterior vaulting of the iris and lens."

Dr. Stahl notes that the Pentacam is





In addition to measuring anterior chamber structures, Oculus's Pentacam functions as a topographer, pachymeter and camera, displays corneal refractive power, and provides densitometry data for monitoring cataract development.

also useful after a lens is implanted. "If the patient has an ICL in the sulcus, you can see if there's enough room between the implant and the crystalline lens to prevent the patient from developing a cataract," he says. "And, you can record the image and check for progression of the vault or cataract development when you follow up later."

Related Advantages

Vance Thompson, MD, who practices in Sioux Falls, S.D., and is assistant professor of ophthalmology at the University of South Dakota School of Medicine, had been using a Pentacam for two months when we spoke. He says he didn't get the instrument to measure anterior chamber depth. Instead, it has been most helpful to him in three other ways. "If I'm going to implant a phakic lens, the eye must have a clean optical system," he explains. "I always ask how the individual's nighttime vision is. If they don't have good image quality at night, it's either related to their optical devices or to ocular pathology, either in the form of higher order aberrations or nuclear sclerosis—early cataract formation that isn't perceptible at the slit lamp.

"Unfortunately, early cataract formation is one of the toughest diagnoses in ophthalmology," he continues. "But I've been amazed to find that in this situation, even though the lens looks clear at the slit lamp, I do Pentacam densitometry and sure enough, the patient has early cataract changes. This is key information when deciding whether or not to implant a phakic lens."

Dr. Thompson says the Pentacam is also helping him learn about the relationship of the crystalline lens to the iris. "When implanting the Verisyse," he explains, "you're trying to minimize iris compression. If a large crystalline lens is bulging the iris forward, that might make someone a less-ideal candidate for a phakic implant. There's no way to determine the angle or rise of the iris plane centrally compared to peripherally without this kind of technology.

"The other way the Pentacam is revolutionary," he adds, "is in providing true corneal power. Unlike traditional means of measuring corneal curvature, the Pentacam doesn't extrapolate measurements; it gives you a true measure of the central curvature. When you don't have historical data, or the contact lens overrefraction isn't going well, it's awesome to have this instrument for measurement."

Using the Visante OCT

The Visante OCT, an optical coherence tomography anterior segment scanner, is currently in clinical trials. ("Visante" is an amalgam of "vision" and "anterior.") It uses 1310-nm infrared light, which readily scans through the sclera and iris, to visualize a "slice" through the anterior

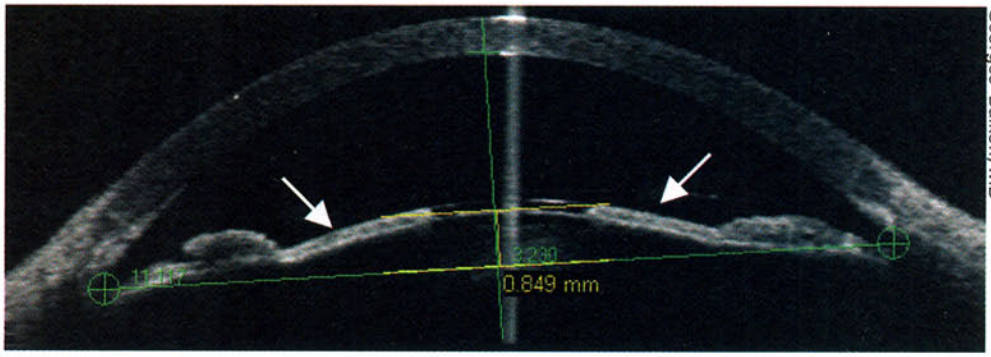
chamber. The Visante is designed to image the shape, size and position of anterior components and make precise measurements of the distances between them, including angle-to-angle, angle size in degrees, pupil diameter, anterior chamber depth, and thickness and radii of curvature of the crystalline lens. It has a resolution of about 10 µm. The Visante can image through an opaque cornea, but not through pigmentation on the posterior side of the iris, so in most eyes it can't measure sulcus to sulcus.

Georges Baikoff, MD, who has an anterior segment practice in Marseilles, France, has screened thousands of patients with a prototype of the Visante OCT. He has used it to predict the risk of pigment dispersion before implanting an Artisan/Verisyse lens, and to demonstrate that the crystalline lens touches many phakic IOLs (both posterior and anterior) during accommodation.[1]

"With the Visante OCT, we can see what conditions exist in the eye with and without accommodation, helping us to determine which type of phakic lens to implant," he says. "In addition, we can predict about how many years the phakic IOL will remain safe, using our knowledge of how the crystalline lens rise will increase with age."

Mark Packer, MD, FACS, practices in Eugene, Ore., and is clinical assistant professor of ophthalmology at Oregon Health & Science University. Dr. Packer's office is a beta test site for Carl Zeiss Meditec, and he had been using a Visante OCT for several weeks when we spoke to him. "The Visante is excellent for taking measurements prior to implantation of the Verisyse IOL," he says. "Its strengths are very high resolution, reproducible and accurate measurements including angle to angle, and very accurate intracorneal measurements for LASIK treatments or enhancements.

The Visante OCT from Carl Zeiss Meditec.



Georges Baikoff, MD

In this Visante OCT scan, iris tissue (marked by arrows) is compressed between an implanted Artisan lens and the crystalline lens, resulting in pigment dispersion.

"With the Verisyse," he adds, "you need to measure chamber depth from the peripheral cornea to the edge of the implant—the point at which the Verisyse is closest to the corneal endothelium. The Visante can get a variety of cross-sectional measurements, including this one."

Dr. Packer admits, however that the major drawback of both the Pentacam and Visante is that they're optical devices, so they can't see the sulcus. "With the forthcoming approval of the ICL," he says, "we need sulcus-to-sulcus measurements. Neither gives that, so we're stuck extrapolating from white-to-white measurements, which we know is imprecise."

Scanning with the Artemis 2

The Artemis 2 is a high-frequency (50 MHz) digital ultrasound arc-scanner that provides very high resolution images and measurements of the cornea and anterior segment. Unlike the Pentacam and Visante, when using the Artemis the patient's eye must be positioned in an eyecup filled with a saline-based interface fluid. However, the Artemis can provide the sulcus-to-sulcus measurement so important when implanting a lens like the ICL. Because it uses ultrasound, precision of Artemis measurements is on the order of 1 µm to 5 µm, depending on the scan depth.

Richard Foulkes, MD, a refractive surgery and IOL specialist practicing in Hinsdale, Ill., and associate professor of ophthalmology at the University of Illinois, has been using the Artemis 2 in his practice for more than a year. (He has no financial interest in the instrument or Ultralink LLC.)

"Right now, the only instrument that can see all the way from one sulcus to the other is the Artemis," he notes. "Also, because the Pentacam and Visante are optical, they have to calculate the effect of the cornea on their measurements and compensate for it; the farther toward the periphery they go, the greater the potential error. The Artemis scanner moves across the eye, so it has the same high level of accuracy at every point.

"In terms of ICLs, this is the brave new world," he continues. "Studies like those done by Liliana Werner, MD, at the Moran Eye Center, have demonstrated conclusively that white-to-white measurements don't match

sulcus-to-sulcus measurements. If you're working without an accurate sulcus-to-sulcus measurement, you might as well pick a medium size ICL and put it in all your patients!

"Another thing you can do with the Artemis that you can't do with the Pentacam or Visante is superimpose scans," he says. "ICLs can settle over the years, changing the relative distance to the crystalline lens. But because we can superimpose Artemis scans on top of one another over time, we can see subtle changes in angulation occurring, as well as other pathology issues."

Dr. Foulkes also sees the high accuracy of Artemis 2 scans as possibly being significant in phakic lenses other than the ICL. "Carlo F. Lovisolo, MD, in Milan, Italy, has reported better outcomes as a result of more accurate placement of anterior chamber phakic IOLs such as the Verisyse when measuring with the Artemis 2 instead of the Orbscan," he notes. "Because he's outside of the United States, he can implant the hyperopic and toric versions of the Verisyse lens, and place the lens posteriorly, clipping it onto the back of the iris. He also implants the toric ICL, and in this situation being able to accurately see the entire

What You See Is What You Get

Rick McCarley, president and CEO of Ophtec USA, the company that developed the Artisan/Verisyse phakic IOL, says that the company is working on technology that will allow surgeons to superimpose an image of the lens over the onscreen picture of the anterior chamber, to determine whether clearances are adequate.

"We're working on this with several instrument manufacturers," he says. "The picture of the anterior chamber is taken as normal. The dimensions of the lens, already entered into the computer, produce an image you can overlay onto the picture based on the lens's attachment site or placement within the eye. So, at least with our lens, you'll be able to view all the relationships between the lens and the tissue before implanting it."

Mr. McCarley notes that even if the instrument in question is able to image the sulcus, this technology might not be helpful for a product like the ICL. "My understanding is that a posterior chamber lens may push the iris forward when inserted. It moves tissue, creating a space that doesn't exist beforehand, like putting your hand into your pocket. You wouldn't be able to simulate that with this type of software."

He's not certain how soon any of the instrument manufacturers will make this option available.

sulcus is extremely important."

Dr. Foulkes notes that this instrument also has other practical clinical uses. "The Artemis 2 also lets us look at the placement of IOL haptics," he says. "Sometimes one haptic ends up sticking into the sulcus and causing pain; with the Artemis you can see exactly where the problem is."

Dr. Foulkes also takes advantage of the Artemis's ability to precisely measure discrete layers of the cornea. "In my refractive practice I won't re-treat a LASIK patient until I have a new Artemis scan so I can determine what's happened to their epithelium," he explains. "In many of these patients, it's actually epithelial hyperplasia that's causing the astigmatism or other complaint. We can treat that with non-surgical options like Acular and Restasis. In many cases we reverse the problem without treating with the laser. We've even been able to show differences in symmetry between mechanical microkeratome and IntraLase flaps with this device," he adds.

Too Expensive and Arduous?

Both Drs. Stahl and Packer acknowledge the technical advantages of the Artemis but are concerned about cost and the difficulty of using a water bath to take the scan. "The Artemis produces unparalleled images of the entire eye with great resolution," notes Dr. Packer. "Unfortunately, it's a large machine, very expensive, and the patient has to put her eye into a water bath. It's not practical for most practices today."

Dr. Foulkes disagrees. "My technician scans an eye in a minute and a half to two minutes. And it's not arduous for the patient. Most of our patients refer to it as the 'eye spa.' It actually feels good. In fact, dry eye and post-LASIK patients really enjoy it!

"Pricewise, you get what you pay for," he says. "Besides, you'll still be able to use this instrument 20 years from now."

Dr. Foulkes acknowledges that it takes more time and skill to use the Artemis than some other measuring options, but says that this is largely a function of the software, which is steadily improving. "Ultralink is working on pupil-tracking technology and automating parts of the scan that are still manual," he notes.

Dr. Foulkes says he finds it very reassuring to have the Artemis 2 in his clinic. "It answers questions the other instruments can't answer," he says. "Some of the things they miss are among the most important questions you need to ask. When you're puzzled about a patient's condition, the answer in most cases has to do with anatomy. In the past we had no way to look at microanatomy. Now we do."

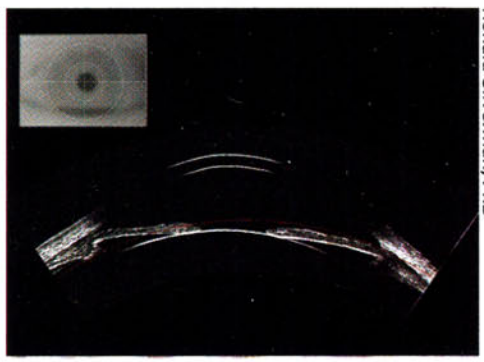
Dr. Foulkes also says the advantages of the Artemis 2 have resulted in a host of patient referrals. "I have patients referred to me by colleagues in a three or four state area," he says. "They're looking for information that only this instrument can give them.

"I get amazing information about a patient's eye in a couple of minutes," he concludes. "If you're worried that this will be too cumbersome or difficult, give it a try. You'll be using it every day and wondering how you lived without it."

Ready for the Future?

The usefulness of instruments such as these will probably increase as more phakic IOLs become available. Dr. Stahl points out that angle-supported lenses have been developed outside the United States, and accurately measuring the anterior chamber will be crucial when implanting them. "The anterior chamber of the eye is not a perfect circle," he notes. "It's more of an oval. If you put an angle-supported lens in the short axis, it could put pressure on the iris and cause either rotation of the lens over time or an ovalization of the pupil. With these devices we can determine the best placement of the lens." It's also clear that being able to monitor the vault of a phakic IOL could help prevent cataracts and glaucoma.

"Before these instruments were available," notes Dr. Stahl, "the only information we had was the anterior chamber depth from the ultrasound measurement for the IOL calculation and the endothelial cell count. Today, I suppose you could get by just using your IOLMaster, but it's good to see the anatomy before you go in there and do surgery. I think most surgeons who implant phakic IOLs are looking at these technologies."



Ronald Silverman, PhD

The Artemis 2, from Ultralink LLC, provides high resolution images and measurements of the cornea and anterior segment, including the sulcus.

1. Baikoff G, Lutun E, Wei Jay, Ferraz C. Contact between three phakic intraocular lens models and the crystalline lens: An anterior chamber optical coherence tomography study. J Cataract Refract Surg 2004;30:2007-2012