Intraocular Lens Power Selection in Eyes With Axial Myopia

BY NICHOLAS BEHUNIN, MD, AND SETH M. PANTANELLI, MD, MS
EDITED BY SHARON FEKRAT, MD, AND INGRID U. SCOTT, MD, MPH

Patients with axial myopia (axial length greater than 25 mm) are at risk for suboptimal refractive outcomes following cataract surgery. Although patients with normal axial lengths achieve refractive outcomes within 0.5 D of predicted 67% to 72% of the time, only 54% of those with axial myopia attain that target when no optimization method is used.[1,2] Several theories exist to explain this phenomenon, including systematic error in axial length measurement, posterior pole staphyloma, and IOL geometry. Whatever the explanation, the fact remains that standard IOL power calculation formulas frequently select IOLs of insufficient power, resulting in postoperative hyperopia.

Many surgeons attempt to compensate for this unwanted outcome by empirically targeting a moderately myopic postoperative refraction (–1.00 to –2.00 D). However, more sophisticated methods have emerged, such as those discussed below. Although no single method has been established as the best for all eyes and all surgeons, any of these approaches, if understood and appropriately implemented, will increase the likelihood of achieving refractive targets.

SETH M. PANTANELLI, MD, MS

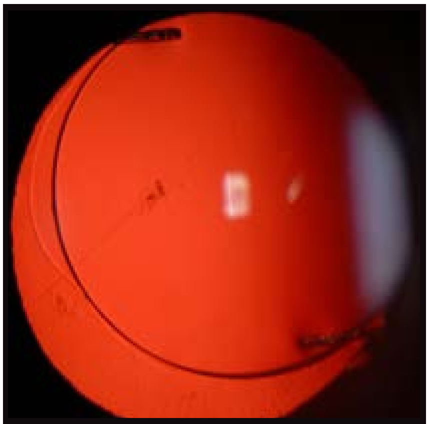
Lens Constant Adjustment

With most IOL power calculation formulas, the shape of the IOL power prediction curve is fixed. This is true, for example, with the SRK/T formula, in which the only variable that can be manipulated is a single A-constant. Changing the A-constant moves the location of the power prediction curve and optimizes the formula so that it operates well over a fixed range of axial lengths, but it performs less well outside that range.

Alternatively, the Haigis formula seeks additional precision by using 3 lens constants (a0, a1, and a2), which adjust both the shape and position of the IOL power prediction curve. The a0 constant moves the power prediction curve up or down (much like the A-constant in SRK/T), while a1 and a2 adjust for the anterior chamber depth and axial length, respectively. The Haigis formula has been validated in several studies involving long eyes.[3]

Terzi, Wang, and Kohnen studied the accuracy of Holladay 2, Hoffer Q, SRK/T, and Haigis IOL power calculation formulas in refractive lens exchange.[3] Their study found that when the manufacturers' lens constants are used, all formulas have a tendency to produce a postoperative hyperopic surprise in eyes with axial myopia. However, with optimized lens constants, the Haigis formula performed best.

Advantages. The Haigis formula comes preloaded in many biometers; however, for greatest accuracy, the individual surgeon must customize the lens constants to account for personal surgical technique and equipment. The spreadsheet needed to optimize the lens constants is available without charge on the website of Warren E. Hill, MD (www.doctor-hill.com/iol-main/haigis.htm). Once fully optimized, the postoperative results can be very accurate (typically ±0.25 D), even for those with axial myopia.



IOL IN HIGH MYOPIA. This –20.00 D myopic eye was implanted with a –1.00 D MA60MA IOL (Alcon).

Limitations. The Haigis optimization process requires considerable time and effort and is not a quick solution. The cataract surgeon must maintain a detailed database of surgical outcomes (minimum of 225) and submit it to Dr. Hill in North America and to Dr. Haigis in Europe prior to optimization.

Axial Length Adjustment

One theory regarding incorrect IOL power involves systematic error in axial length measurement. Optical biometry relies on a global index of refraction for all eyes. However, in eyes with axial myopia, the vitreous cavity makes up a greater proportion of the globe, and the vitreous undergoes early liquefaction. Thus, use of this standard index of refraction may yield inaccurate axial length measurement.

Wang and colleagues proposed a method of axial length adjustment to improve postoperative refractive prediction in long eyes.[3] They evaluated the Holladay 1, Haigis, SRK/T, and Hoffer Q power calculation formulas in eyes with axial length greater than 25 mm. They looked at IOLs in 2 groups: power greater than 5 D and power of 5 D or less. In both groups, they found that adjusting axial length significantly reduced the mean numerical error as well as the percentage of eyes that would otherwise have experienced postoperative hyperopia.

Advantages. This method of adjusting axial length is simple to implement and requires no A-constant optimization. The axial length adjustment equations are published in the *Journal of Cataract and Refractive Surgery*.[4]

Limitations. Only a small sample of IOLs among those in the study were –5 to +5 D, so the equations may be less accurate with very-low-power positive or negative lenses. Also, this method requires a manual calculation and may be less convenient than use of newer formulas (e.g., Holladay II or Barrett Universal) incorporated in some biometry systems.

Universal Formula

Another theory about the cause of inaccurate refractive outcomes in patients with axial myopia is that the IOL power calculation formulas are flawed. Barrett argued that hyperopic surprise occurs because current IOL power calculation formulas are not designed for use with negative-powered IOLs.[5] He proposed a thick lens formula that determines lens position via anatomical depth, utilizes a lens factor related to the physical position of the principal planes of the IOL, and calculates the change in principal planes for positive and negative IOLs. Barrett's formula is termed the "universal formula" because it is designed for use with multiple lens styles and with short, medium, and long axial lengths. To validate his formula, Barrett compared it with the SRK/T (using manufacturer-recommended A-constants) in 60 myopic patients with IOLs less than 5 D or with negative-powered lenses. He found that the universal formula yielded statistically significantly lower mean error and mean absolute error in predicted lens power.

Advantages. The universal formula is simple to implement, can be used from the outset without standardization, and is available free at www.apacrs.org/barrett_universal2/.

Limitations. The Barrett Universal II Formula has recently become available for use on the Haag-Streit Lenstar. However, it is not currently available on the Zeiss IOLMaster. Cataract surgeons whose equipment does not include the formula must go to the website and manually enter optical biometry measurements for each eye to get lens predictions.

Future Directions

It is inevitable that power prediction models will continue to evolve and produce ever better refractive outcomes in long eyes. While intraoperative aberrometry has already shown promise in improving outcomes for eyes without virgin corneas, its applicability to long eyes has not yet been investigated.[6] Ray-tracing software is another intriguing option that may, once integrated into modern biometry units, transform our understanding of IOL selection. ■

1 Simon SS et al. *Ophthalmology.* 2014;121(2):440-444.
2 Roessler GF et al. *Ophthalmic Physiol Opt.* 2012;32(3):228-233.
3 Terzi E et al. *J Cataract Refract Surg.* 2009;35(7):1181-1189.
4 Wang L et al. *J Cataract Refract Surg.* 2011;37(11):2018-2027.
5 Barrett GD. *J Cataract Refract Surg.* 1993;19(6):713-720.
6 Canto AP. *J Refract Surg.* 2013;29(7):484-489.

Dr. ***Behunin*** *is an ophthalmology resident, and* ***Dr. Pantanelli*** *is an assistant professor of ophthalmology; both are at Penn State Hershey Eye Center, in Hershey. Relevant financial disclosures: None.*