Biometry Calculations for Phakic IOLs

Lens sizing and power selection are important factors for success with this refractive surgical option.

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Refractive error is a global public health issue that affects up to one-third of people in the United States and in Western Europe who are over the age of 40 years.[1] The incidence of refractive errors, especially myopia, appears to be increasing.[2] Although there is a distinct racial imbalance in the increasing prevalence of refractive error,[3] widespread socioeconomic changes appear to be a driving force that affects all races,[4] as is greater prevalence of near-work activities among children.[5]

Correcting refractive errors is, therefore, a greater public health challenge than ever before. Solutions can be either surgical or nonsurgical; surgical solutions involve altering the refractive power of the cornea, replacing the crystalline lens, or introducing a second lens to the phakic eye,[6] a condition that has been dubbed *duophakia*.[7]

Duophakia avoids the risks attendant with either clear lens extraction or LASIK, and the operation can be reversed or redone if the patient desires.[8] The optical result of the insertion of a phakic IOL also produces less spherical aberration and coma than LASIK[9] and can improve the natural optics of the eye under dim light conditions.[10]

Phakic IOLs have come a long way since they were first described in the 1950s.[11] Initial postoperative complications were addressed and solved one by one, and modern phakic IOLs can be considered a safe alternative in correcting refractive error. It must be noted, however, that the excellent outcomes routinely achieved with contemporary phakic IOL designs are related to the development of safe preoperative selection of patients and increasingly accurate biometric measurements. Indeed, the few complications that do occur in modern practice are often related to inaccurate selection or preoperative biometric analysis of patients.[6] This article presents some important pointers for proper biometry and IOL selection in phakic IOL surgery.

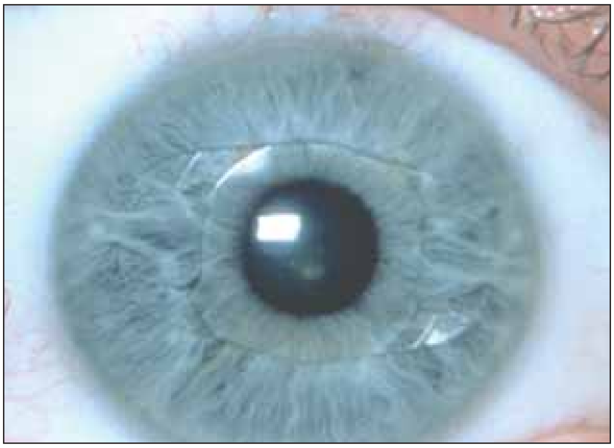

Figure 1. The Artisan PMMA lens is fixated on the anterior surface of the iris.

CALCULATING ACCURATE BIOMETRY

When a phakic IOL is inserted into a human eye, the two most important refractive surfaces—the cornea and the crystalline lens—remain unaltered, and thus a direct calculation of the power needed can be done based on preoperative refraction, corneal power, and vertex distance.[12] Calculating the thickness and the refractive index of the crystalline lens and even measuring the axial length of the eye are unnecessary. The only other factor to consider is the desired postoperative refraction. However, errors can still arise if the corneal surface curvature is measured inaccurately due to contact lens wear or previous keratorefractive surgery.[6,13]

The basic theory of phakic IOL power calculation revolves around the fact that the power of the implanted lens at a given distance behind the posterior corneal surface is equivalent to that measured at a given distance (V) from the corneal vertex.[14] Two formulas,[12,13] taken together, can be used to calculate this.

Formula No. 1: ELP = AA+SF

With this formula, ELP = expected lens position in mm (distance from the corneal vertex to the principal plane of the IOL); AA = anatomic anterior chamber depth in millimeters (distance from corneal vertex to plane of iris root); and SF = surgical factor in millimeters (distance from plane of iris root to principal plane of IOL). This last value is negative for lenses in the anterior chamber.

Formula No. 2:

$$IOL = \frac{1336}{\frac{1336}{\frac{1000}{\frac{1000}{PreRx} - V} + K} - ELP} - \frac{1336}{\frac{1336}{\frac{1000}{\frac{1000}{DPostRx} - V} + K} - ELP}$$

With this formula, IOL = power of the IOL in diopters; ELP = expected lens position (see Fomula No. 1); K = corneal power in diopters; V = distance of the refraction plane from the corneal vertex; PreRx = preoperative refraction in diopters; DPostRx = desired postoperative refraction.

For this equation to be effective, the cornea is assumed to be a thin lens. Therefore, the vertices of the anterior and posterior corneal surfaces are the same, and the corneal thickness is ignored for the purposes of calculation.[6] An alternative formula that can be used for anterior chamber IOLs is as follows:[15]

Formula No. 3:

$$IOL = \frac{1336}{\frac{1336}{K+Refc} - ELP} - \frac{1336}{\frac{1336}{K} - ELP}$$

With this formula, Refc = refraction at the corneal vertex, in diopters; and ELP = effective lens position (note: not expected lens position, as in Formulas No. 1 and 2) measured in meters. This ELP is the difference between the anterior chamber depth, including the corneal thickness, and the distance between the IOL and the crystalline lens.[2,15] This last value differs with various lenses, and is given at 0.8 mm for the Artisan lens (Ophtec GmbH, Groningen, Netherlands; Figure 1) and 1.0 mm for the ZSAL-4 (Morcher GmbH, Stuttgart, Germany), for example.[16] An alternative formula for posterior chamber phakic IOLs is as follows:[17]

Formula No. 4:

$$IOL = \frac{1336}{\frac{1336}{K+ECL} - T - ACD - 0.1} - \frac{1336}{\frac{1336}{K - T - ACD - 0.1}}$$

With this formula, T = corneal thickness in millimeters; ACD = anterior chamber depth in millimeters; ECL = equivalent contact lens power at the corneal level.

Calculating phakic IOL power using these formulas provides good postoperative refractive results, assuming the initial measurements were performed correctly.[15-17] The other important factor that must be taken into account when selecting phakic IOLs, however, is sizing.

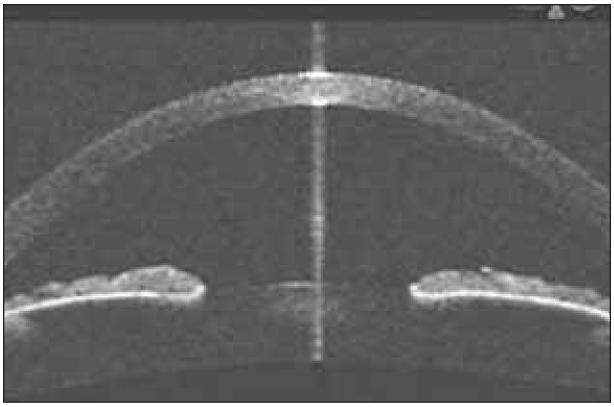

Figure 2. An image of the anterior chamber taken with optical coherence tomography.

ACCURATE SIZING: MEASURING DIMENSIONS

Not all phakic IOLs require sizing; the Artisan lens notably has a one-size-fits-all configuration. The white-to-white (WTW) distance, or the horizontal corneal diameter, is traditionally used to calculate the lens size by simply measuring at the slit lamp and adding 0.5 mm to the result.[6] This is not a very scientific method of calculating accurate size, however. According to one report, for an average European with a WTW distance of 11.7 mm, the angle-to-angle (ATA) distance is 11.9 mm, and the sulcus-to-sulcus (STS) measurement is 11.2 mm.[18] Additionally, the limbal area has a transition zone of grey tissue that results in interobserver bias in performing these measurements. In an attempt to overcome this difficulty, the IOLMaster (Carl Zeiss Meditec, Jena, Germany) or Orbscan II (Bausch + Lomb, Rochester, New York) can be used to measure the WTW distance more accurately, although this does not overcome the difficulty of predicting ATA or STS diameters from this value.

Anterior segment optical coherence tomography (OCT) technology, such as with the Visante OCT (Carl Zeiss Meditec), is an effective technology to aid accurate phakic IOL sizing by directly measuring the ATA distance (Figure 2). Unfortunately, due to retroiridial shadowing, it is not similarly effective for measuring the STS for posterior chamber phakic IOLs. Instead, very high-frequency ultrasound biomicroscopy (UBM) can be used to measure these distances directly. The first generation of UBM systems, such as the Eye Cubed (Ellex, Adelaide, Australia) used frequencies of 50 and 20 MHz to provide image resolution of approximately 30 and 75 µm, respectively,[6] but the whole angle and sulcus complex could not be measured in one scan; multiple scans pasted together were used to

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obtain images and measurements of the whole complex. Subsequently, the Artemis 2 (Ultralink, St. Petersburg, Florida) was developed, in which a computer-controlled 50-MHz UBM scan travels around the circumference of the cornea, permitting 3-D images to be reconstructed from the data.[6,19] No statistically significant differences were found in comparison of measurements taken with the Visante OCT and the Artemis 2.20.

Computer algorithm software has also been developed, such as the Lovisolo-Calossi Phakic IOL Sizing Software, which uses information including radius of curvature of the crystalline lens to predict the correct size of the lens required.[6]

Accurate sizing is particularly important for posterior chamber phakic IOLs because, if the STS diameter is overestimated and a larger phakic IOL is inserted, vaulting of the lens can occur, resulting in angle narrowing and pigment dispersion. Conversely, if the size of the phakic IOL is too small because the STS was underestimated, the phakic IOL may rotate, inducing an anterior subcapsular cataract.[19]

CONCLUSION

Lens sizing and IOL power selection, together with patient selection, are by far the most important factors for achieving success with phakic IOLs. If these choices have been made correctly, more often than not the battle is won before the patient has even entered the operating room.

It must be noted that the data available in making these assessments are mostly from follow-up periods of less than 10 years. Lens technology is changing all the time, and the patients requesting this surgery are usually young, with a lifetime ahead of them in which any number of problems may come to light. Even with this in mind, the ingenuity with which previous problems have been recognized and solved should be appreciated, and it appears that phakic IOLs have a bright future as an essential part of every ophthalmologist's armory in the fight against the global increase in refractive error. ■

TAKE-HOME MESSAGE

- Phakic IOL lens power can be calculated based on preoperative refraction, corneal power, and vertex distance.
- The size of the phakic IOL must also be considered, particulary for posterior chamber phakic IOLs.
- Computer algorithm software is being developed to predict the correct lens size.

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