Improved Accuracy With a Vergence-Based Online Toric Intraocular Lens Back-calculator

Potvin et al. are to be congratulated on their excellent analysis of factors associated with residual astigmatism after toric intraocular lens (IOL) implantation using their online toric IOL back-calculator.[1] Providing this calculator has helped many surgeons and patients achieve excellent outcomes that would have otherwise been impossible.

We would like to make two points that should make their results even better. The first relates to using a constant ratio equation (usually 1.46) between the toricity of the IOL and the corneal astigmatism. The ratio is not constant but varies as a function of the IOL spherical equivalent power and effective lens position. The ratio is progressively higher for IOLs that are less than 22.00 diopters (D) and progressively lower for IOLs that are greater than 22.00 D. This error has been pointed out by several investigators with the forward toric IOL calculation[2-5] and results in the same error in the backward calculation. We humbly suggest that the developers change the calculator to implement the thin lens vergence equation[6] that will eliminate this error and improve the results for the lower and higher IOL powers.

The second point relates to an alternative method other than using the observed orientation of the IOL. The alternative method may be performed using the postoperative keratometry and postoperative refraction and should give similar results to the observed orientation method as shown in **Figure 1**. The postoperative keratometry method yields a 4 (counterclockwise rotation) and the postoperative observed IOL meridian yields a 6 (counter clockwise rotation with slightly different predicted residual refractions). When the rotations are this close, the surgeon can be confident of the predictability of the result. When they are different, all measurements should be repeated (postoperative refraction, postoperative keratometry values, and observed IOL axis) and if the methods still differ, then the postoperative keratometry values are usually irregular and cannot be trusted. The vergence-based Holladay Toric Front- and Back-Calculator and Holladay 2 Formula are open public access at www.hicsoap.com under the Calculators tab.[7]

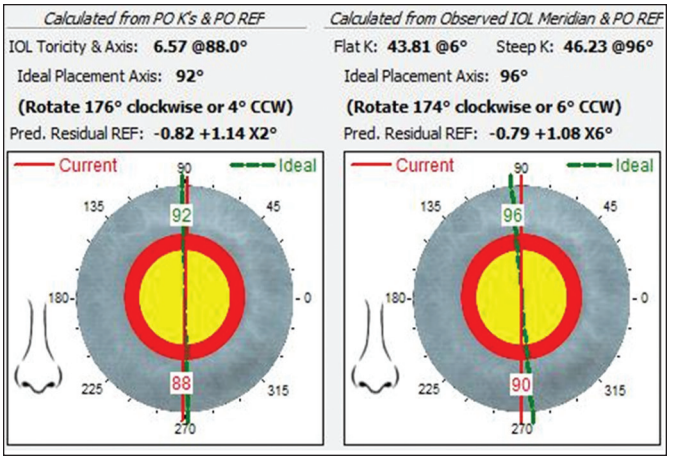

Figure 1. Postoperative keratometry (PO K) and postoperative refraction (PO REF) method 1 (left) and postoperative observed intraocular lens (IOL) meridian and PO REF method 2 (right) using the vergence-based toric IOL back-calculator. CCW = counterclockwise

REFERENCES

1. Potvin R, Kramer BA, Hardten DR, Berdahl JP. Factors associated with residual astigmatism after toric intraocular lens implantation reported in an online toric intraocular lens back-calculator. *J Refract Surg.* 2018;34(6):366-371. doi:10.3928/1081597X-20180327-01
2. Abulafia A, Koch DD, Holladay JT, Wang L, Hill W. Pursuing perfection in IOL calculations: IV. Rethinking astigmatism analysis for IOL-based surgery: suggested terminology, analysis, and standards for outcome reports. *J Cataract Refract Surg.* In press.
3. Goggin M, Moore S, Esterman A. Toric intraocular lens outcome using the manufacturer's prediction of corneal plane equivalent intraocular lens cylinder power. *Arch Ophthalmol.* 2011;129:1004-1008.
4. Holladay JT. Exact toric IOL calculations using currently available lens constants. *Arch Ophthalmol.* 2012;130:946-947.
5. Fam HB, Lim KL. Meridional analysis for calculating the expected spherocylindrical refraction in eyes with toric intraocular lenses. *J Cataract Refract Surg.* 2007;33:2072-2076.
6. Holladay JT. Standardizing constants for ultrasonic biometry, keratometry, and intraocular lens power calculations. *J Cataract Refract Surg.* 1997;23:1356-1370.
7. Holladay JT. Holladay IOL Consultant and Surgical Outcomes Assessment. http://www.hicsoap.com. Accessed July 2, 2018.

Jack T. Holladay, MD, MSEE
Houston, Texas

Dr. Holladay is the developer of the Holladay IOL Consultant software with the toric calculator and is the president of Holladay IOL Consulting Inc., which is the distributor.

Reply

We thank Dr. Holladay for his comments regarding our article.[1]

To his first point regarding more appropriate determination of cylinder power at the corneal plane, we agree it would be helpful. We are working on a version of the web site that would include consideration of the sphere power of the intraocular lens (IOL) to calculate the effective cylinder power of any given IOL at the corneal plane. We recognize that this approach may not be as precise as a thin lens vertex calculation, but the differences are likely to be nominal. Further, we believe that our use of the sphere power of the IOL would

TABLE 1
Cylinder Power at the Corneal Plane

	Axial Length (mm)	
Flat/Steep K (D)	**20**	**28**
40/45	4.20	3.71
35/40	4.33	4.14

K = keratometry; D = diopters

be a good proxy for a thin lens vertex calculation and would strike a balance between accuracy and usability; the data requirements from surgeons using the site would not increase. We expect the new formula would improve the results of the toric IOL back-calculations provided by the site. However, it is worth pointing out that these relative adjustments to the nominal IOL cylinder power to compensate for axial length and keratometry considerations are generally modest, except in extreme cases of both variables (long eyes with steep corneas or short eyes with flat corneas).[2] **Table 1** shows the calculated cylinder power from an online calculator that adjusts for these variables where a T9 lens, with a nominal cylinder correction at the corneal plane of 4.11 diopters (D) is planned.[3] The maximum difference from nominal (4.11) is only 0.40 D, or 10% of the nominal power at the corneal plane.

Regarding the second point, the alternative method may have some merit, but validating that approach is beyond the scope of the current article. An analysis of results from both methods when results are in agreement, and when results are not, would be required to demonstrate the potential for such an alternative to improve toric back-calculations. If warranted, the alternative approach could be considered, although again it would require more data to be input by surgeons using the site.

The method of back-calculation we have adopted is based only on the current IOL position and cylinder power, and how a reorientation of the lens would alter the manifest refraction. Because the manifest refraction includes the patient's compensation for effects of lens position, posterior corneal astigmatism, and possible higher order aberrations, we believe this is the preferred approach.

REFERENCES

1. Potvin R, Kramer BA, Hardten DR, Berdahl JP. Factors associated with residual astigmatism after toric intraocular lens implantation reported in an online toric intraocular lens back-calculator. *J Refract Surg.* 2018;34(6):366-371. doi:10.3928/1081597X-20180327-01
2. Savini G, Hoffer KJ, Carbonelli M, Ducoli P, Barboni P. Influence of axial length and corneal power on the astigmatic power of toric intraocular lenses. *J Cataract Refract Surg.* 2013;39:1900-1903.
3. Online Barrett Toric Calculator on the ASCSR web site. http://www.ascrs.org/barrett-toric-calculator. Accessed July 13, 2018.

Richard Potvin, MASc, OD
Brent A. Kramer, MD
David R. Hardten, MD
John P. Berdahl, MD
Akron, New York

Dr. Potvin receives fees from Ocular Surgical Data, LLC, and Alcon. Dr. Hardten is a consultant for Johnson & Johnson, ESI, Inc., and TLC Vision, and an owner of Ocular Surgical Data, LLC. Dr. Berdahl is an owner of Ocular Surgical Data, LLC. Dr. Kramer has no financial or proprietary interest in the materials presented herein.

doi:10.3928/1081597X-20180723-02