THE LENS CONSTANT

The first installment of this two-part series discusses this portion of IOL power calculations and how to manipulate it.

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The term *lens constant* is potentially inaccurate, as it actually describes a variable used in IOL power calculation. It is a number that, when used appropriately, should vary with any change in IOL type, material, surgeon, or biometer and that, once defined, should continue to be optimized regularly. The lens constant has, however, become the value used to characterize an individual IOL. It is at once a simple descriptor and a black box of influences from every clinical and optical aspect relating to the IOL.

FUNDAMENTAL 1 IOL POWER CALCULATION

Before going into greater detail about lens constants, it is important to discuss a few details about IOL power calculation in general. The appropriate IOL power to achieve a refractive target for an individual eye is determined by considering the impact of several ocular measurements including—but not limited to—axial length (AL), keratometric power, anterior chamber depth (ACD), lens thickness, and white-to-white distance.

Initially based on theoretical eye models, later on regression modelling of refractive outcomes, and most recently on a combination of these and more modern methods (ray tracing and machine learning), the relative weighting of the impact of each of these variables on effective lens position (ELP) prediction and estimated refractive outcome has been refined over the years. Existing methods of IOL power calculation are extremely precise in a standard range of eyes. Further enhancement of refractive outcome prediction by taking into account new biometric variables is likely to be minor in eyes of average dimensions and ratios. For example, the influence of newly measurable variables such as posterior corneal curvature has been investigated in the quest to refine surgeons' predictive abilities, and, in the near future, other variables such as lens tilt may give further incremental improvements in the accuracy of prediction.

The value of each biometric variable and its relative impact on the ELP and estimated refractive outcome is combined in the form of an IOL formula. Simply put, the ideal IOL power to produce the desired outcome can be attained if the exact refractive power of the cornea, the exact length of the eye, and precisely where the IOL will be placed are known.

IOL power calculations or estimations have become fairly accurate, but they still are not perfect. Refractive surprises, therefore, can occur. This is simply because our measurements of such a complex biological system involving a tear film and multiple refractive surfaces are not perfect, and we still estimate rather than know with certainty the final position of the IOL.

The original IOL formulas based on either mathematical principles or regression analysis of postoperative refractive outcomes are still good for average eyes with corneal curvature, AL, and ratio of ACD to AL within certain limits. The SRK formula, for example, dramatically improved IOL power calculation for average eyes but struggled with unusually long or short eyes. The third-generation formulas are the most well-known and include the Hoffer Q, Holladay 1, and SRK/T. These merge regression data with theoretical modeling and treat the IOL as a thin lens with one plane. The formulas in this generation are still relatively simple and rely mostly on axial length and keratometry to make their predictions and recommendations. Third-generation formulas can and should be optimized with a lens constant. This is known as the *A-constant* in the SRK/T formula, the *surgeon factor* in the Holladay 1 formula, and the *pseudophakic ACD constant* in the Hoffer Q formula. Collectively, however, these terms have become known as *A-constants*. The A-constant allows an adjustment to be made to the predicted refractive outcome if a systematic error is found, such as if an audit of postoperative outcomes finds that visual outcomes are more myopic than predicted by a certain formula.

It is now standard practice to use a newer-generation formula such as the Haigis, Holladay 2, Olsen, and Barrett Universal II. Each requires a greater number of biometric variables, which are used to predict the IOL's virtual ELP. These formulas are much better at predicting the ELP in a wider range of eyes with various combinations of AL and ACD. Accuracy continues to suffer at the extremes of AL, especially in very short eyes where small errors in biometry can result in relatively large refractive errors. Although these modern formulas provide improved predictability over previous generations, they, too, should be optimized using refractive outcomes.

FUNDAMENTAL 2 IOL FORMULA VARIABLES

AL and corneal power have the greatest impact on IOL power calculation.

Axial length. This measurement is widely considered to be the most consistent among the values used in IOL power calculation. The AL measurement should be the distance from the front surface of the cornea to the retinal pigment epithelium. Variation arises for a number of reasons, including differences in the area of the retina measured, lenticular density, corneal thickness, the state of the vitreous, and the angle at which the measurement is taken. Variation is less with optical biometers than ultrasound. Using OCT analysis to confirm the alignment of measurement with the fovea is helpful. Because axial length measurement is particularly problematic in highly myopic eyes, the Wang-Koch modification to AL measured by optical biometry was introduced for several formulas and improves outcomes.[1]

Corneal shape and power. Corneal curvature measurement must factor in tear film quality and stability, and most standard biometers are limited to measuring a steep and flat meridian at right angles at a determined diameter from the center of fixation. Significant differences in keratometry readings obtained on the same day by the same device and operator have been published.[2] In some ways, this calls into question the idea that we can precisely measure variables such as surgically induced astigmatism (SIA) or posterior corneal astigmatism as accurately as we would like to imagine.

ELP. This term describes the position at which the IOL power acts within the optical system of the eye and where the IOL will position itself in the long term. The ELP cannot be definitively calculated preoperatively; it can only be predicted. In most eyes with cataracts, the standard crystalline lens is around five times thicker than an IOL. The capsular bag must contract to hold the IOL in position. Variations in zonular length and strength, capsular contraction, capsulorhexis size, and IOL construction as well as a history of vitrectomy produce tiny but significant differences in where the IOL rests within the eye.

Unfortunately, the impact of other variables on ELP is not consistent. For instance, we might expect an eye with a long AL and flat keratometry to have a deep anterior chamber. The anterior chamber, however, may be surprisingly shallow and the IOL farther forward than would have been predicted using only certain variables. This is one reason why some formulas are better suited to short eyes and others to long eyes. ELP is one of the unsolved problems of IOL power calculation. We are good but not perfect at it.

FUNDAMENTAL 3 FRUSTRATIONS IN POSTOPERATIVE IOL POWER REFINEMENT

Two main issues can decrease the refractive accuracy of our predictions.

Subjective refraction. One of the most frustrating problems is the subjective nature of the refractive endpoint. We are using a blunt tool to refine an extremely precise process. After an eye recovers from cataract surgery, a subjective refraction provides important information for the optimization of a formula using the lens constant. Few patients, however, are capable of discerning a refinement in subjective refraction of 0.25 D, let alone the 0.12 D level of precision we would prefer. An objective method to replace subjective refraction is not currently available. Autorefractions from a machine tend to require refinement because an autorefraction considers the eye but a subjective refraction takes into account the whole visual pathway.

SIA. Even if the IOL power calculation is highly accurate, the unpredictable power and orientation of SIA can change the keratometry values and produce a new refractive error. This cannot currently be predicted preoperatively, and the best we can do is make incisions as small and as far away from the central cornea as possible.

FUNDAMENTAL 4 DEFINING THE LENS CONSTANT

It is difficult to define what a lens constant is succinctly. The lens constant is a value without units and is not multiplied or divided by any other variable. It therefore has a 1:1 ratio with the formula's recommended IOL power outcome. So, an increase of 0.50 in the lens constant will produce an IOL power outcome prediction that is also 0.50 D greater. This relationship indicates that the lens constant must vary with IOL design (material, shape, and in vivo behavior). Two IOLs that have an identical shape are not expected to give the same refractive outcome if they are constructed of different materials that interact with light differently.

This concept of the lens constant as a basic identifier of an IOL is simplistic. At its most complex, a lens constant represents the cumulative outcomes from a multitude of surgeries and refinements. This single number is carefully shaped to fit the combination of surgeons with a specific group of eyes.

FUNDAMENTAL 5 UNDERSTANDING THE LENS CONSTANT

I think of a lens constant as a special code for an IOL model that is specific to that design and material. At some point, the manufacturer said this is how the IOL is expected it to act inside an eye, and for its power to be accurately calculated, we have assigned it this number.

Optimizing lens constants for a patient's eye as well as preferences in biometry and surgery has been shown to improve refractive outcomes.[3] It is a simple but often overlooked step that, when coupled with a modern IOL formula, is likely to improve results more than simply upgrading biometry equipment.

CONCLUSION

The job of the lens constant is to account for the shortcomings of other IOL formula variables. Ideally, if many of those variables are consistent, errors can be adjusted for with changes to the lens constant.

Theoretically, if I were to operate on a large number of eyes with a consistent biometer, IOL, surgical technique, and amount and orientation of SIA, I could use a lens constant optimized for eyes with various combinations of AL and ACD. Even more subgroups could be added depending on lens thickness with slight adjustments to the lens constants. It would take a huge number of eyes, however, for me to be able to analyze the results and look for systematic errors in this way. We surgeons therefore typically optimize our lens constant for a particular IOL model and then use that lens constant in a wide range of eyes whenever we implant that particular IOL.

Part two of this series will discuss lens constant optimization in more detail and practical steps in optimizing your own lens constants. ■

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