Surgeons weigh in on the value of this technology in cataract surgery.

BY ERIK L. MERTENS, MD, FEBOphth; AND PAUL-ROLF PREUSSNER, MD, PhD

Guiding Outcomes With Intraoperative Aberrometry

By Erik L. Mertens, MD, FEBOphth

Many aspects of cataract surgery have improved over the past 20 years. Phacoemulsification equipment is more efficient; toric, multifocal, and combination multifocal-toric IOLs are now available to more precisely meet our patients’ visual requirements; and IOL power calculations have advanced, as has the diagnostic technology used to determine the best IOL option for each patient. However, despite all of these improvements, one aspect of cataract surgery remains a bit of a guessing game: knowing what a patient’s refractive result will be at the end of a procedure.

Now, with the availability of the Optiwave Refractive Analysis System (ORA System; WaveTec Vision) intraoperative wavefront aberrometer, surgeons can better control the patient’s postoperative refractive error without having to wait 1 week to 1 month for a refraction check. The system is designed to perform aphakic and pseudophakic measurements in order to gather real-time refractive information. It can also be used to ensure that the appropriate IOL power has been implanted and to guide the placement of toric IOLs, the Visian ICL (STAAR Surgical), and limbal relaxing incisions. The aberrometer can also perform aphakic measurements in postrefractive-surgery eyes, improving the refractive results in this challenging patient population.

The ORA System currently measures sphere, cylinder, and axis, and acquires these data in seconds. Rather

Figure 1. Once a toric IOL is implanted and rotated to the desired axis, an ORA measurement is performed to determine if the IOL is in the appropriate position. If it is not, the system will indicate the necessary direction and degree of rotation.
than being based on Hartmann-Shack aberrometry, which has a limited dynamic range (typically from -10.00 D to 8.00 D), ORA utilizes Talbot-Moiré interferometry, which maintains high resolution throughout its wide dynamic range (-5.00 D to 20.00 D). This allows accurate intraoperative measurement of aphakic eyes.

**HOW IT WORKS**

To use the system, patient data, including IOL power calculations, are loaded in advance. Each system is customized with the list of IOLs that the surgeon uses. In our case, this includes aspheric, multifocal, toric, and multifocal-toric IOLs, as well as ICLs and additive IOLs.

For aphakic measurements, following phacoemulsification, the patient’s intraocular pressure should be checked to ensure a measurement of 21 mm Hg. The patient fixates on the LEDs to help ensure correct positioning of the eye, and then the measurement is performed. The system takes 40 consecutive measurements in approximately 30 to 40 seconds, and these are used to produce an IOL power suggestion. For toric IOLs, once the IOL is implanted and rotated to the desired axis, an ORA measurement is performed to determine if the IOL is in the appropriate position. If it is not, the system will indicate the necessary direction and degree of rotation (Figure 1). Once the IOL is within the targeted refraction, the system will indicate that no further rotation is necessary. The procedure is similar when counterincisions or limbal relaxing incisions are used. Once the incision is created, the surgeon performs an ORA measurement to assess the residual astigmatism and then titrate, as recommended, until the desired correction is achieved.

For pseudophakic measurements, the procedure is the same: The IOP is checked, and the IOL power is measured and then, if necessary or desired, adjusted.

**USER EXPERIENCE**

We started using the ORA System at Medipolis in August 2012, becoming one of the first European centers to have access to this technology. We have found that ORA is easily integrated into our surgical workflow, adding little additional time to the length of the overall procedure. Users of this technology will be required to adapt to the change in optics due to the attachment of the aberrometer to the scope; this shortens the workspace between the surgeon and the patient and can lead to breaks in the sterile field, which is something to guard against.

A second adjustment that users will have to make involves gaining trust in and experience with a tool that can produce an accurate picture of the patient’s postoperative refractive result. Up until this point, we have relied on our preoperative diagnostic work-up and IOL calculations to determine optimum IOL power. However, with ORA, we have a tool that provides this information at the end of the surgical case. Adjusting to this approach may be easier said than done, and there is a learning curve associated with becoming comfortable with switching an IOL based on a system’s recommendation.

**ADVANTAGES**

Given the accuracy of new-technology IOLs and improved methods of IOL power calculation, does ORA make a difference in outcomes? Our experience shows that the answer to this question is a definite yes. In particular, ORA helps us deliver the best possible outcomes for toric IOL and ICL patients, as well as in eyes that pose more of a challenge for traditional IOL power calculation methods, such as those that have had previous corneal surgery.

With the use of the intraoperative wavefront aberrometer, when the patient leaves the operating room, we have a higher degree of confidence that the refractive result will be near the target that we set preoperatively. In fact, a recent analysis of our outcomes with ORA found that we had a mean absolute value prediction error of 0.30 D ±0.29 D, with 56% of eyes demonstrating less than 0.25 D of residual refractive error and 80% with less than 0.50 D.

**Erik L. Mertens, MD, FEBOphth, is Medical Director of Medipolis, Antwerp, Belgium. Dr. Mertens is a Co-Chief Medical Editor of CRST Europe. He states that has no financial interest to disclose and may be reached at tel: +32 3 828 29 49; e-mail: e.mertens@medipolis.be.**

---

**Intraoperative Aberrometry: An Unnecessary Tool**

By Paul-Rolf Preussner, MD, PhD

Intraoperative aberrometry is currently an unnecessary tool for the cataract surgeon because higher accuracy can be achieved today with state-of-the-art IOL calculation methods than with intraoperative measurements. This statement applies to both rotationally symmetric and toric IOLs and to virgin as well as postrefractive-surgery eyes. Additionally, even if aberrometric measurements can be performed with high accuracy,
the optical characteristics of an eye during surgery are different from those of an eye under normal conditions for several reasons.

No. 1. The position of the IOL in the capsular bag during surgery is different from its position after capsular bag shrinkage, which is finally achieved 6 to 8 weeks after surgery. This difference is mostly responsible for a shift in defocus, but it can also affect IOL decentration or the rotation of toric IOLs.

No. 2. Under physiologic conditions, the outermost refracting corneal surface is the tear film. During surgery, it is the film of a saline solution that has slightly varied optical properties and that causes different hydration of the corneal epithelium.

No. 3. The hydration of the corneal stroma is also different during surgery. Water enters the corneal stroma, particularly at the incisions. This causes asymmetric corneal swelling, which mainly affects astigmatism and coma.

No. 4. Intraoperatively, the temperature inside the eye is lower than normal because the irrigation solution has a lower temperature. This changes the refractive index of the aqueous humor, the IOL, and the cornea.

No. 5. The patient’s intraocular pressure may be different from the physiologic value, thus changing the axial eye length and corneal shape.

No. 6. Some IOL models require more than 24 hours to achieve osmotic equilibrium with their environment. Different water or electrolyte uptake of the IOL changes the refractive index.

COMPARING ACCURACY

All of the aforementioned arguments are plausible, but they are difficult to quantify. Therefore, as a final decisive criterion, the accuracy of outcomes with intraoperative aberrometry must be compared with the best possible outcomes achieved without it. To do so, we re-digitized data from a study by Chen (42 eyes) using intraoperative refraction and compared the refractive prediction error to that of the ray-tracing IOL calculation by Hoffmann et al (115 eyes with 20/20 visual acuity or better and implanted with aspheric aberration-correcting IOLs). The standard deviations of the prediction errors in the studies by Chen and Hoffmann et al were 0.59 D and 0.29 D, respectively. The mean absolute errors were 0.43 D and 0.21 D, and the median absolute errors were 0.38 D and 0.17 D, respectively. The proportion of eyes within ±1.00 D of target refraction was 100% versus 90%, and within ±0.50 D was 91% versus 73%, respectively.
In both patient groups, the average prediction errors were adjusted to zero in order to eliminate all sources of avoidable systematic errors. In the ray-tracing calculation group, this is logically equivalent to the process of optimizing IOL constants; however, to be fair, the systematic offset of 0.22 D found in the aberrometry group was treated the same way mathematically. Roughly speaking, the prediction errors of intraoperative aberrometry in Chen’s article are higher by a factor of 2 than those in the paper of Hoffmann et al. Wiley and Bafna\(^1\) reported a mean absolute error of 0.36 D with intraoperative aberrometry, which is more than 50% higher than the corresponding value of Hoffmann et al.

The achievable prediction errors of toric IOL calculation using corneal tomography and Okulix ray tracing (Tedics Peric & Jöher GbR) are consistent with the data for spherical IOLs. The mean absolute cylinder vector prediction error in 44 eyes with visual acuity of 20/20 was 0.43 D (median, 0.38 D).\(^4\) In post-LASIK eyes, approximately the same accuracy as in virgin eyes can be achieved with ray tracing based on corneal tomography; even the knowledge of prior corneal surgery is not needed. The outcome in a small series of subsequently operated eyes (without any selection) is shown in Figure 2. Okulix ray tracing is compared with competing methods as far as applicable.

**REQUIRED CONDITIONS**

In addition to these arguments concerning the accuracy of intraoperative aberrometry in comparison with state-of-the-art IOL calculation accuracy, some conditions that are needed to achieve the possible accuracy of intraoperative aberrometry may be difficult or even dangerous to realize, and the measured results may not generally be helpful.

First, high-quality aberrometry requires the patient’s fixation. This is possible only with topical anesthesia: ie, it excludes other methods of anesthesia. Second, the speculum has a significant effect on corneal shape\(^5\) and therefore must be removed during measurement; removing and replacing the speculum can increase the risk of intraoperative infection (endophthalmitis). Third, viscoelastics must be carefully washed out prior to aberrometry, but if intraocular manipulations are needed after aberrometry, viscoelastics may be needed again. Last, supposing the aberrometry shows a defocus difference of 0.75 D from the target refraction, what is the surgeon to do? Exchange the IOL? It is questionable whether the measurement can be trusted and whether the surgical risk is acceptable.

**CONCLUSION**

Greater accuracy can currently be achieved with state-of-the-art IOL calculation methods than with intraoperative aberrometry. Further, the optical characteristics of an eye intraoperatively are different from those of an eye in normal conditions. The performance of high-quality intraoperative aberrometry comes with a set of additional requirements and may not equate to better results.

**TAKE-HOME MESSAGE**

- Intraoperative wavefront aberrometry enables surgeons to control the patient’s postoperative refractive error without having to wait 1 week to 1 month for a refraction check.
- However, high accuracy can also be achieved with state-of-the-art IOL calculation methods, and the optical characteristics of an eye intraoperatively are different from those of an eye in normal conditions.

---

4. Hoffmann P. A novel approach for calculating toric intraocular lenses with higher accuracy. Paper presented at: XXX Congress of the ESCRS; September 8-12, 2012; Milan, Italy.