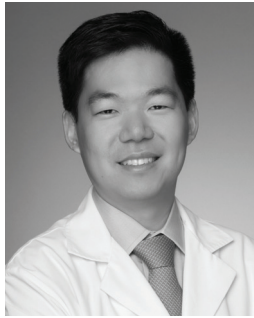




ADVANCED CLINICAL CASES



IOL POWER CALCULATIONS FOR EYES WITH ASTIGMATISM

A consistent approach can yield success even in irregular eyes.

BY BRYAN S. LEE, MD, JD

By definition, calculating for a toric IOL requires selecting a spherical power, cylindrical power, and axis. All patients in our office receive three preoperative astigmatism measurements: auto keratometer, IOLMaster 700 (Carl Zeiss Meditec), and iTrace (Tracey Technologies). The iTrace gives a best-fit keratometry (K) reading cumulatively through the central 3 mm that I use instead of its simulated K readings. It is critical that the patient's head be level, even if it is habitually tilted, and the studies should be performed on a pristine cornea. Patients are asked to stop wearing soft contact lenses 2 weeks prior to their visit and rigid gas permeable lenses 3 weeks before their appointment—longer if necessary for their corneal topography to become regular.

The ideal candidate for toric correction has regular astigmatism, with agreement among the three K measurements. Fortunately, most individuals fit this description. Simply picking the toric power based on this number, however, can lead to unsatisfactory results.

It is important to keep the axis of the correction in mind, undercorrecting with-the-rule cylinder and overcorrecting against-the-rule cylinder. As reported by Koch et al, the posterior cornea causes against-the-rule cylinder that is not captured well by most devices.¹⁻³ Furthermore, IOLs with high spherical powers have a greater toric effect, even if their toricity is identical.⁴⁻⁷ That means that a +28.00 D SA6AT4 AcrySof IQ Toric IOL (Alcon) will correct more astigmatism than a +8.00 D SA6AT4 lens. Similarly, the ratio between the toric power at the IOL plane and the corneal plane depends on the IOL's position.

I do not use a manufacturer's online calculator, but these tools have improved and are excellent because most take IOL power and posterior corneal astigmatism into account.⁸⁻¹⁰ Another option now available is the Barrett Toric Formula. It

may be accessed through a link in the "Online Tools" area of the American Society of Cataract and Refractive Surgery's website (www.ascrs.org) or the Asia-Pacific Association of Cataract & Refractive Surgeons' website (www.apacrs.org). I use the HofferQ, Holladay 1, SRK/T, Holladay 2, Haigis, and Barrett formulas in combination to choose the spherical power and then calculate the cylindrical power separately. I utilize intraoperative aberrometry to fine-tune both the IOL's spherical power and the axis, but I rarely change the cylindrical power unless I am using aberrometry to help decide between two powers. Using a digital marking system has improved the accuracy of my toric IOL placement and reduced the time I spend on aberrometry adjustments, but with careful marking and technique, surgeons can achieve fantastic results with manual marking alone.

CASE EXAMPLE NO. 1

The patient had undergone cataract surgery with a multifocal IOL in her right eye 10 years earlier. Her habitual glasses prescription in her left eye was -2.75 D sphere, but she reported progressive worsening of her vision and was referred for cataract surgery. Her BCVA was 20/300 with a refraction of -4.00 +5.50 × 95°, and she had a 3+ nuclear cataract. The slit-lamp examination showed nasal Salzmann nodules in her left eye.

I regularly see patients with unrecognized Salzmann nodules. Ideally, nodules that are central or cause significant irregularity should be addressed before cataract surgery. Simply implanting a T9 AcrySof IOL or a ZCT600 Tecnis Toric IOL (Johnson & Johnson Vision) might seem tempting because the Ks were so consistent (keratometer 5.75 D @ 92°; IOLMaster 5.78 D @ 93°; topographer 5.40 D @ 92°). It is better to reduce the cylinder and make the cornea more regular, however, so I performed a superficial keratectomy and removed the Salzmann nodules first.



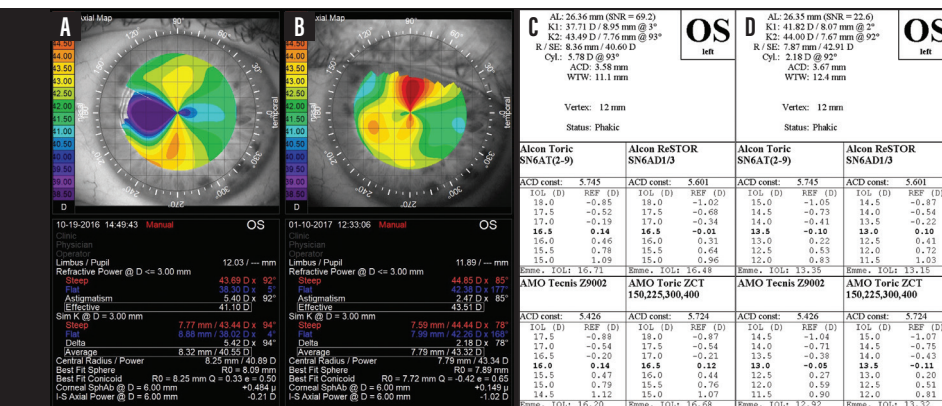


Figure 1. The difference in topography before (A, C) nodule removal and 8 weeks later (B, D).

The astigmatism still was not totally symmetric, but it was consistent and much lower in magnitude (keratometer 2.12 D @ 84°; IOLMaster 2.18 D @ 92°; topographer 2.47 D @ 85°). The IOL power changed by more than 3.00 D (Figure 1). Because the astigmatism was with the rule, I implanted an AcrySof SN6AT5 lens and aimed for -1.50 D. The patient achieved a visual acuity of 20/20+2 with -1.50 D sphere.

CASE EXAMPLE NO. 2

The patient had a history of bilateral LASIK and presented with a decline in vision from cataract. She desired intermediate myopia in her left eye, which she had had after LASIK.

The refractive power measurement, which sums up the central 3 mm of the cornea, showed astigmatism of 1.83 D @ 123°. There was definite asymmetry, however, and the patient had significant coma, as evident in the aberrations displayed in the lower left corner of Figure 2. Her Ks were 1.63 D @ 102°, whereas her IOLMaster

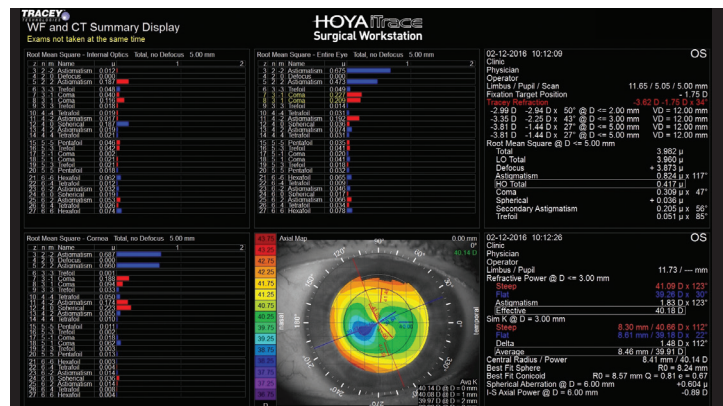


Figure 2. The patient shows typical post-LASIK changes, which can make correcting astigmatism more challenging.

Ks were 1.28 D @ 113°. A repeat IOLMaster measurement was 1.87 D @ 117°.

Irregular astigmatism and mildly inconsistent measurements are common among post-LASIK patients. Having this patient use artificial tears frequently and repeating the biometry helped because the subsequent IOLMaster Ks were consistent with the topography measurements. In this situation, the auto Ks were the outlier. I think that is because that instrument was measuring farthest from the center of the cornea. The more central portion of the topography was consistent with the 123° axis, and the more peripheral cornea was consistent with the 102° axis from the keratometer. After considering all of the measurements together, I implanted a ZCT225 (Johnson & Johnson Vision) at 123°, and the patient achieved a visual acuity of 20/20 with -1.25 D sphere. ■

TAKE-HOME POINTS

- Careful biometry is critical to accurate astigmatism management. If the different methods of measuring cylinder produce inconsistent results, then treat the ocular surface and recheck the measurements. Make sure your staff is consistently positioning patients correctly.
- Salzmann nodules are a common cause of irregular astigmatism and should be addressed if their size is significant or their location is central.
- Toric IOL planning requires accounting for posterior corneal astigmatism, which you can do directly or using a method that includes it such as the Barrett Toric Formula.
- The process of selecting a toric presbyopia-correcting IOL is identical to choosing the equivalent toric monofocal IOL.
- Preoperative measurements are generally better than intraoperative aberrometry for choosing the toric IOL's power and axis, but intraoperative aberrometry is valuable as a tiebreaker and for making subtle axis adjustments.

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BRYAN S. LEE, MD, JD

- Altos Eye Physicians, Los Altos, California
- bryan@bryanlee.pro; Twitter @bryanleemd
- Financial disclosure: None



INTRAOPERATIVE ABERROMETRY FOR MANAGING ASTIGMATISM

This is the only tool for directly determining net corneal power after the cataract incision has been made and the nucleus has been removed.

BY ROBIN VANN, MD

I was already performing research on the cause of variations in surgically induced astigmatism when the institution where I work purchased an intraoperative aberrometer (ORA System; Alcon) in April 2016. At that time, I was also learning more about the influence of posterior corneal astigmatism on refractive results. Naturally, I began using intraoperative aberrometry as part of my efforts to fine-tune my surgical outcomes.

I have found that surgically induced astigmatism can vary from case to case and that the relaxing effect of the cataract incision may not be along the plane of that incision. In other words, it is not possible to use the cataract incision to decrease astigmatism with any kind of accuracy or consistency. Intraoperative aberrometry is the only means by which to directly measure the exact impact of the cataract incision and the power of the anterior and posterior surfaces of the cornea. I rely on this instrument for making my final selection of a toric

IOL power in the OR and for refining the IOL's alignment to minimize residual astigmatism. Two very different cases show the breadth of how useful intraoperative aberrometry can be for customizing astigmatism management.

CASE EXAMPLE NO. 1

A 68-year-old woman came to see me for a cataract surgery evaluation. Upon examination, the patient's UCVA measured 20/80 OD and 20/60 OS, and her BCVA was plano $-4.75 \times 180^\circ = 20/60$ OD and $+1.50 -4.50 \times 178^\circ = 20/50$ OS. She had a 2+ to 3+ nuclear sclerotic cataract in her right eye and a 2+ nuclear sclerotic cataract in her left eye (Figure 1). Biometry measurements revealed that the patient had a greater amount of with-the-rule astigmatism in both eyes, confirmed by corneal topography (Figure 2), than is correctable by a toric IOL alone, 5.43 D @ 88° OD and 5.36 D @ 84° OS. I therefore recommended a combination of a toric

lens implant with possible limbal relaxing incisions. The patient agreed and opted for standard rather than laser cataract surgery. To further refine the astigmatic treatment, I discussed with her using intraoperative aberrometry to guide my surgical plan, including IOL selection.

I operated on the patient's right eye first. Intraoperative aberrometry found 4.72 D of astigmatism at 116° and confirmed the preoperative toric calculator recommendation of the 19.50 D model T9 AcrySof IQ Toric IOL (Alcon). After inserting the IOL and

		OD Right eye		OS Left eye	
Measuring mode	Mode	Phakic		Phakic	
Axial length	AL	22.67 mm	± 0.071 mm	22.91 mm	± 0.028 mm
Cornea thickness	CCT	563 μ m	± 4.4 μ m	564 μ m	± 2.8 μ m
Aqueous depth	AD	2.25 mm	± 0.008 mm	2.35 mm	± 0.005 mm
Anterior chamber depth incl.	ACD	2.81 mm	± 0.006 mm	2.91 mm	± 0.007 mm
Lens thickness	LT	4.70 mm	± 0.130 mm	4.70 mm	± 0.013 mm
Retina thickness	RT	200** μ m	± 0.0 μ m	200** μ m	± 0.0 μ m
Flat meridian	K1	44.55 D @ 178°	± 0.201 D	43.43 D @ 174°	± 0.080 D
Steep meridian	K2	49.98 D @ 88°	± 0.471 D	48.79 D @ 84°	± 0.182 D
Astigmatism	AST	5.43 D @ 88°	$\pm 1.3^\circ$	5.36 D @ 84°	$\pm 0.7^\circ$
Keratometric index	n	1.3375		1.3375	
White to White	WTW	10.98 mm	± 0.153 mm	10.95 mm	± 0.025 mm

Figure 1. Preoperative biometry with the Lenstar (Haag-Streit).

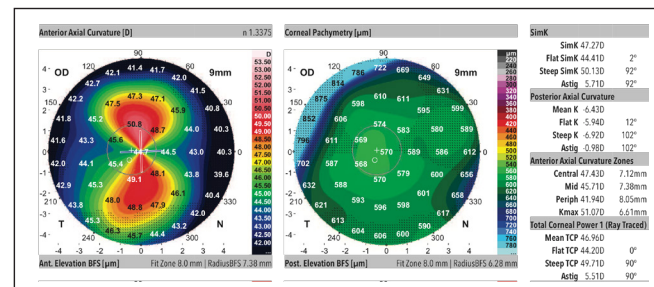


Figure 2. Corneal topography.



		OD Right eye		OS Left eye	
Measuring mode	Mode	Phakic		Phakic	
Axial length	AL	24.28 mm	±0.015 mm	24.07 mm	±0.004 mm
Cornea thickness	CCT	560 μm	±0.8 μm	557 μm	±1.4 μm
Aqueous depth	AD	2.90 mm	±0.012 mm	2.93 mm	±0.018 mm
Anterior chamber depth inc.	ACD	3.46 mm	±0.012 mm	3.49 mm	±0.018 mm
Lens thickness	LT	3.84 mm	±0.148 mm	3.91 mm	±0.015 mm
Retina thickness	RT	200** μm	±0.0 μm	200** μm	±0.0 μm
Flat meridian	K1	42.71 D @ 111°	±0.133 D	43.45 D @ 84°	±0.033 D
Steep meridian	K2	43.95 D @ 21°	±0.173 D	44.51 D @ 174°	±0.065 D
Astigmatism	AST	1.25 D @ 21°	±4.2°	1.07 D @ 174°	±3.9°
Keratometric index	n	1.3375		1.3375	

Figure 3. Preoperative biometry with the Lenstar.

optimizing its axial alignment, 1.80 D astigmatism remained. Using intraoperative aberrometry to guide my relaxing incisions, I was able to reduce the final pseudophakic reading to -0.45 D with astigmatism of 0.90 D @ 116°.

Postoperatively, the patient did very well, with 20/20 UCVA at her final 1-month postoperative visit. Her final refraction was +0.25 D sphere and a keratometry reading of 43.77/49.2 @ 89° (5.43).

CASE EXAMPLE NO. 2

A 79-year-old man presented with a complaint of a progressive decline in vision. The patient had a BCVA of 20/30 OU with a refraction of +1.25 -2.00 × 120° OD and a refraction of +1.50 -1.25 × 81° OS that decreased to 20/60 OD and 20/100 OS with glare testing. The astigmatism in his left eye was against the rule, 1.07 D @ 174° (Figure 3). The patient chose to undergo laser cataract surgery and implantation of the AcrySof IQ Restor Multifocal Toric IOL (Alcon).

Preoperatively, the Barrett Toric Calculator identified the axis of astigmatism at 176°. After the laser portion of the cataract procedure, the intraoperative aphakic aberrometry reading confirmed the preoperative toric power. During the pseudophakic alignment of the toric IOL, however, I changed the preoperative axial recommendation of 176° to the 170° axis, with predicted residual astigmatism of 0.23 D × 143°. Postoperatively, the patient had residual astigmatism of 0.25 D and a UCVA of 20/20 in the operated eye. His final refraction was +0.25 -0.25 × 103°, and the keratometry reading was 44.12/45.18 @ 169° (1.08). ■

ROBIN VANN, MD

- Medical Director, Duke Eye Center Operating Rooms, Durham, North Carolina
- robin.vann@duke.edu
- Financial disclosure: Consultant (Alcon)

TAKE-HOME POINTS

- ▶ To learn to trust the aberrometer, use it in every case until you understand when it serves you well and when it does not. Do not change your treatment plan at all. Just read the results from the aberrometer, and see what it is doing. During this time, you can learn to understand the screenshots, the fringe pattern during good fixation, and the warning signs that can pop up and get comfortable measuring the IOP with a Barraquer tonometer.
- ▶ Aberrometers may not be able to obtain accurate measurements in eyes with irregular astigmatism or irregular surface disease such as Salzmann nodular degeneration or anterior basement membrane dystrophy.
- ▶ Once scrubbed in, you will be unable to control the machine directly in the OR. Designate an aberrometry champion in the OR who understands how the machine works and how to operate the various screens for capturing measurements. The better your champion is, the easier it will be for you to decide when to capture an image or follow the aberrometer's recommendation. You may want an aberrometry champion in your clinic as well, and that staff member should thoroughly understand the device and data entry.
- ▶ Patient fixation is key to successful aberrometry readings. The device therefore may not be an option in patients who have nystagmus or who have limited central vision such as those with macular degeneration and previous macular holes. Even large vitreous floaters can be impediments.
- ▶ Lubricate and protect the ocular surface to optimize aberrometry measurements. Limit exposure and thus drying. Minimize patients' use of medications that may be toxic to the ocular surface. Cut the drapes carefully to ensure that they are adequately recessed.
- ▶ If the material encroaches on the field and covers any of the cornea, it can influence aberrometry readings. Likewise, an overly tight lid speculum can affect astigmatism measurements. Lifting the speculum off the globe, wiping the cul-de-sac of balanced salt solution or OVD, and measuring the IOP are critical for consistent, reliable measurements.
- ▶ Guard against oversedation. Early on, my patients were too somnolent to fixate on the aberrometer's little red light. I had to train my nurse anesthetists that light sedation is required for cases in which I will use intraoperative aberrometry.
- ▶ Properly positioning the patient's head is critical to accurate measurements. For example, a head tucked in toward the chest can cause the upper eyelid to exert pressure on the cornea, which will produce misleading values. If the head is rotated too far to the right or left, the bridge of the nose can partially obstruct the machine.



TORIC IOL SELECTION

Tips for success with these premium lenses.

BY ZAINA AL-MOHTASEB, MD

Cataract surgery has become a refractive procedure, which means that ophthalmologists must address astigmatism to achieve satisfactory results. More than 0.50 D of residual astigmatism is visually significant and can result in ghosting and shadows.¹

Before considering astigmatic correction, I perform a qualitative assessment of the corneal surface using topography and a slit-lamp examination. Does the patient have irregular astigmatism, keratoconus, or subtle corneal pathology such as epithelial basement membrane dystrophy? Once I am sure the patient has true corneal astigmatism, I review results from two topographers that can measure anterior and posterior astigmatism as well as perform optical biometry to make sure the magnitude and meridian match among devices (within 0.50 D and 10°, respectively). If there is a big difference between the biometer and the topographers, for example, I consider treating the astigmatism postoperatively.

When picking toricity and the alignment meridian, I

use the Baylor Nomogram as well as the IOL manufacturer's online calculator. The data I enter are an average of the measurements obtained with the two topographers and the optical biometer I used, typically the Galilei Dual Scheimpflug Analyzer (Ziemer Ophthalmic Systems), Cassini (i-Optics), and IOLMaster 700 (Carl Zeiss Meditec). Surgeons without all of these tools can still use toric IOLs effectively. Placing a toric IOL based on consistent astigmatism measurements between a topographer and biometer using manual markings can produce excellent refractive outcomes.

I recommend toric IOLs for patients with as little as 0.80 D of against-the-rule (ATR) astigmatism, especially if they have a high amount of posterior corneal astigmatism. I also favor a toric IOL if the patient has 1.00 D or more of with-the-rule (WTR) astigmatism. I use a 2.4-mm incision, which results in minimal surgically induced astigmatism.² Patients who have chosen a multifocal or extended depth of focus IOL should also have their

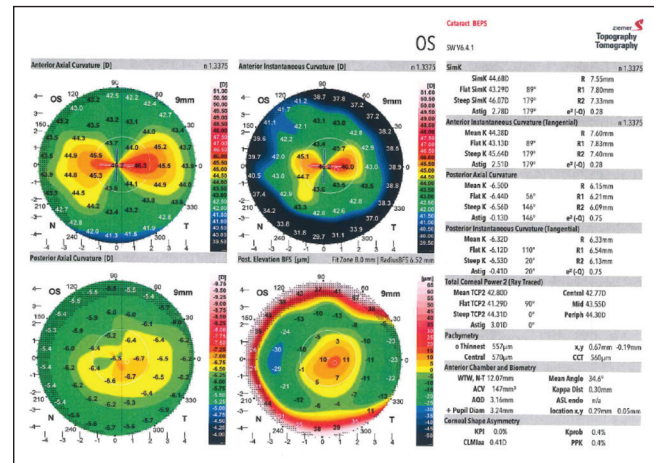


Figure 1. The Galilei Dual Scheimpflug Analyzer showed the magnitude and meridian of astigmatism in the patient's left eye.

astigmatism corrected to decrease the risk of blurry vision, glare, and halos.

In the United States, the main toric platforms are the Tecnis Toric IOL (ZCT line, Johnson & Johnson Vision [J&J Vision]) and the AcrySof IQ Toric IOL (SN6AT line, Alcon). Combining presbyopic and astigmatic correction are the Tecnis Symphony Toric IOL (J&J Vision), the AcrySof IQ Restor +2.5 D Multifocal Toric IOL with Activefocus optical design (Alcon), the AcrySof IQ Restor +3.0 D Multifocal Toric IOL (Alcon), and the Trulign Toric IOL (Bausch + Lomb). I have experience with the platforms from J&J Vision and Alcon, and both are excellent for correcting astigmatism. Data show that

Alcon's platform rotates less than J&J Vision's.^{3,4}

CASE EXAMPLE

A 66-year-old man presented with decreased vision, glare, and halos that were affecting his ability to drive at night. A slit-lamp examination showed a 2+ nuclear sclerotic cataract, but the rest of the anterior segment and posterior segment examination was normal. There were no signs of dry eye disease. Placido ring topography showed crisp rings and no sign of epitheliopathy.

The patient had significant astigmatism on manifest refraction, both topography devices, and the biometer, and it was similar in magnitude and meridian on all devices (Figures 1 and 2).

TAKE-HOME POINTS

- ▶ Patients who have regular astigmatism and no corneal pathology are candidates for toric IOLs.
- ▶ If the patient will receive a premium IOL, it is critical that he or she understand the reason for the price. Particularly helpful, in my experience, are brochures that display simulated images of vision after cataract removal with and without astigmatic correction. Eye models and color topography are also excellent educational tools.
- ▶ I usually aim for as little residual postoperative corneal astigmatism as possible. The anterior steep corneal meridian typically shifts toward a horizontal orientation over time, whereas the orientation of the posterior steep meridian remains vertical despite advancing age. As studies have shown, the anterior cornea tends to develop ATR astigmatism with age, whereas the posterior cornea in most eyes displays ATR astigmatism irrespective of age.⁵ For younger patients, I therefore target a little (< 0.25 D) WTR astigmatism.
- ▶ Optimal outcomes depend on the proper level of toric correction, accurate alignment, and rotational stability of toric IOLs. Three areas for potential error with a toric IOL are reference marking, marking the alignment axis, and alignment of the actual IOL. In the preoperative holding area, it is important to mark 3, 6, and 9 o'clock on the eye for the reference axis because ocular alignment can vary by more than 10° in 8% of patients when they move from an upright to a supine position.⁶ The next step is to make the correct alignment mark intraoperatively,
- either manually (bubble markers, graduated markers, etc.) or using an automated system (Verion Image Guided System, Alcon; Callisto Eye, Carl Zeiss Meditec; TrueGuide, TrueVision). Third, I typically align the toric IOL 10° shy of the axis initially. I use bimanual irrigation and aspiration to remove the OVD while keeping the IOL stable with the aspirator. With a Sinskey hook, I rotate the IOL to the correct axis and then hydrate the incision prior to removing the irrigator to keep the IOL from rotating. Intraoperative aberrometry can also assist with IOL toricity and alignment.
- ▶ Despite diligence and attention to detail, a surgeon will encounter the occasional refractive surprise. In these cases, evaluating outcomes and considering them objectively will sharpen his or her skill set.

Using the magnitude and meridian of astigmatism from the Lenstar (Lenstar), I entered preoperative data into the Baylor nomogram and the Alcon online toric calculator, which incorporates the Barrett calculator. Both nomograms recommended a 17.00 D model SN6AT8 AcrySof IQ Toric IOL (Alcon) to minimize ATR astigmatism without flipping the axis. Given the ATR shift in astigmatism with age, I left the patient with a little WTR astigmatism.

In the preoperative area, I manually marked the 3-, 6-, and 9-o'clock axes on the eye. Next, I used the Catalys Precision Laser System (J&J Vision) to place two 10° intrastromal marks at the intended meridian, create the anterior capsulotomy, and soften the nucleus.

In the OR, after removing the cataract and cortex and filling the bag with an OVD, I performed intraoperative aberrometry (ORA System,

Alcon), which confirmed the chosen toric IOL and axis. I implanted the IOL and oriented it to the intended axis with bimanual irrigation and aspiration.

Three weeks after surgery, the patient's UCVA measured 20/20 with a manifest refraction of -0.50 D and no residual astigmatism. He was very happy with the result. ■

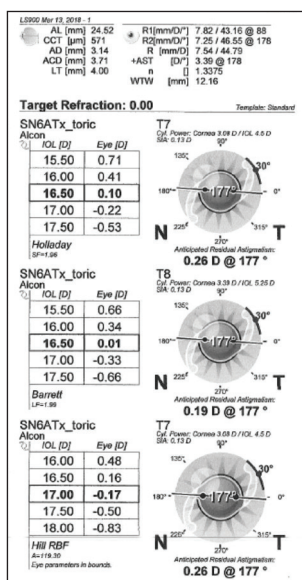
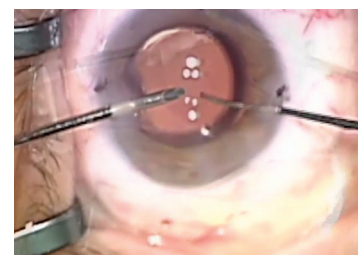


Figure 2. The Lenstar biometer showed the magnitude and meridian of astigmatism in the patient's left eye.

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ZAINA AL-MOHTASEB, MD

- Assistant Professor of Ophthalmology and Associate Residency Program Director, Baylor College of Medicine, Houston, Texas
- Cornea, cataract, and refractive surgery, Baylor College of Medicine, Houston, Texas
- zaina@bcm.edu; Twitter @Zaina_1225
- Financial disclosure: Consultant (Alcon, Bausch + Lomb, Carl Zeiss Meditec); Research funding (Johnson & Johnson Vision)

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