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# Staying on Target With Better Biometry

A roundtable discussion about the new LENSTAR LS900, the first biometer of the entire eye.

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# CONTENTS

## TARGETING PATIENT SATISFACTION

**Dr. Packer:** The purpose of this roundtable is to discuss accuracy and precision in IOL power calculations and biometry using the LENSTAR LS900 optical biometry device (Haag-Streit USA, Mason, Ohio; Figures 1 and 2), which received FDA clearance on October 20, 2009. With premium IOLs, such as presbyopia-correcting multifocal and accommodating IOLs and also toric lenses, the accuracy of our preoperative calculations is critical. Obviously, the worst part about missing a target refraction is displeasing the patient. How often do you panelists think an error in preoperative measurements (most importantly, keratometry or axial length) is the source of patients' dissatisfaction postoperatively?

**Dr. Devgan:** I am in solo practice and implant a lot of premium IOLs, often in patients who have undergone prior corneal refractive surgery. In these eyes, it is very difficult to obtain an accurate preoperative measurement to predict the corneal power, and this may be a source of error. Part of the difficulty is that most biometric devices are designed to measure the cornea in a larger diameter, so it is harder to measure a true central corneal power.

**Dr. Packer:** Dr. O'Brien, what percentage of your cataract patients has undergone previous keratorefractive surgery, such as LASIK or PRK?

**Dr. O'Brien:** These patients used to be rare, but they are becoming commonplace. In the course of our weekly cataract surgical schedule, typically two or three patients out of a group of 12 to 15 have had prior keratorefractive procedures. Postrefractive patients represent perhaps 10% to 15% of my patient population, and the number is growing as the population ages.

**Dr. Packer:** Aside from that group, do you have any other concerns about measurement errors?

**Dr. O'Brien:** Yes. In Palm Beach, older cataract patients are still interested in premium refractive IOLs. However, many of these individuals have ocular surface disorders that sometimes contribute to an error in the input and subsequently the clinical outcome.

**Dr. Packer:** Dr. Osher, the issues of post-LASIK eyes and patients with ocular surface disease relate to limitations of topography and keratometry, which result in missed refractive targets. Do you find that errors in noncorneal measurements also factor into suboptimal outcomes?

**Dr. Osher:** Even in perfect conditions, there are always inconsistencies and imperfect outcomes. My staff and I use multiple tests to determine the patient's axial length and corneal curvature. When we evaluate all the tests, the surgeon must judge which information is likely to be most accurate. When implanting premium lenses, we focus on achieving emmetropia. This can be challenging with long eyes, short eyes, and postrefractive surgical eyes. The ophthalmic community will welcome with open arms any technology that can improve our accuracy in lens selection.

## PREOPERATIVE SCREENING

**Dr. Packer:** When you are counseling a patient who wants a presbyopia-correcting lens, what preoperative measurements do you obtain?

**Dr. Osher:** Approximately 25% of my patients are candidates for toric implants or incisional astigmatic procedures, and I go overboard with taking preoperative measurements in these eyes. My work-up of the cornea includes manual keratometry, optical keratometry, and corneal topography. My staff and I perform biometry by measuring ultrasonic axial length as well as optical axial length. If we cannot obtain accurate readings with the IOLMaster (Carl Zeiss Meditec, Inc., Dublin, California), which is often the case with posterior subcapsular and also mature cataracts, we will use immersion ultrasound. We also use four IOL calculations in every surgical patient, and still we are not perfect. No matter how good we get, there will be plenty of opportunities to become even better!

**Figure 1. The LENSTAR LS900.**

**Figure 2. The LENSTAR LS900's workstation.**

**Dr. Packer:** Dr. Yoo, do you have a similar number of postkeratorefractive patients as Dr. O'Brien?

**Dr. Yoo:** We have fewer postkeratorefractive patients on the Miami campus, where the demographic is a bit younger. We see many patients with posterior subcapsular cataracts and some with more mature nuclear sclerosis, as well as cataracts related to trauma or steroid use. My colleagues and I conducted a study between our results with conventional A-scan biometry and the IOLMaster to see how close we were to the target refraction.[1] We reviewed 421 eyes in this study. Of the IOLMaster eyes, 79% were within 1.00 D, 45% were within 0.50 D, and 23.5% were within 0.25 D of the targeted refraction. Of the eyes that underwent ultrasound biometry, 71.3% achieved within 1.00 D, 37.5% were within 0.50 D, and 18.8% were within 0.25 D of the targeted refraction. With the refractive IOL market growing and patients' expectations rising, however, those percentages are no longer a worthy goal for refractive lens surgeons. So, we were interested in learning why we were missing the mark in a significant percentage of patients and in finding diagnostic and surgical technologies that could improve our targeted refractions. Our current diagnostic technology is unable to accurately measure extreme eyes (those with dense cataracts, staphylomas, abnormal macular contours, and high myopia). We are looking forward to the new LENSTAR technology, which we believe will be able to measure these eyes (Table 1).

## THE COST OF MISSED OUTCOMES

**Dr. Packer:** Do you have a sense of what it costs your practice to correct the 10% of patients who were more than ±0.50 D off their targets?

**Dr. Yoo:** Fortunately, our clinic provides not only refractive lens surgery but also laser vision correction, so we can keep these patients in house and fine-tune their results with either an IOL exchange or laser vision correction. Of course, these enhancements do cost us, so we want to minimize their number.

**Dr. Packer:** Dr. Snyder, do you also implant a lot of toric lenses?

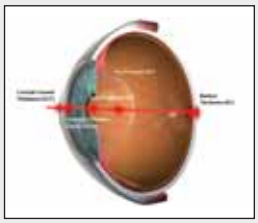
**Dr. Snyder:** Yes, I implant many toric IOLs as well as presbyopia-correcting lenses.

**Dr. Packer:** How do you optimize your patients' outcomes? Take us through your measurement calculations and surgery.

### TABLE 1. LENSTAR LS900 MEASUREMENTS

The LENSTAR LS900 offers one-touch

- keratometry (32 markers)
- white-to-white distance
- pachymetry
- anterior chamber depth
- lens thickness
- pupillometry
- axial length
- eccentricity of the visual axis
- retinal thickness



**Dr. Snyder:** Similar to Dr. Osher, I always have my staff perform manual keratometry, topography, and optical keratometry on all eyes at the time of the initial consultation. We have been using the IOLMaster primarily and the LENSTAR as a shadow while it was undergoing FDA review. If there is any disagreement between the measurements, then we re-examine the patient for corneal abnormalities. In recent years, I have noticed that it is no longer just premium IOL patients who demand to hit on target; those who choose a monofocal IOL and do not have astigmatism are also unhappy if they do not achieve their targeted refraction. Just because these patients did not place an emphasis on quality near vision does not mean that they want to wear glasses for distance. So, I now treat all my patients as premium patients, whether they choose a premium IOL or not.

**Dr. Packer:** How do you manage missed outcomes, and what do you think they cost your practice?

**Dr. Snyder:** A practice's cost for missed targets is greater than simply the price of enhancing them with laser vision correction or replacing the implanted lens with one of a more appropriate power. The greater detriment to the practice is the fact that these patients are complaining to their acquaintances for a prolonged period of time. We usually do not perform an enhancement promptly; we typically wait a minimum of 1 month until the patient's refractive error stabilizes. In that interim, these patients continue to be unhappy. Everyone they know is asking them how their cataract surgery went, and they are complaining. People who hear from an unhappy friend will then think twice before scheduling their own consultation, because they do not know if the patient is unhappy because he selected the wrong implant or because he now has slight myopia that will ultimately be corrected. Furthermore, these acquaintances are unlikely to ask their friend how his vision is 3 months later, after he has been corrected and is

> **"The LENSTAR allows surgeons to measure the cornea a little more centrally than previous methods for more accurate readings."**
> *—H. John Shammas, MD*

happy. So, I look at the cost of missing a target in terms of marketing efforts and lost revenue.

**Dr. Packer:** So, there is an intangible cost of negative word of mouth and damaged reputation that is very hard to quantify, but certainly very real.

**Dr. Shammas:** I agree with Dr. Snyder. From the patient's perspective, it is immaterial what size incision you make or from what position you operate. Patients only care about the postoperative result. A patient is happy if he can see well, the way you told him he would see postoperatively.

Furthermore, the average ophthalmologist has no idea how to achieve accurate axial length measurements, K readings, or formulas. I see a fair amount of patients referred from other ophthalmologists because of missed outcomes, which usually result from an error in axial length.

## CHALLENGING EYES

**Dr. Packer:** Dr. Shammas, please talk about the eyes that are more difficult to measure. We all know that short and hyperopic eyes pose a challenge for biometry as well as IOL calculation formulas. What is the best way to take these measurements in the hyperopic eye?

**Dr. Shammas:** The problem Dr. Devgan described with postrefractive corneas is very common now. The LENSTAR allows surgeons to measure the cornea more centrally than previous methods for more accurate readings. The other challenge is estimating where the implant is going to sit inside the eye, which is why we have so many formulas (although none is specifically designed to address short eyes). IOL positioning is most difficult in hyperopic eyes, where any error in the axial length measurement becomes magnified. An error in axial length of 0.1 mm will result in a 0.25 D error in a normal eye, 0.20 D of error in a long eye, and 0.33 D of error in a short eye. Another common mistake surgeons make with short eyes is to misestimate the anterior chamber's depth. Finally, until now, it has been hard to measure the lens' thickness (Figure 3), unless we perform ultrasound biometry on top of the optical biometry, like Dr. Osher does. Most surgeons do not do this, however. So, all of these errors accumulate in short eyes to cause surgeons to miss the final refraction.

**Dr. Packer:** How important is calculating the anterior chamber's depth relative to axial length or keratometry in the most commonly used IOL formulas? What is the most common cause of error in calculating this measurement?

**Dr. Shammas:** Most ophthalmologists are still using third-generation IOL formulas, such as the SRK/T, the Holladay 1, and the Hoffer Q. To estimate the position of the implant inside the eye, these formulas use only the axial length and the corneal curvature. Wolfgang Haigis, PhD, created a two-variable IOL formula that bases the lens' position on the axial length and the presurgical depth of the anterior chamber, which is the measurement from the anterior cornea to the anterior surface of the crystalline lens. With a more accurate anterior chamber depth, a Haigis formula will give a much better result in short eyes.

Fourth-generation IOL formulas include the Holladay II and the Olsen formula by Thomas Olsen, MD.[2] These formulas depend on four variables instead of two: the axial length, the corneal curvature, the anterior chamber depth, and the lens thickness. Before the LENSTAR, the only way to measure lens thickness to use in these formulas was with immersion ultrasound or a contact A-scan. Surgeons who are using optical biometry only and have no ability to calculate lens thickness cannot accurately use a fourth-generation formula. The LENSTAR calculates lens thickness and thus solves this problem.


**Figure 3. The LENSTAR LS900's scans appear similar to immersion ultrasound, and all gates can be moved.**

**Dr. Packer:** Dr. Devgan, you mentioned keratometry specifically and its problematic nature in postkeratorefractive eyes. How do you use the IOLMaster's keratometry in untreated as well as post-LASIK eyes?

**Dr. Devgan:** I measure my patients' K values before surgery using both manual keratometry and an automated method, such as the LENSTAR or the IOLMaster. I also use various types of topography. Choosing which measurements to trust is only an issue if the measurements disagree. If this happens, I will use the K values that are closest to the visual axis, because they are likely the best representation. Because the LENSTAR gives corneal measurements that are closest to the central visual axis, it is quite accurate. Again, I run into the most difficulty with postrefractive eyes, because the anterior curvature of the cornea no longer has the same relationship to the posterior curvature. There is no single best formula for calculating these eyes. Using a service like the Post-Refractive Surgery IOL Calculator on the ASCRS Web site (http://iol.ascrs.org/) is helpful, but it still does not work perfectly in these patients. Because of these shortcomings, I offer free enhancements for patients who select premium IOLs. I also make sure they understand preoperatively that the IOL calculations are purely estimates and not true measurements.

**Dr. Packer:** Dr. O'Brien, you also treat a high number of post-LASIK eyes. What is your current approach? If you use the ASCRS online calculator and get a range of answers using different formulas, from 23.00 to 27.00 D, then what?

**Dr. O'Brien:** Despite having all these formulas, many times, my staff and I have to go back to the patient's previous records and be especially meticulous with our IOL calculations, particularly in post-RK patients and even in those who have had prior LASIK, in order to try to avoid a 9.00 D or 10.00 D surprise. I agree with Dr. Devgan that these eyes are challenging because of having a central scotoma , if you will, that prevents us from determining the central corneal flatness. So, I try to take all these factors into account when performing IOL calculations. I generally err on the side of slightly myopic postoperative results.

**Dr. Devgan:** I think accurate IOL calculations are most important in patients who have undergone prior hyperopic LASIK. I want to make sure these individuals do not end up hyperopic again postoperatively, because further hyperopic excimer ablations may not be an option. Fortunately, refractive errors in these eyes usually are myopic.

> **"Because the LENSTAR gives corneal measurements that are closest to the central visual axis, it is quite accurate."**
> *—Uday Devgan, MD*

**Dr. O'Brien:** Right. These patients will accept a myopic surprise much more graciously than a hyperopic surprise.

**Dr. Packer:** What are the most challenging types of post-LASIK eyes?

**Dr. Yoo:** As more people who have had previous refractive surgery reach the age of needing IOL surgery, surgeons will increasingly encounter these challenging eyes. Eyes that have undergone high corrections are at particular risk for missed targets. Eyes that have had previous LASIK for moderate amounts of myopia or hyperopia are less of a challenge, because their refractive keratometry is not so different from their pre-refractive K readings. Conventional methods of IOL calculations work pretty well for those eyes, which fortunately are the majority. The most problematic eyes are those that have no history, so we cannot know if they were highly myopic before the laser vision correction.

Ianchulev et al published a technique[3] for intraoperative optical refractive biometry that we use to check IOL calculations intraoperatively for postrefractive eyes. We shoot an aphakic autorefraction, use the nomogram, and confirm an accurate IOL calculation. Operating room retinoscopy is another good resource for biometry.[4] With new technologies like the LENSTAR, however, we hope to be able to develop formulas that can account for postsurgical eyes.

**Dr. Packer:** How do you measure IOP and intraoperative alignment when you obtain this refractometry?

**Dr. Yoo:** That is a real issue. When taking measurements intraoperatively, surgeons need to control for IOP, surface quality, parallax, etc. If they take multiple readings of an aphakic autorefraction, for example, and have consistent readings, they can feel reasonably certain that the spherical equivalent at least will be in an accurate range. I think the measurement of astigmatism still needs work, however.

## ADVANCED ACCURACY

**Dr. Snyder:** I am increasingly concerned with the axis of astigmatism when I perform preoperative lens calculations. It occurred to me that patients' heads may drift off to the

> **"The precision of the LENSTAR's biometric calculations is fantastic."**
> *—H. John Shammas, MD*

side when their measurements are being taken. We can make sure their heads are perfectly aligned when they are perpendicular to the floor, but if the measurement is not taken in the exact same position, then we do not know what we are capturing. I especially appreciate that with the LENSTAR, I can look at the image of the eye while the device is capturing its keratometry and see where the horizontal and vertical meridians are based on the reflex of the lights (Figure 4). This allows me to select a landmark based on the moment that the keratometry was captured, so I do not have to worry about whether the patient was tilting his head. What I really want to identify is the corneal astigmatism relative to a landmark on the globe. I like to print out the LENSTAR's picture at the moment of capture to confirm my astigmatic landmarks with those I select at the slit lamp.

**Dr. Packer:** Dr. Snyder has pointed out a significant advantage that the LENSTAR offers in terms of finding the axis of astigmatism. Dr. Shammas, in what other ways do you think the LENSTAR will advance our biometry?

**Dr. Shammas:** The precision of the LENSTAR's biometric calculations is fantastic. When the IOLMaster first became available, it created a new level of accuracy in biometry, beyond that of immersion A-scan, even. The LENSTAR takes the accuracy of these measurements a step further. The IOLMaster takes four measurements in a row, but if these measurements are erroneous, then their average will still be erroneous. With the LENSTAR, the physician has to focus the device and take measurements three separate times. If he makes an error, he can strike it out and put another measurement in. I think the precision of the LENSTAR's measurements is going to be exquisite.

**Dr. Packer:** Is it important that the LENSTAR takes nine different measurements simultaneously on the visual axis?

**Dr. Shammas:** In the study my colleagues and I conducted comparing the measurements of the IOLMaster and the LENSTAR, the axial length calculations and the Ks were comparable.[5] The biggest difference between the two devices is in measuring anterior chamber depth. The LENSTAR takes this measurement through the visual axis, which is far more accurate than through slit-lamp illumination.

**Dr. Packer:** I also noticed a difference in the anterior chamber depth measurement between the two machines. This concerns me, because this calculation is very important in shorter eyes when using the fourth-generation formulas. I also anticipate that we will be able to improve our refractive accuracy by obtaining a more precise measurement of the anterior chamber depth and adding the lens thickness calculation that we can now get optically rather than having to use immersion A-scan.

**Dr. Shammas:** I agree. In average eyes with a normal axial length and keratometry, there will not be a huge difference between any of the formulas. The greatest difference is seen in short eyes.

**Dr. Packer:** Dr. Devgan, you perform a lot of refractive lens surgery. The LENSTAR limits its axial length measurement to 32 mm. Do you feel that is a serious limitation?

**Dr. Devgan:** The number of people with an axial length of more than 32 mm is rare, so it is not much of a limitation. Furthermore, the same error in axial length measurement, such as being off by 1 mm, produces less of a difference in the IOL power in highly myopic eyes compared with emmetropic eyes. The former tend to be the most forgiving of variances in axial length measurements.

**Dr. O'Brien:** Unless they have a staphyloma.

**Dr. Devgan:** Correct. However, with the LENSTAR, you can be certain you are measuring the eye's axial length to the fovea. I also feel that corneal thickness is an important measurement in biometry. The LENSTAR provides pachymetry as well as eight other values (Figure 5). Pachymetry tells


**Figure 4. The LENSTAR's red-free digital iris photo shows iris landmarks and identifies the patient's actual visual axis. The photo is also used to measure the pupil's diameter and white-to-white length.**

me if something is wrong with the eye. Have I missed some guttata? Is the cornea thicker than normal? Does the patient have Fuch's dystrophy that I have not seen? Is the cornea thinner than I expect? Has the patient had too much prior refractive surgery? We sometimes see eyes that have undergone more than 10.00 D of prior LASIK and have 300 µm of residual corneal thickness. There is no room left to do a future laser correction. Finally, if I need to perform a limbal relaxing incision or other incisional astigmatic technique in an eye that has a very thick central corneal measurement, I will probably have to adjust the depth or increase the arc length in order to achieve the effect.

**Dr. Packer:** On what measurement do you rely to guide limbal relaxing incisions?

**Dr. Devgan:** To accurately determine the alignment of the steep corneal axis, I use the automated keratometric reading from the LENSTAR in combination with manual keratometry and corneal topography. The corneal pachymetry tells me if I will need to adjust the depth of my limbal relaxing incision. Surgeons must also remember to take into account the astigmatic effect of the main phaco incision.

## TRUE CORNEAL POWER

**Dr. Packer:** Dr. O'Brien, the LENSTAR takes readings in two circles, 16 points in each circle, for a total of 32 readings. The inner circle has a diameter of 1.65 mm, and the outer circle has a diameter of 2.3 mm. Are those optimal diameters for obtaining the best measurement of the patient's true corneal power?

**Dr. O'Brien:** As I said, it is difficult to pinpoint the true central power in some eyes, but I think the LENSTAR's approach does offer some advantages over previous methods, certainly to manual keratometry. We also have to take into account the pupil's diameter in certain patients. As Dr. Yoo mentioned, younger patients in particular have larger pupils. In older patients whose pupils do not grow much larger than 3 mm in diameter, it is less of an issue.

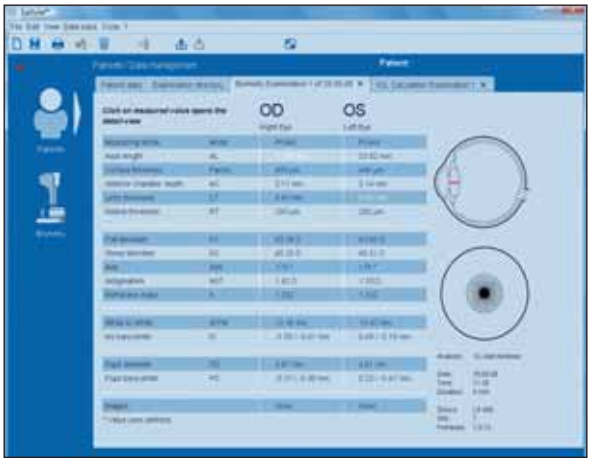



**Figure 5. The LENSTAR LS900's measurements results screen shows data for nine values.**

> **"It is difficult to pinpoint the true central power in some eyes, but I think the LENSTAR's approach does offer some advantages over previous methods."**
> *—Terrence P. O'Brien, MD*

**Dr. Packer:** The LENSTAR calculates the keratometric value by 32 projected light reflections, which are arranged on two rings, as I mentioned, with 16 measuring points on each ring. Averaging over a relatively larger number of points may improve accuracy and reliability. The inner circle, which consists of 16 LEDs, is projected onto the cornea in a 1.65-mm-diameter ring, which is a relatively small diameter. It gets closer to the "central scotoma" you mention, Dr. O'Brien, and may therefore be beneficial for calculating the keratometry of corneas that are altered centrally after keratorefractive surgery for myopic correction.

**Dr. Devgan:** Using the LENSTAR to measure closer to the central visual axis provides a better representation of the true corneal power. A great example is an eye that has undergone hyperopic LASIK or RK and subsequently has a smaller functional optical zone. Keratometry performed at a larger zone will give a false representation of the true corneal power. The closer the keratometry is to the central visual axis, the more accurate the IOL calculations will be and the less chance for a postoperative refractive surprise.

## TO DILATE BEFORE OR AFTER MEASUREMENTS?

**Dr. Osher:** Is it problematic to take all these measurements with the eye dilated?

**Dr. O'Brien:** Based on our keratorefractive experience, we try to assiduously avoid dilating patients before we capture all their information.

**Dr. Osher:** Yes, but cataract surgeons generally dilate their patients before sending them to get their testing done. Should LENSTAR measurements be taken before dilation?

**"LENSTAR measurements have helped me detect abnormalities in a few patients who presented with various complicated situations."**
*—Michael E. Snyder, MD*

**Dr. Devgan:** If you measure the depth of the anterior chamber in an eye with pseudoexfoliation in the nondilated state, you may have a 25-mm eye with a shallow anterior chamber depth, which indicates that the zonules are a little loose. You may be able to see that the lens-iris diaphragm is pushed forward. If you dilate that same eye and repeat the measurements, the anterior chamber will be deeper. So, I think the timing matters.

**Dr. Snyder:** Dr. Osher makes a very important point. I currently obtain the LENSTAR measurements before I see patients, because the data guide me in advising them. At least twice per week, a patient presents for a cataract consultation who is either a hyperope or has a near-plano refraction and who has an axial length of greater than 25 mm. These individuals are obviously at a greater risk for retinal detachment, and informing them of that risk increases my level of service. Furthermore, LENSTAR measurements have helped me detect abnormalities in a few patients who presented with various complicated situations such as trauma or after anterior segment surgery. For example, I detected a shorter axial length in an eye that had undergone previous iris repair, and it changed my treatment plan for the patient. Or, frequently, I see patients with a slightly elevated IOP, and I do not know if it is caused by an abnormal corneal thickness or something else. When I have that information in front of me now, I can better advise patients of their surgical risks and options before we determine if they wish to have surgery.

**Dr. Osher:** I completely agree. You want as much information as possible before surgery. I'm simply asking whether it matters when we dilate the pupil.

**Dr. Devgan:** I think it is best to use the LENSTAR on an undilated eye that has not had its pressure taken. I would not perform these measurements after the technician has already applanated the cornea and dilated the eye.

**Dr. Osher:** I agree that some testing should be performed on an undilated eye. That's what I do.

**Dr. Yoo:** Right. Keratometry and the center of the pupil can be altered by dilation drops.

**Dr. Snyder:** Now that I am able to obtain simultaneous keratometric (Figure 6), line of sight, and pupil measurements with the LENSTAR, I will probably start performing my biometry before dilation as well.

**Dr. Osher:** We are here to learn as well as to teach. With any new technology, we don't know what we don't know! Perhaps I am not taking these measurements at the optimal time.

**Dr. Packer:** From a practical perspective, should all patients who enter the office receive a LENSTAR examination before seeing the physician, before we know if they are going to have cataract surgery? Should we perform this screening before we consult with our patients or test their acuity? You've suggested that performing keratometry and biometry prior to dilation will provide more accurate information for IOL power calculation. Previous studies of partial-coherence interferometry[6] and ultrasound[7] have found differences in keratometry and central corneal thickness when performed before and after dilation, but no differences in anterior chamber depth, axial length, or calculated IOL power. By the time we examine patients and determine whether they are candidates for cataract surgery, it is too late to get an untouched image of the eye with the LENSTAR. We certainly are not able to take advantage of the device's pupillometry feature. So now, should we couple LENSTAR measurements with the autorefraction for everyone, even potential cataract patients?

**Dr. Shammas:** That approach may work for high-volume cataract surgeons, but I do not think it makes sense for the average ophthalmologist. I would not want to see clinicians


**Figure 6. The keratometry screen on the LENSTAR LS900.**

being charged with billing for unnecessary testing. Or maybe we would not bill for it?

**Dr. Snyder:** If I think performing this testing on every patient will help me do a better job as a surgeon, I will eat the cost from the patients who do not schedule for surgery.

**Dr. Packer:** I think many ophthalmologists are faced with this conundrum. Medicare states that a test such as axial length cannot be billed except on the order of the physician. We cannot order that test until we have decided whether to recommend cataract surgery, and we cannot decide to recommend cataract surgery until we examine the patient.

**Dr. Snyder:** We can collect that information in order to give somebody good advice. For my process, I can standard-order the test to be performed before I see the patient. I will take LENSTAR measurements on everybody, but I only bill for that test if the patient schedules surgery.

**Dr. Yoo:** That's right, we can use a standard order, just like for dilating drops.

**Dr. Devgan:** Or topography. Every patient who presents for cataract surgery evaluation gets topography, but unless there is a pre-existing indication for the test, such as irregular astigmatism or keratoconus, the cost is absorbed by the practice and not billed.

**Dr. O'Brien:** I think keratorefractive surgeons need the LENSTAR results in advance of dilation. If we can acquire nine data measurements in 30 seconds, that information will help us manage the patient better.

**Dr. Snyder:** We should not allow billing practices to dictate how we care for patients. This information is valuable; it may change how we educate people about their options. Whether or not we are paid for doing it is a different issue that must be addressed separately.

## IMAGING CAPABILITY

**Dr. Packer:** The LENSTAR is based on optical low-coherence reflectometry and uses a superluminescent diode (SLD) at 820 nm coupled to the reflectometer as a measurement and fixation beam for the patient. Because of the different spectral characteristics, a higher resolution can be achieved with the use of an SLD compared with a multimode laser diode.[8] Dr. O'Brien, have you seen any cataract so dense that it cannot be measured with optical biometry?

**Dr. O'Brien:** Yes, we have. Dr. Yoo was describing our patient mix. Certainly, in Palm Beach and Miami, we have a higher population of patients who have such a dense obscuration of the media that it is difficult to capture the data. If we had a method to reliably capture those eyes, we could treat those patients more effectively.

**Dr. Packer:** Are you testing the LENSTAR to determine the percentage of your patients for whom you will still need to use immersion A-scanning?

**Dr. O'Brien:** Yes, we are excited about applying the LENSTAR to this group of patients, in whom previous efforts to capture lenticular information had shortcomings.

> **"I see a great opportunity to improve our accuracy with toric IOLs and incisional surgery."**
> *—Robert H. Osher, MD*

## DR. OSHER'S IRIS LANDMARKING

**Dr. Packer:** Dr. Osher, please describe your concept of iris landmarking for toric IOLs and refractive astigmatic correction and how the red-free image from the LENSTAR may figure into that technique.

**Dr. Osher:** I see a great opportunity to improve our accuracy with toric IOLs and incisional surgery. I think the practice of applying ink marks to the cornea is terribly inaccurate.

**Dr. O'Brien:** That is correct. Under anxiety and stress, the body releases catecholamines, which cause the eye to cyclorotate (usually excyclorotate).

**Dr. Osher:** Not only that, but the near synkinesis is activated. As the patient is approached with a marking pen, near-object awareness creates accommodation, pupillary miosis, and co-contraction of the medial recti. Even if distance fixation were perfect, marking is unreliable. Every degree of misalignment is a 3.3% reduction of the refractive outcome. So, 10° of misalignment compromises one-third of the intended effect. That result is really unacceptable in today's exacting surgical climate.

So, in searching for a better approach to aligning toric lenses, I started to simply draw the blood vessels of the limbus in 2005. I learned that the vessels are not a good reference point, because they blanche when Neo-Synephrine (Bayer Corporation, West Haven, Connecticut) is given. In

addition, instilling a topical anesthetic and a topical antibiotic irritates the eye and causes a ciliary flush, which confuses recognition of the blood vessels. After that idea failed, I realized that every iris has unique crypts, stromal patterns, nevi, pigment, vessels, and Brushfield spots that will not change location. I hypothesized that if it were possible to capture these landmarks on an image when the pupil is dilated during the original examination, we could identify them again in the OR to aid in toric lens alignment.

I was able to work with industry to develop an imaging system that captures a high-definition photograph of the iris. Next, I generate an overlay that allows me to overlay the major meridia onto the image. I can also move a radial cursor onto any landmark, and it records the actual location and degrees. Finally, I can press one more button and apply a "goal line" to the image, which will facilitate positioning the toric lens along the steepest meridian. Then, I simply print out this image and take it with me to the OR where it is easy to re-identify the major meridia and the goal line that can be marked with a point cautery.

**Dr. Snyder:** What Dr. Osher has identified is of tremendous benefit to surgeons who need a more accurate method for calculating where the line of sight and the visual axis are relative to the limbus and the pupillary aperture. This is another area in which I find the LENSTAR very useful, particularly with my multifocal IOL patients. Typically, we want to center IOLs on the visual axis. If we do not feel confident in identifying that axis, we center them on the pupil. The LENSTAR tells us exactly how far the line of sight is off the center of the pupil and thereby enables us to adjust for it in the OR when placing a multifocal lens. Thus, we can get better results by aligning with the line of sight rather than with the geometric axis of the eye.

## OTHER USES

**Dr. Packer:** Are there any technical areas in which the LENSTAR will assist us, such as patient flow, accuracy, and office procedures? I am looking forward to the integration of the LENSTAR with the Holladay IOL Consultant (Holladay Consulting, Inc., Bellaire, Texas). It is a source of potential error that a technician must read from one screen and input data into another; I always worry that he or she has mistyped the axial length.

**Dr. O'Brien:** The personal computer will eliminate the potential for human transcriptional error.

**Dr. Packer:** What is the potential for networking with electronic medical records (EMR)? I have been using the General Electric Centricity system (GE Healthcare, Waukesha, Wisconsin) for 3.5 years. We are thrilled with the results. Next, we will integrate all our diagnostic equipment, such as visual fields, topographers, and the LENSTAR itself, into this EMR system so we can eliminate much of the scanning and shredding we do now. Are you all using EMR now?

**Dr. Snyder:** We have a computerized system that directly imports Orbscan topographies (Bausch + Lomb, Rochester, New York) as well as visual field, retinal, and optical coherence tomography testing. It will be a tremendous advantage for us to be able to import the LENSTAR data directly as well. I especially appreciate being able to bring up all of a patient's data on a computer screen while the individual is in front of me in the examination room. It is cumbersome to sift through reams of paper at a desk.

**Dr. Packer:** I am incredibly impressed by this group of surgeons and the dedication you all show to obtaining optimal results for your patients. Achieving the best possible results will never be the wrong thing to do, and the LENSTAR technology certainly promises to improve our biometry.

**Dr. Shammas:** The LENSTAR is easy to use, precise, and gives very accurate results. I think it will be a valuable addition to our armamentarium.

**Dr. Snyder:** Changing the standard of care is the hallmark of good medicine, and whenever I have the opportunity to be in the same room as Dr. Osher, I always end up changing my clinical procedures. Dr. Osher posed the question of whether we should take LENSTAR measurements before we touch the eye, and I think I am going to start doing that. The LENSTAR allows us to collect information that we have previously ignored. I now plan to incorporate pupillary measurements into my routine patient work-up. I appreciate the opportunity to advance my level of service.

**Dr. Packer:** Yes, the ophthalmic standard of care just went up a notch. ❍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