INNOVATIVE TORIC IOL CALCULATORS AND HOW TO USE THEM

Surgeons describe tools they have created to improve toric IOL calculations and to fix refractive surprises.

BY NOEL ALPINS, FRANZCO, FRCOPHTH, FACS; GRAHAM D. BARRETT, MD, FRANZCO; MARK S. HANSEN, MD; JOHN P. BERDAHL, MD; DAVID R. HARDTEN, MD; AND JACK T. HOLLADAY, MD, MSEE, FACS

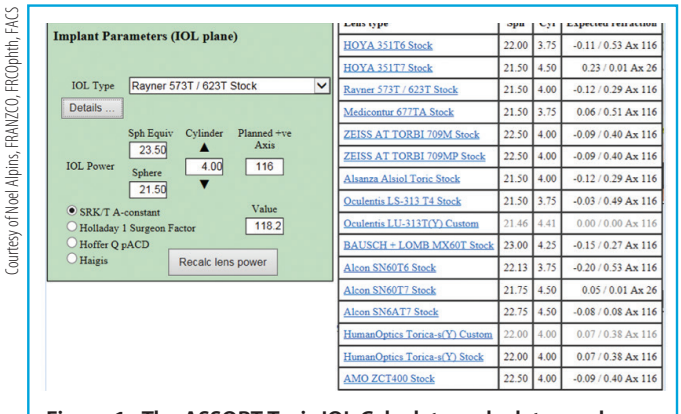
ASSORT Toric Calculator

By Noel Alpins, FRANZCO, FRCOphth, FACS

The ASSORT Toric Calculator offers unique features, designed for accuracy and functionality, that are not available on other calculators provided by implant companies or private groups. Its primary unique feature is the ability to calculate the most effective implant (sphere and toricity) available from all companies worldwide and compare IOLs based on the target spherocylindrical refraction that is calculated to remain postoperatively (Figure 1). The user can do this in a universal generic calculation without having to visit several separate corporate websites, some of which have inaccuracies of varying origins.[1]

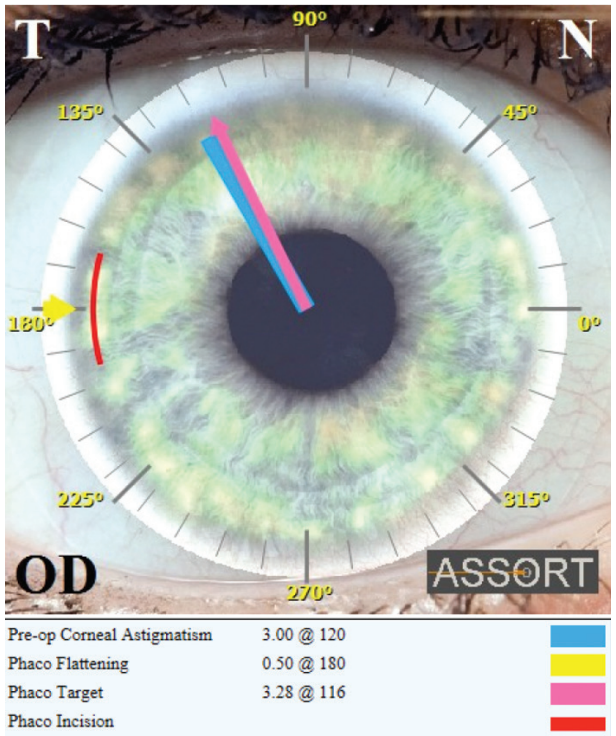
Available at www.assort.com

With the ASSORT Toric Calculator, accuracy is achieved by using calculations that parallel those of popular laser interferometry biometers, and the software also includes optimized lens constants for commonly used formulas, such as Hoffer, Haigis, Holladay, and SRK/T, to obtain the effective lens position (ELP). Other parameters used in the calculations include



Courtesy of Noel Alpins, FRANZCO, FRCOphth, FACS

Figure 1. The ASSORT Toric IOL Calculator calculates and displays parameters for toric IOLs available worldwide and adjusts its recommendations based on expected postoperative spherocylindrical refraction.



Courtesy of Noel Alpins, FRANZCO, FRCOphth, FACS

Figure 2. The dynamic display of the ASSORT calculator allows the surgeon to move the phaco incision around the eye to determine the targeted corneal astigmatism.

Courtesy of Noel Alpins, FRANZCO, FRCOphth, FACS

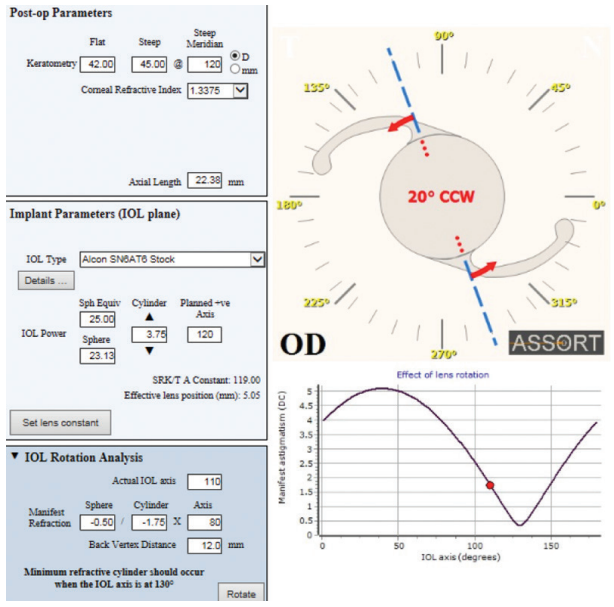


Figure 3. Postoperative analysis in the event of a refractive surprise can calculate the optimal rotation of an implanted toric IOL to result in minimal refractive cylinder.

axial length, average keratometry (K) in diopters or radius of curvature, corneal toric power according to associated spherical implant power, and anterior chamber depth. The astigmatic effect of the phaco incision can be dynamically adjusted based on incision placement (Figure 2). The new parameter of corneal topographic astigmatism (CorT Total) can be employed to include an accurate measure of corneal astigmatism with inclusion of the posterior cornea. There is also an option to step up and down implant power for the available sphere and cylinder separately, with a display of calculated target spherocylindrical refraction. This is invaluable in evaluating preferred lens choice for any implant.

Another unique feature of the ASSORT Toric Calculator is its ability to perform calculations to address postoperative refractive surprises. The calculator can quantify both numerically and graphically how much benefit can be obtained from IOL rotation, IOL exchange, or LASIK to improve an unsatisfactory outcome according to the implant used (Figure 3).[2] The Alpins method calculations are concurrently included to assist in the decision-making process.[3,4]

In summary, the ASSORT Toric Calculator displays all pre- and postoperative toric implant requirements. It contains the parameters for the most accurate calculation for any implant desired and assists in resolving refractive cylinder surprises that are bound to occur in some cases.[2]

1. Goggin M, Moore S, Esterman A. Outcome of toric intraocular lens implantation after adjusting for anterior chamber depth and intraocular lens sphere equivalent power effects. *JAMA Ophthalmol.* 2011;129:998-1003.
2. Alpins NA, Stamatelatos G. Refractive surprise after toric intraocular lens implantation: graph analysis. *J Cataract Refract Surg.* 2014;40:283-294.
3. Alpins NA. A new method of analyzing vectors for changes in astigmatism. *J Cataract Refract Surg.* 1993;19:524-533.
4. Alpins NA. Astigmatism analysis by the Alpins method. *J Cataract Refract Surg.* 2001;27:31-49.

Barrett Toric Calculator

By Graham D. Barrett, MD, FRANZCO

Our ability to provide excellent unaided acuity after cataract surgery improved dramatically with the introduction of toric IOLs. Nevertheless, despite accurate keratometry, precise alignment, and complex calculations, the refractive outcome after toric IOL implantation is not always predictable. Choosing the correct toric IOL for patients is more challenging than choosing a spherical IOL power, as we have to consider the magnitude and axis of the toric cylinder required. In order to avoid unexpected astigmatic outcomes, we must consider which devices should be used to measure the cornea, how to interpret the measurements, which methods to use to predict the required cylinder, and which technique will most acccurately align the toric IOL axis.

Available at
www.ascrs.org/barrett-toric-calculator
www.apacrs.org/toric_calculator/Toric%20Calculator.aspx

Methods to predict the required cylinder. Louis Émile Javal, MD, a 19th century ophthalmologist, first noted that he could not account for total ocular astigmatism by simply measuring the power of the anterior cornea. This phenomenon is known as *Javal's rule* and is thought to be due to the posterior cornea contributing, on average, 0.50 D of against-the-rule astigmatism.

There are several toric IOL calculators available. The Alcon calculator (see *Manufacturer-Specific Toric IOL Calculators*) uses a fixed ratio in calculating the corneal vector of the cylinder power for a toric IOL. This can be adjusted for the posterior cornea's contribution using the Baylor nomogram. The Holladay calculator uses ELP to calculate the corneal vector of the toric IOL, and it can be adjusted based on the Baylor nomogram or direct measurement of the posterior cornea. Another alternative is to go to the Asia-Pacific Association of Cataract and Refractive Surgeons (APACRS) or American Society of Cataract and Refractive Surgery (ASCRS) websites and use a toric calculator I developed, which is also available on the Lenstar biometer (Haag-Streit).

The Barrett Toric Calculator. The Barrett Toric Calculator (Figure 4) uses the Universal II formula to predict the required spherical equivalent IOL power. The calculator derives the posterior corneal curvature based on a theoretical model proposed to explain the behavior of the posterior cornea. The toric IOL cylinder power required to correct the corneal astigmatism—including posterior corneal astigmatism—is calculated from the predicted ELP using vector calculations for each eye. In a study conducted

Courtesy of Graham D. Barrett, MD, FRANZCO

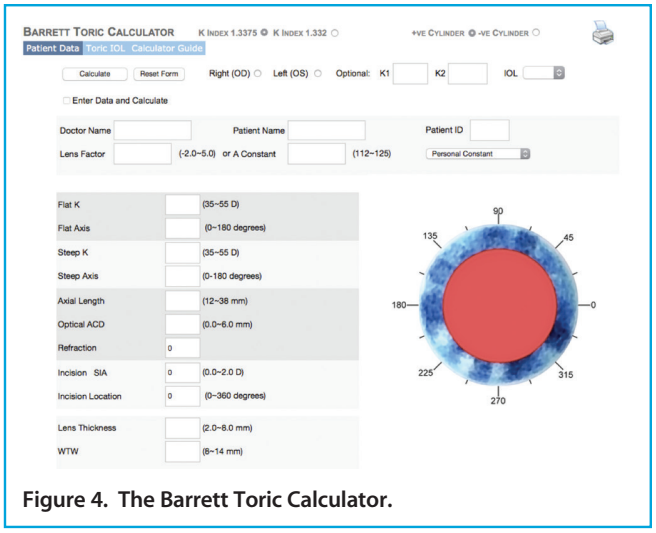


Figure 4. The Barrett Toric Calculator.

Courtesy of Graham D. Barrett, MD, FRANZCO

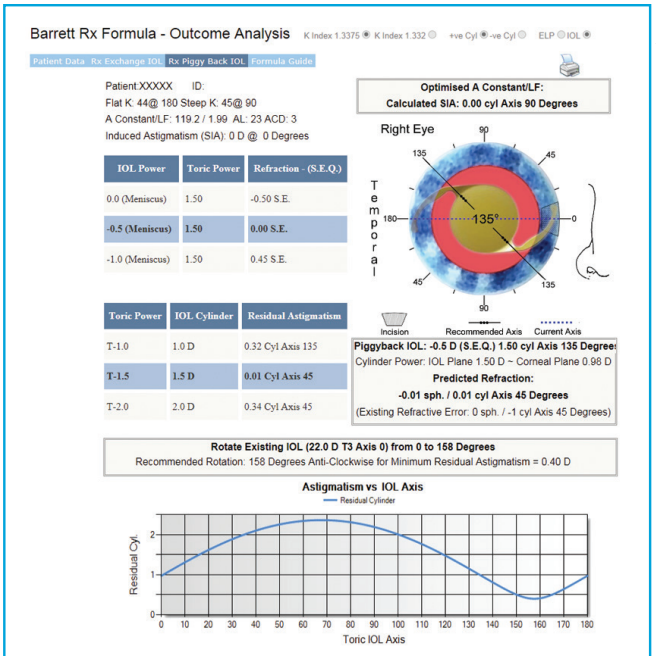


Figure 5. The Barrett Rx formula.

at Ein-Tal Eye Center and awaiting publication in the *Journal of Cataract and Refractive Surgery*, the most accurate prediction of residual astigmatism was achieved with the Barrett Toric IOL calculator in combination with the Lenstar.

In a subsequent study I performed with my fellow Adi Abulafia, MD, in Perth, Australia, we analyzed 54 eyes implanted with toric IOLs, comparing pre- and postoperative Ks, the intended versus actual axis of alignment, and different calculators to identify the relative contribution of each of these factors to errors in predicted residual astigmatism. The results showed that errors in estimating surgically induced astigmatism (SIA) adversely affect the predictability of toric IOL outcomes and that utilizing the centroid value for SIA offers significant improvement. Similarly, eliminating errors in axis alignment offers further improvement, but the effect is less significant.

The most important benefit, however, that can be obtained in improving toric IOL outcomes comes from use of an improved calculator. In addition to the Barrett Calculator, the Barrett Rx formula is also available online (Figure 5). This formula recommends the required IOL power for lens exchange, piggyback IOLs, or the rotation of an existing toric IOL to correct for an unexpected refractive outcome.

Techniques to acccurately align the toric IOL axis. An error in alignment of 1° reduces the effective correction of a toric IOL by an estimated 3%. Although, clinically, the impact of misalignment appears to be less than not taking into account factors such as posterior corneal astigmatism, there are several techniques that can be considered to improve alignment.

Today, we have sophisticated systems to help minimize errors in alignment of a toric IOL on the required axis. These include intraoperative determination of the axis with wavefront devices or image-guided systems.

I use the toriCAM app (developed by Graham D. Barrett, MD, FRANZCO; https://itunes.apple.com/us/app/id910004717?mt=8), which is simple to use but accurate. First, I dry the limbus with a cellulose spear to prevent smearing and mark the limbus at what I perceive to be 180°. I then use the toriCAM app to align the red reference axis indicator with the limbal marks, press the camera button, and capture an image. The images are stored in the photo

MANUFACTURER-SPECIFIC TORIC IOL CALCULATORS

- **Alcon**
  www.acrysoftoriccalculator.com
- **Abbott Medical Optics**
  www.amoeasy.com/calc
- **Bausch + Lomb**
  trulign.com/professionals/en-us/toriccalculator.aspx
- **Carl Zeiss Meditec**
  zcalc.meditec.zeiss.com/zcalc/
- **Oculentis**
  www.lentistoric.com/GB/Intro.aspx
- **Rayner Intraocular Lenses**
  www.rayner.com/raytrace
- **STAAR Surgical**
  www.staartoric.com

album of my iPhone, and toriCAM records the reference axis, patient name, and date and time of the image. I then set the desired toric axis on my marker and offset the reference axis accordingly. A custom toric marker specifically for the toriCAM app is available, allowing the surgeon to set the reference axis as indicated by the app independently from the toric axis recommended by the toric calculator. Applying the inked marker then provides accurate marks with which the toric IOL can be aligned after insertion.

Avoiding unexpected outcomes with toric IOLs is as important as selecting the appropriate spherical IOL power. Understanding the source of potential errors during measurement, prediction, and alignment—with careful attention to each step in the process—can minimize the likelihood of an unexpected astigmatic result.

Toric Results Analyzer



By Mark S. Hansen, MD; John P. Berdahl, MD; and David R. Hardten, MD

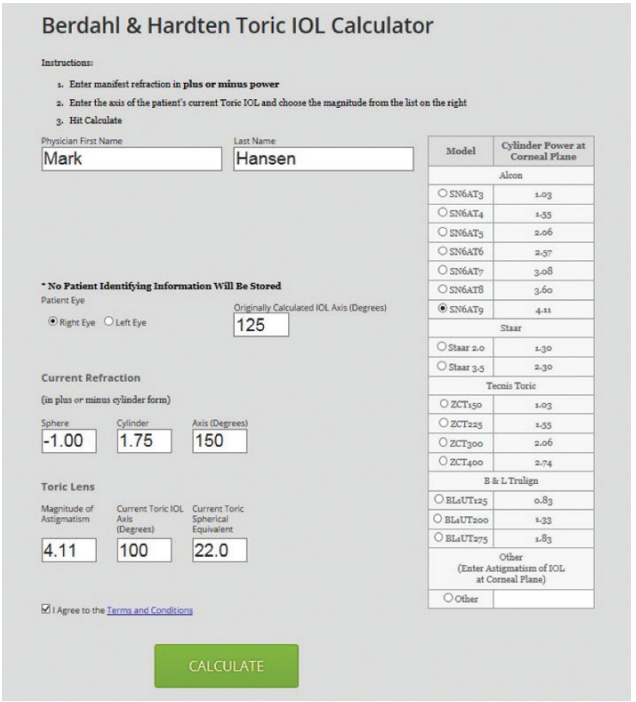
The Toric Results Analyzer calculator was developed by Drs. Berdahl and Hardten as a tool for dealing with residual astigmatism following toric IOL implantation. Residual astigmatism often remains after surgery, and this is confirmed by the fact that surgeons have used the Toric Results Analyzer for more than 20,000 IOL calculations over the past 2 years.

This easy-to-use calculator helps surgeons determine if residual astigmatism following toric IOL implantation can be corrected by simply rotating the lens. It also provides information that can be used to determine the ideal rotation of the lens to correct residual astigmatism and can provide information for an IOL exchange if a higher or lower toric power is needed. In cases in which rotation or exchange would not be useful, most surgeons opt for laser vision correction.

Available at www.astigmatismfix.com

The information required to use the calculator includes the patient's current refraction (in plus or minus sphere), the intended IOL axis, and the toric lens information (spherical power and cylinder power at corneal plane), including the current axis (Figure 6).

After this information is entered, the calculator indicates the axis the lens should be rotated to in order to decrease the amount of astigmatism to an acceptable level (Figure 7).



Courtesy of Mark S. Hansen, MD; John P. Berdahl, MD; and David R. Hardten, MD

Figure 6. The information required by the Toric Results Analyzer includes the patient's current refraction; the intended IOL axis; and the toric lens information, including the current axis.

If the predicted refraction after rotation is acceptable as the intended target, then rotating the lens can be attempted. If the expected refraction after rotating the lens would not be acceptable, then a lens exchange or laser vision correction can be considered.

Following is a step-by-step approach to easily integrate this application into clinical use:

- Measure manifest refraction.
- Measure the IOL axis and determine the power and toricity. It is important to get the axis measurement accurate. This can best be achieved at the slit lamp when the patient is dilated. Align a slit beam with the axis of the toric lens marks. Then use a smartphone app (such as Axis Assistant) to determine the axis of the beam.
- Enter the information at www.astigmatismfix.com.
- Determine whether rotating the lens will neutralize the astigmatism and whether the resulting spherical equivalent is appropriate.
- Determine a surgical plan; if the lens can be rotated easily, mark the current and ideal axis, loosen the IOL with an OVD, and rotate the lens to align with the ideal axis.

The basic concept of this tool is to determine whether simply rotating the lens to the ideal axis will sufficiently reduce the amount of unexpected postoperative astigmatism.

Courtesy of Mark S. Hansen, MD; John P. Berdahl, MD; and David R. Hardten, MD

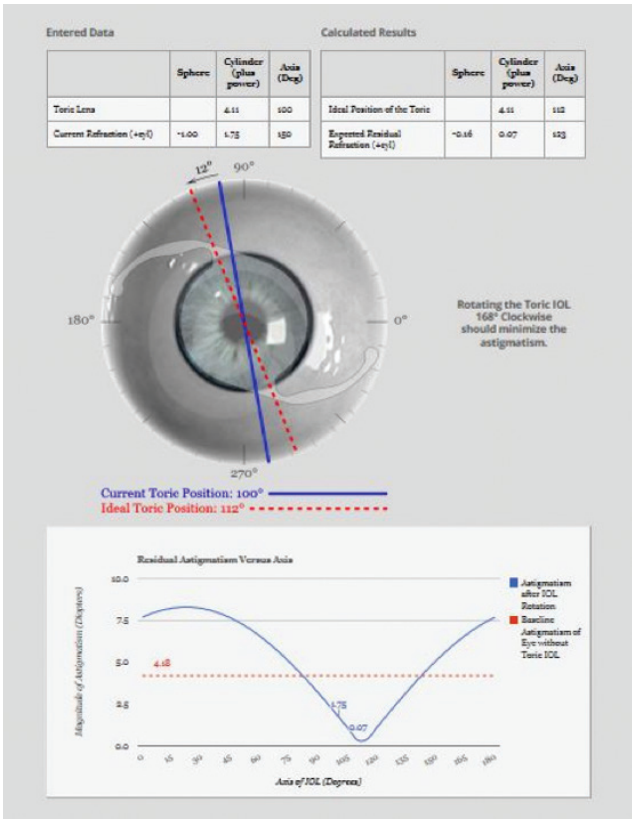


Figure 7. After the information is entered, the calculator indicates which axis the lens should be rotated to in order to decrease the amount of astigmatism to an acceptable level.

Holladay IOL Consultant

By Jack T. Holladay, MD, MSEE, FACS

The Holladay IOL Consultant software features both a Toric PreOp Planner for forward calculation and a Toric PostOp Back Calculator for back calculation.

Toric PreOp Planner. The Toric PreOp Planner allows the user to determine the ideal toricity and axis of placement for a toric IOL using K readings and the expected SIA from the cataract incision. It does not use a constant ratio of 1.46 to determine the ideal toricity of the IOL from the corneal astigmatism—an approach used by some other calculators that can result in errors with low- and high-powered IOLs. Before using the planner, the surgeon should confirm that the K readings and the axes for the flat and steep Ks are correct. The magnitude and axis of the manifest refraction are irrelevant, as the crystalline lens will be removed.

Next, the surgeon enters the magnitude of the SIA. For

Courtesy of Jack T. Holladay, MD, MSEE, FACS

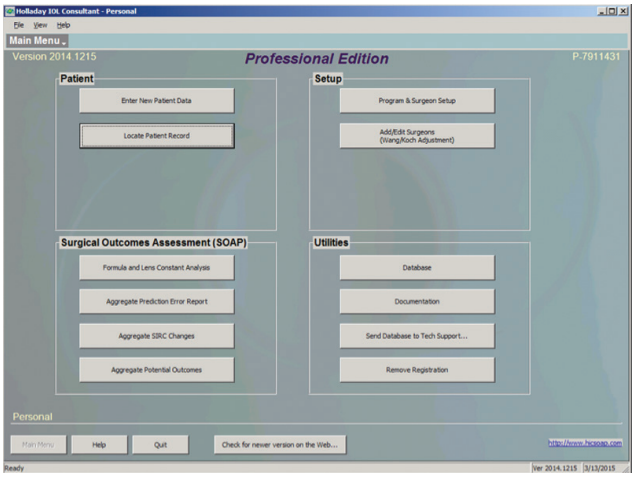


Figure 8. The Holladay IOL Consultant main menu.

Courtesy of Jack T. Holladay, MD, MSEE, FACS

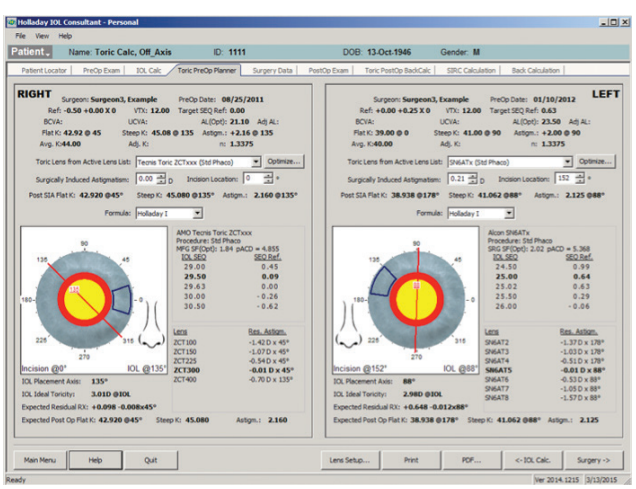


Figure 9. The Holladay IOL Consultant Toric PreOp Planner.

Courtesy of Jack T. Holladay, MD, MSEE, FACS

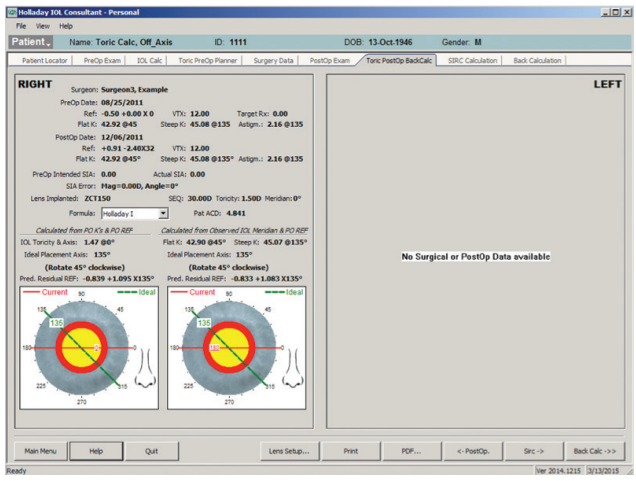


Figure 10. The Holladay IOL Consultant Toric PostOp Back Calculator.

modern small-incision cataract surgery, this value is usually between 0.00 and 0.50 D. For a given surgeon, if pre- and postoperative Ks have been entered, the mean value (centroid) may be found on the Aggregate Surgically Induced Refractive Changes (SIRC) on the main menu (Figure 8).

The SIRC from K's button and Minus Cylinder must be checked to obtain the correct value. In the example in Figure 8, the magnitude of the SIA is -0.21 D with the incision at 152° in the left eye. The user would enter 0.21 D, ignoring the sign. The meridional location of the cataract incision must be entered (152°). As soon as the magnitude and axis of the cataract incision have been entered, a black arcuate trapezoid is shown at the limbus on the drawing (Figure 9).

A drop-down list of available toric IOLs is displayed. The user selects the toric IOL model and the IOL formula to be used (Holladay 2 is recommended). Once this has been done, the steep axis of the cornea and the calculated correct axis for the IOL are shown. Displayed below the picture is the axis of placement, the ideal toricity of the IOL, and the remaining residual refraction with the nearest available toric IOL. All available toricities are shown, with the nearest to the ideal toricity highlighted in bold print and the residual refraction for each available toricity.

Toric PostOp Back Calculator. The Toric PostOp Back Calculator allows the surgeon to determine the exact amount that the toric IOL should be rotated to produce the smallest residual astigmatism. Two methods can be used to achieve this. One method uses the postoperative Ks and postoperative refraction, and the other uses the IOL meridian observed at the slit lamp and the postoperative refraction; both determine (1) the toricity of the IOL and its current placement axis, (2) the ideal placement axis, (3) the amount of clockwise rotation necessary to achieve the ideal placement axis, and (4) the predicted residual refraction at the ideal placement axis. Then a green line appears in the diagram to illustrate the ideal axis of placement for the IOL (Figure 10).

It is prudent to measure both the postoperative Ks and observed IOL meridian along with the postoperative refraction to double-check the amount of rotation required to rotate the IOL to the ideal axis of placement. The two methods should agree to within a few degrees. When they do not match, something is wrong, and measurements should be repeated until they agree.

As with forward calculation using the Toric IOL Planner, the equations for back calculation are exact and utilize the ELP and IOL power and toricity. Approximation calculators that use a constant ratio (~1.46) to convert the cylinder at the IOL plane to the cylinder at the corneal plane will not get the same answer, especially for low- and high-power IOLs. If a calculator does not require the spherical equivalent power of the IOL as input data, the calculator uses the approximation method.

All IOL powers in the Holladay IOL Consultant are given as spheroequivalent power (SEQ) and toricity. The SEQ power of an IOL is equal to the sphere plus one-half of the toricity.

For example, a 20.00 D SEQ and 2.00 D of toricity is actually 19.00 D of sphere with 2.00 D of toricity. All US and most European manufacturers label IOLs with SEQ power and toricity, as required by the American National Standards Institute (ANSI) and International Organization for Standardization (ISO), especially so that if one drops down or up a toric step size, the SEQ power of the recommended IOL power never changes; if sphere and toricity are reported, then this is not true, and both values must change so that the SEQ remains constant. In short, calculators that report sphere and cylinder require the surgeon to determine the SEQ power when ordering an IOL, whereas this is done automatically in the Holladay IOL Consultant. ■

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