Ray Tracing for Post-LASIK Patients

A better approach to IOL calculations. | BJØRN GJERDRUM, OD, PHD

The most challenging population in which to perform accurate IOL calculations is post-LASIK patients. Traditional formulas such as the SRK/T, Holladay II, and Barrett Universal II use keratometry to predict the postoperative refractive outcome. In normal eyes, these formulas produce reliable results. In post-LASIK eyes, however, this method is erroneous because refractive surgery alters the corneal curvature. The use of these formulas therefore often leads to significant unintended postoperative refractive errors, mainly an under- or overestimation of the required IOL power in eyes that had previous myopic and hyperopic refractive surgery, respectively.

Alternatively, post–laser vision correction (LVC) formulas can be used, such as the Double-K, Haigis-L, Wang-Koch-Maloney, and Barrett True K. Although these formulas provide more accurate outcomes in post-LASIK eyes compared to traditional formulas, they are all theoretical formulas that either require historical measurements or use a no-history/regression analysis or an assumed posterior corneal power to predict the total corneal power. They also rely on paraxial assumptions. Such correctional assumptions are not accurate for the human eye.

Another option for IOL calculations in post-LVC eyes is to use ray tracing. This method uses exact calculations based on Snell's law for single rays at varying radial distances. Ray tracing does not incorporate any paraxial assumptions. The accuracy, however, is dependent on the availability and accuracy of the data. Today, a device such as the ANTERION (Heidelberg Engineering), which combines corneal topography and tomography, biometry, IOL calculation, anterior chamber and angle assessments, and high-resolution imaging into one device, can help to provide the most complete and accurate data needed to produce excellent IOL power calculations. The ANTERION offers a comprehensive suite of established IOL formulas and provides an interface to OKULIX, an IOL calculation method using ray tracing to calculate the optimal IOL power. ANTERION's high data quality can make the biggest differences in challenging eyes, including those that have undergone refractive surgery as well as in short eyes and in eyes with unusual corneal geometry and corneal pathologies.

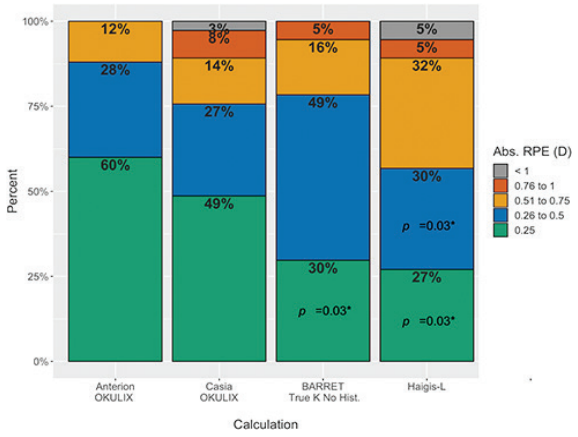
SOFTWARE OVERVIEW

OKULIX uses full-aperture ray tracing to capture the pupil size and manufacturer-provided IOL data like corneal radii, refractive index, asphericity, and lens thickness. Rather than using effective lens position, OKULIX predicts the geometrical IOL position based on the axial length, anterior chamber depth, and lens thickness. There's no need for personalized lens constants. The software can incorporate anterior and posterior corneal tomography and corneal thickness. When these measurements are available, the calculation is independent of patient history. Rather than calculating the IOL power for a theoretical best focal point, OKULIX calculates the power that will provide the smallest simulated foveal image. In this way, it also accounts for spherical aberrations.

The OKULIX calculation software shows the predictive procedural refraction in terms of the best focus, which is used for surgery planning, as well as the procedural refraction for the paraxial calculation. The difference between these two values represents the spherical aberrations. The software also calculates the predictive geometrical postoperative anterior chamber depth.

STUDY RESULTS

We compared the refractive precision of OCT ray-tracing IOL calculations with the ANTERION and Casia 1000 (Tomey) to post-LVC IOL calculation achieved with the Barrett True K and Haigis-L with the Lenstar LS 900 (Haag-Streit).



Source: Gjerdrum B, Gundersen KJ, Lundmark PO, Aakre BM. Refractive precision of ray tracing IOL calculations based on OCT data versus traditional IOL calculation formulas based on reflectometry in patients with a history of laser vision correction for myopia. *Clin Ophthalmol*. 2021;15:845-857.

Figure 3. Comparison of the absolute refractive prediction error between different IOL calculation methods in patients with a history of previous myopic laser vision correction. The combination ANTERION + OKULIX showed the highest percentage of eyes within ±0.25 D, and all eyes were within ±0.75 D.

A total of 37 eyes of 20 patients who had previously undergone laser vision correction for myopia were included in the results. The correlatiton between two eyes of a patient were accounted for. The mean age of patients was 57 years, and the mean planned LVC correction was for -3.70 D myopia (range, -10.00 to -1.60 D). The mean power of the implanted IOL was 20.30 D (range, 15.00–24.50 D). About 65% of patients received a toric IOL.

We determined that the OKULIX calculation based on the ANTERION data had the lowest mean refractive prediction error. This was statistically significantly different from all three other calculations, including the OKULIX calculation with the Casia data. Further, the ANTERION OKULIX calculation was the only one that had no outliers on the whiskers box plot, which is about 1.5 standard deviations.

The ANTERION OKULIX calculation also had the lowest mean absolute prediction error, but this was only statistically different from the Haigis-L calculation. About 60% of eyes were within ±0.25 D with the ANTERION OKULIX calculation, 49% with the Casia OKULIX calculation, and 30% and 27%, respectively, for the two formulas based on the reflectometry. The percentages for both these formulas were significantly different from the ANTERION OKULIX calculation. About 88%, 76%, 79%, and 57% of eyes were within ±0.50 D of the intended target with the ANTERION OKULIX, Casia OKULIX, Barrett, and Haigis-L calculations, respectively. Only with the ANTERION OKULIX calculation were all the eyes within ±0.75 D (Figure 3).

CONCLUSION

Ray tracing is a better approach to IOL calculations, especially in post-LVC eyes. This method takes individual measurements, is independent of ocular history, and avoids the need for personalized lens constants. Of the IOL calculation methods we have studied, ray tracing with the ANTERION OKULIX provided the best arithmetic mean absolute prediction error with the lowest range of refractive error. About 60% of eyes were within ±0.25 D of the refractive target at 3 months postoperative. ■

1. Gjerdrum B, Gundersen KJ, Lundmark PO, Aakre BM. Refractive precision of ray tracing IOL calculations based on OCT data versus traditional IOL calculation formulas based on reflectometry in patients with a history of laser vision correction for myopia. *Clin Ophthalmol*. 2021;15:845-857.

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