Intraoperative Wavefront Aberrometer

A versatile tool in refractive cataract surgery.

BY ERIC D. DONNENFELD, MD

The technology that surgeons employ for preoperative work-up plays an important role in achieving the best visual results. Nonetheless, a significant number of patients do not achieve a plano result after cataract surgery. Unfortunately, we still do not know if our IOL calculations, limbal relaxing incisions (LRIs), or placement of a toric IOL is accurate until we see patients postoperatively. IOL power calculations are especially difficult in eyes that have undergone radial keratotomy (RK), LASIK, or PRK. Moreover, we work under the assumption that every cataract incision will have the same effect on the eye's cylinder. What has been missing is a tool that allows us to determine intraoperatively whether we have achieved our refractive goal.

The introduction of the ORange intraoperative wavefront aberrometer (WaveTec Vision, Aliso Viejo, California) allows us to measure the impact of the cataract surgical procedure and to determine if the result is close to the intended postoperative correction. This article reviews the multiple applications of the aberrometer as well as the initial clinical experience of users including myself.

AN OVERVIEW

The ORange provides a real-time evaluation of sphere, cylinder, and axis in a matter of seconds. Attaching to the bottom of the surgical microscope (Figure 1), this lightweight aberrometer has a small footprint.

As small and compact as the ORange is, its large dynamic range (-5.00 to +20.00 D) exceeds that of office-based wavefront aberrometry systems. Conventional wavefront technologies such as Hartmann-Shack are capable of measuring refractive power in a limited dynamic range, typically from -10.00 to 8.00 D. The ORange uses Talbot-Moiré interferometry, which has a wider range of effective measurement than Hartmann-Shack and maintains a high resolution throughout its wide dynamic range. As a result, the aberrometer can accurately measure aphakic eyes intraoperatively, which promotes more accurate IOL power calculations, particularly in eyes that have undergone refractive surgery.

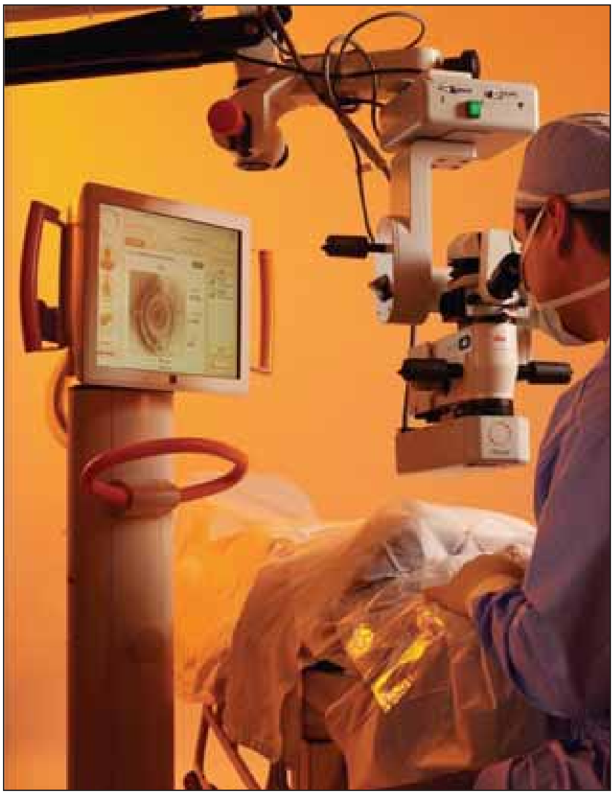

Figure 1. The ORange in the OR.

Current applications of the ORange include measuring LRIs, guiding their placement, and ensuring the accurate positioning of toric IOLs. I also use the ORange unit to perform aphakic IOL calculations in highly myopic eyes.

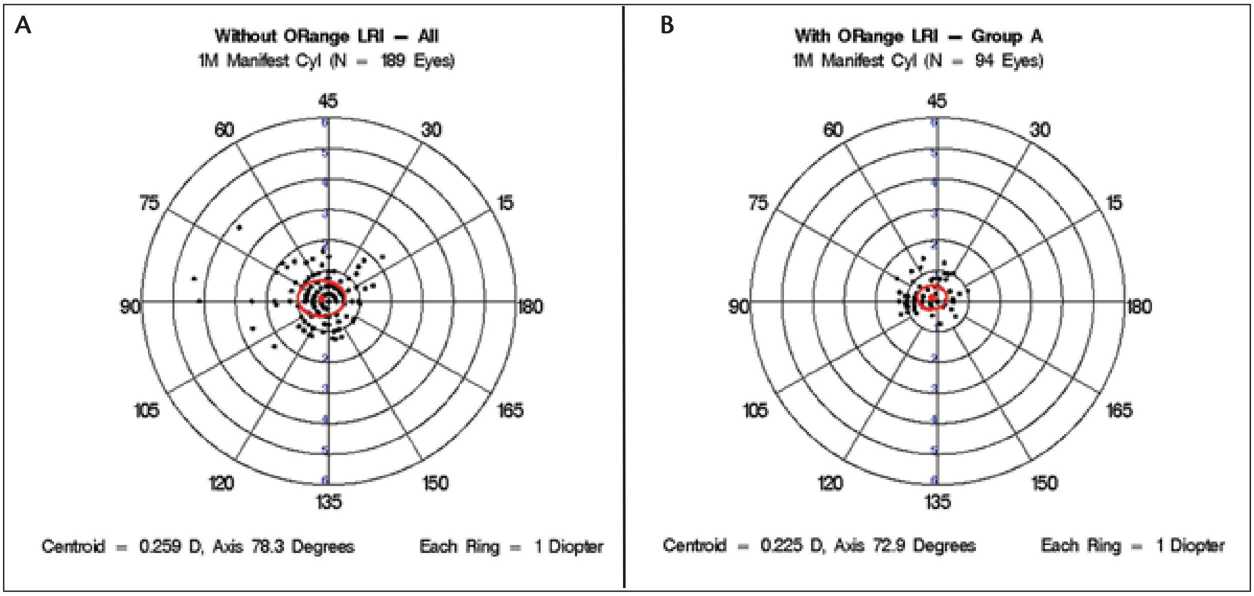

Figure 2. Vector analysis shows the presence of cylindrical outliers after cataract surgery with LRIs performed (A) without or (B) with the ORange aberrometer.

The addition of a hyperopic lens to the aberrometer will enable surgeons to perform on-the-table IOL calculations in aphakic eyes.

LRIs

The growing volume of multifocal IOLs implanted has renewed surgeons' interest in LRIs. Although many of us use this approach to reduce cylinder, there is a need to perform LRIs in conventional IOL surgeries as well, and to improve their relatively unpredictable results. The greatest amount of hands-on experience with the ORange to date is with LRIs, including a multicenter study in which surgeons compared residual astigmatism after surgery using the ORange with the results for a control group. The data showed that the intraoperative use of the ORange can significantly improve visual outcomes with LRIs when it is used intraoperatively.[1]

Involving the first 10 ORange users in the United States, the prospective study compared the 1-month results among eyes in which surgeons used the ORange during the LRI procedure and eyes in which they did not use the aberrometer. Of the 94 eyes in the ORange group, the mean cylinder decreased from 1.45 D preoperatively to 0.47 D postoperatively. Thirty-nine percent of these eyes received an enhancement of the LRIs based on the ORange measurement. In the control group of 189 eyes, the mean refractive cylinder decreased from 1.47 D preoperatively to 0.70 D postoperatively (Figure 2).

TAKE-HOME MESSAGE

- The ORange provides real-time evaluation of sphere, cylinder, and axis in a matter of seconds.
- Current applications include measuring LRIs, guiding their placement, and ensuring the accurate positioning of toric IOLs.

TORIC IOLs

When we implant toric IOLs, we can use the ORange to ensure lens placement on the desired axis and guide the IOL's rotation if it is not in the correct position. This aberrometer has significantly improved my accuracy and outcomes with toric IOLs.

Currently we visually mark the limbus to find the correct axis for a toric IOL's placement. This step is combined with a crossed cylindrical calculation of the keratometric cylinder and the assumed value (most commonly 0.50 D) for induced cylinder at the axis of the phaco incision. This approach is suboptimal for three reasons:

- Visually marking the eye is inherently inaccurate;
- The keratometric cylinder is centered on the corneal apex and not the patient's visual axis; and
- Each cornea will respond differently to the phaco incision and can deviate from the assumed amount.

Even the slight misalignment of a toric IOL can affect the visual outcome. If the toric IOL is 4° off axis, its effectiveness decreases by 14%. If the lens is 30° off axis, it provides no cylindrical correction. Greater than 30° of off-axis rotation

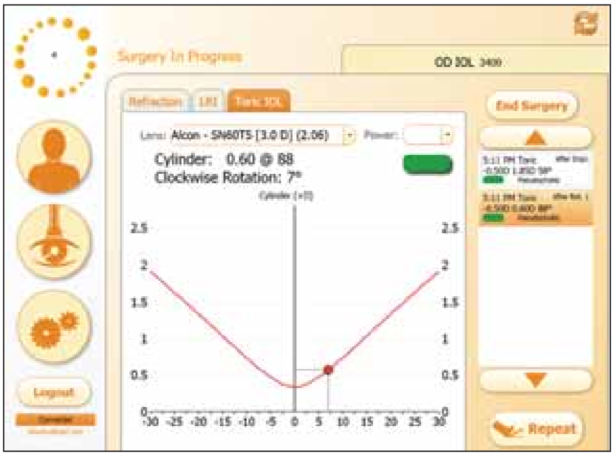

Figure 3. The ORange indicates how much the surgeon should rotate a toric IOL.

induces additional cylinder. The ORange shows us how far to rotate the IOL so that it is in exactly the right place (Figure 3). At the 2009 American Society of Cataract and Refractive Surgery (ASCRS) annual meeting, my colleagues and I presented a study in which we compared how accurately we placed toric IOLs with and without the ORange.[2] In the ORange group (n=19 eyes), the mean anticipated residual astigmatism was 0.37 D, and the mean final residual refractive cylinder at 1 month was 0.48 D. In the standard toric eyes (n=30), the mean anticipated residual astigmatism was 0.42 D, and the mean final residual refractive cylinder at 1 month was 0.73 D.

EYES AFTER REFRACTIVE SURGERY

In the past 2 years, more than 20 studies have been published on the subject of IOL calculations in eyes that have undergone refractive surgery. These eyes represent a unique challenge, and we are going to see more of them as the baby boomers move toward their Medicare years (in the United States). Theories as to why it is difficult to perform an IOL calculation in eyes that have undergone refractive surgery include:

- Inaccurate measurements of corneal curvature;
- Measured keratometric values that are higher than the actual power; and
- IOL positions derived from decreased corneal powers that are incorrect in some IOL power formulas.

The bottom line is that a great deal of guesswork remains with current IOL calculation programs. The ORange has demonstrated real value in eyes that have a history of refractive surgery. We can measure the pseudophakic eye and determine if the IOL is the correct power before the patient leaves the OR. One of the surgeons with the greatest experience in this area is Dan Tran, MD, of Newport Beach, California. He has used the ORange in more than 50 cataract surgery cases involving corneas that have a history of refractive surgery, including myopic and hyperopic LASIK, radial keratotomy, and astigmatic keratotomy. Before using the ORange, he had refractive surprises in approximately 30% of these cases. Dr. Tran reports that he has had no refractive surprises when he has followed the ORange's recommendations.[3]

In one case example provided by Dr. Tran, a 78-year-old woman had undergone bilateral LASIK the previous year. Her manifest refraction 3 months after LASIK was -1.50 -0.75 X 28° OD and -2.50 -0.75 X 120° OS. The surgical plan was to implant a spherical acrylic monofocal IOL in her left eye with a targeted refractive outcome of between -1.75 and -2.00 D. The IOL calculations using different methodologies yielded inconsistent results: they recommended a range of IOL powers from 13.50 to 16.50 D. During surgery, Dr. Tran implanted a 16.50 D IOL and then performed an ORange measurement that showed -4.74 +0.84 X 114° with a spherical equivalent of 4.32 D. Based on this information, Dr. Tran exchanged the IOL for a 13.00 D lens. Three weeks postoperatively, the patient had a manifest refraction of -1.50 -0.75 X 55°, well within the targeted refractive outcome.

CONCLUSION

Surgeons who have been using the ORange as part of a clinical investigation for the past 18 months have found it an indispensible tool. The aberrometer has helped me to improve my accuracy and outcomes. As a result, I now use the ORange to refine my IOL selection for all highly myopic, hyperopic, and post-LASIK eyes. I also use this device for cataract surgery on demanding patients as well as those who will receive a toric IOL and/or LRIs. ■

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