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Intraocular lens power calculations in eyes with previous corneal refractive surgery: Challenges, approaches, and outcomes

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Abstract:

In eyes with previous corneal refractive surgery, difficulties in accurately determining corneal refractive power and in predicting the effective lens position create challenges in intraocular lens (IOL) power calculations. There are three categories of methods proposed based on the use of historical data acquired prior to the corneal refractive surgery. The American Society of Cataract and Refractive Surgery postrefractive IOL calculator incorporates many commonly used methods. Accuracy of refractive prediction errors within ± 0.5 D is achieved in 0% to 85% of eyes with previous myopic LASIK/photorefractive keratectomy (PRK), 38.1% to 71.9% of eyes with prior hyperopic LASIK/PRK, and 29% to 87.5% of eyes with previous radial keratotomy. IOLs with negative spherical aberration (SA) may reduce the positive corneal SA induced by myopic correction, and IOLs with zero SA best match corneal SA in eyes with prior hyperopic correction. Toric, extended-depth-of-focus, and multifocal IOLs may provide excellent outcomes in selected cases that meet certain corneal topographic criteria. Further advances are needed to improve the accuracy of IOL power calculation in eyes with previous corneal refractive surgery.

Keywords:

Corneal refractive surgery, intraocular lens power calculation, LASIK, photorefractive keratectomy, radial keratotomy, small-incision lenticule extraction

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Introduction

Accurate intraocular lens (IOL) power calculation is a crucial element for meeting the ever-increasing expectations of patients undergoing cataract surgery. Despite advances in ocular biometry measurements and IOL calculation formulas, accurate IOL power calculation is still challenging in eyes that have undergone laser *in-situ* keratomileusis (LASIK), excimer laser photorefractive keratectomy (PRK), or radial keratotomy (RK).

Since 2011, more than 1.5 million small-incision lenticule extraction (SMILE) procedures are being performed worldwide. Although refractive outcomes of cataract surgery following SMILE have not been published yet in the peer-reviewed literature, we do expect that IOL power calculation in post-SMILE eyes will become a common challenge for ophthalmologists in the near future. In 884 eyes that underwent either FS-LASIK or SMILE, Gyldenkerne *et al*.[1] reported that the anterior corneal surface in the central 2.00-mm zone is steeper in post-SMILE corneas but flatter in the corneal periphery as compared with that of FS-LASIK. This indicates that SMILE produces different corneal shape changes as compared with those of FS-LASIK.

This review will focus on: (1) the challenges in IOL power calculation in these eyes, (2) approaches that have been proposed

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for IOL power calculation in these eyes, (3) refractive outcomes that we might expect with various methods, and (4) IOL type selection for these eyes.

Challenges in Intraocular Lens Power Calculation

In eyes with previous corneal refractive surgery, difficulty in obtaining accurate corneal refractive power and error in predicting the effective lens position (ELP) primarily contribute to challenges in IOL power calculations.

Difficulty in obtaining accurate corneal refractive power

The following three factors contribute to inaccurate estimation of corneal refractive power.

Standardized refractive index of cornea

Corneal refractive surgery procedures change the relationship between the front and back surfaces of the cornea. Using the Galilei dual Scheimpflug Analyzer (Ziemer Ophthalmic Systems AG, Port, Switzerland), we found that the ratios of posterior/anterior corneal radii of curvatures are 0.816 in normal eyes, 0.765 in myopic LASIK/PRK eyes, and 0.857 in hyperopic LASIK/PRK eyes.[2] In a recent study of 114 RK eyes, using the Avanti anterior-segment optical coherence tomography (OCT, Optovue, Fremont, CA, USA), we found that the ratio of posterior/anterior corneal radii of curvatures was 0.94 (unpublished data). If the standardized value for the refractive index of cornea (1.3375) is used in LASIK, PRK, or RK eyes, the calculated total corneal power from the anterior corneal curvature would be inaccurate.

Changes in posterior corneal curvature

It has been reported that LASIK and PRK procedures induce minimal changes in posterior corneal curvature. However, RK can produce dramatic posterior corneal changes that are hard to measure and that contribute IOL power calculation errors.

Inaccurate measurement of anterior corneal curvature

Standard keratometry readings ignore the central cornea altered by the corneal refractive surgery. Due to the large variation in corneal curvatures within the central area following corneal refractive surgery, it is difficult for the standard keratometry or corneal topography/tomography to measure the anterior corneal curvature accurately.

To overcome the issues of standardized refractive index of cornea and changes in posterior corneal curvature, corneal refractive power can be calculated based on measurements from both anterior and posterior corneal surfaces. With advanced technology, new devices that measure both anterior and posterior corneal surfaces have become available, such as the Scheimpflug and OCT devices. Average values over the central 3–4-mm zone are more accurate than standard keratometry readings. Robust devices are needed to accurately measure the irregular corneas following corneal refractive surgery.

Error in predicting the effective lens position

To predict the ELP, many IOL calculation formulas use corneal power values in their calculations. Following corneal refractive procedures, corneal power is altered, and the predicted ELP is misleading if the altered postoperative corneal power value is used in the ELP calculation. For example, in eyes following myopic LASIK/PRK, the flattened corneal power values cause these formulas to predict a falsely shallow ELP and calculate insufficient IOL power, resulting in a postoperative hyperopic surprise.

To avoid the ELP-related IOL prediction error, Aramberri proposed the double-K method.[3] With the double-K method, the prerefractive surgery corneal power is used to estimate the ELP and the postrefractive surgery corneal power is used to calculate the IOL power. The Holladay Consultant Program previously used this approach. In a previous study,[4] we compared the IOL prediction using the double-K method and standard IOL power calculation formulas. We found that the ELP-related IOL prediction errors are the greatest for SRK/T, followed by Holladay 2, Holladay 1, and Hoffer Q formulas. The ELP-related IOL prediction errors also decrease in long eyes and increase with increasing amount of refractive correction. Studies demonstrated that the double-K method improves the accuracy of IOL power calculation in eyes with previous LASIK/PRK.[3,5,6]

Alternatively, to avoid the ELP-related IOL prediction error, one may use the IOL power calculation formulas that do not use the corneal power values to predict ELP, such as the Haigis-L and Shammas formulas.[7,8]

Methods Proposed for Intraocular Lens Power Calculation in Postrefractive Eyes

To improve the accuracy of IOL power prediction in eyes following corneal refractive surgery, many formulas and approaches have been proposed, which can be categorized into the following three groups of methods based on whether and how they use historical data acquired prior to the corneal refractive surgery.

Methods using historical data completely

Methods in this category solely use historical data to estimate corneal power. Methods in this group include: clinical history method, which was the first approach to be described,[9] Feiz–Mannis IOL power adjustment method,[10] and corneal bypass method.[11]

Theoretically, these methods should be accurate; however, clinical studies have shown that they are less accurate than the formulas in other categories described in the sections below.[12] Historical data are often obtained from outside offices, and it is often difficult to accurately determine when the refraction following the corneal refractive surgery is stabilized prior to cataract development. The limitation with methods in this category is that they are highly sensitive to errors in the historically obtained data. A 1.0-D error in either the keratometric or refractive values translates to approximately a 1.0-D postoperative refractive error.

Methods using a combination of historical data and current data

Several methods use a combination of the surgically induced refractive change and current corneal power measurements. They modify either corneal power values measured at the time the patient presents for cataract surgery or calculated IOL power based on refractive change induced by the LASIK/PRK surgery.

Methods modifying corneal power values

Based on the surgically induced refractive change, several methods have been proposed to modify the corneal power values obtained from different corneal topographers. These methods include the Adjusted EyeSys EffRP (EyeSys Vision, Houston, TX, USA), Adjusted Atlas Ring Values and Adjusted Atlas Zone Value (Atlas 9000 topographer, Carl Zeiss Meditec AG, Germany), and Adjusted ACCP (Topographic Modeling System, Tomey Corp., Phoenix, AZ, USA).[6,13] The Barrett True-K formula also uses the current corneal power values obtained from ocular biometers and surgically induced refractive change. This formula is not published, and it is not clear how the amount of refractive change is used.

Methods modifying intraocular lens power

The Masket formula calculates the IOL power using the current corneal power value first, and then the calculated IOL power is adjusted by 32.6% of the surgically induced refractive change.[14] The Modified Masket formula is a formula modified by Dr. Warren Hill based on the Masket formula.

Methods using a combination of historical data and current corneal power values multiply the surgically induced refractive change by a fraction of between 0.15 and 0.33, depending on the formula. This indicates that 1.0 D of error in the estimation of surgically induced refractive change produces 0.15–0.33 D of error in postoperative refraction, reducing potential errors caused by having inaccurate historical data. Studies have shown that some of these methods have consistently been among the more accurate approaches.[15]

Methods using no historical data

Surgeons most often are required to use only methods requiring no historical data, because the majority of patients do not have historical data available. Methods requiring no historical data fall into the following two categories, depending on whether they use anterior corneal power measurements alone or both measured anterior and posterior corneal values.

Formulas Using Anterior Corneal Measurement

Based on either regression analysis or assumed posterior corneal power, methods adjust measured corneal power from the anterior corneal surface.

- Wang–Koch–Maloney: Using this method,[6] the Atlas 4-mm zone value obtained from the Atlas topographer is converted to anterior corneal power by multiplying it by 376.0/337.5, or 1.114. Then, an assumed posterior corneal power of 5.59 D is subtracted from the anterior corneal power to estimate the post-LASIK/PRK corneal power. IOL power is then calculated using the Shammas-PL formula[8]
- Shammas method: To estimate the post-LASIK/PRK corneal power, based on regression analysis, this method adjusts the measured post-LASIK/PRK keratometry readings.[8] IOL power is then calculated using the Shammas-PL formula
- Haigis-L: Based on the corneal powers calculated from the historical method, this formula uses a regression equation to modify the post-LASIK corneal radius of curvature obtained from the IOLMaster or other biometer. IOL power is then calculated using the Haigis formula[7]
- Potvin–Hill Pentacam: Using regression analysis, this method estimates the post-LASIK/PRK corneal power using the TNP_Apex_Zone40 value from the Pentacam, axial length, and anterior chamber depth value.[16] For IOL power calculation, the Shammas-PL formula is used
- Barrett True K No History: This is a modified version of the Barrett True K formula when the amount of refractive correction is not available. For IOL power calculation, the Barrett Universal II formula is used. Details regarding the Barrett True-K and Universal II formulas are not published.

Formulas Using Both Anterior and Posterior Corneal Measurements

- OCT-based IOL calculation formula: The OCT-based IOL calculation formula was developed by Tang *et al*.[17] using the RTVue (Optovue Inc., Fremont, CA, USA). Based on the anterior and posterior corneal powers and the central corneal thickness, net corneal power is calculated using the Gaussian thick lens formula. Then, the net corneal power is converted to an effective corneal power based on linear regression analysis for IOL power calculation. The IOL power is then calculated using the vergence formula

- Total keratometry: The total keratometry from the IOLMaster 700 (Carl Zeiss Meditec AG, Jena, Germany) is a new measurement that combines telecentric keratometry and swept OCT technology for the assessment of anterior and posterior corneal curvatures[18]
- Ray tracing formula: The Okulix is a program package that calculates single rays using Snell's law software (Tedics Peric and Jöher GbR, Dortmund, Germany). The axial length value can be entered either manually or by a computer linked to the measuring device. As an alternative to entering corneal radii by hand, they can also be taken from a two-dimensional corneal topographic map.

Web-based postrefractive intraocular lens calculator

In order to simplify the complicated and time-consuming calculations discussed above, we developed a web-based postrefractive IOL power calculator in 2007 [Figure 1]. It is accessible from the American Society of Cataract and Refractive Surgery (ASCRS) website (www.ascrs.org). The calculator includes three modules for eyes with previous myopic LASIK/PRK, hyperopic LASIK/PRK, or RK.[15] For eyes with previous myopic or hyperopic LASIK/PRK, the various calculation methods available are categorized into the following two groups: (1) methods using refractive changes induced by LASIK/PRK and corneal measurements at the time of cataract surgery, and (2) methods using no prior data. Pop-up windows are included to explain each method in detail. The calculator is updated regularly and has over a million usages per year.

Dr. Graham Barrett from Australia developed the Barrett True K and Barrett True K No History formulas. These formulas are accessible from the Asia-Pacific Association of Cataract and Refractive Surgeons website (www.apacrs.org) and some ocular biometers. These formulas are also included in the ASCRS postrefractive IOL calculator at ascrs.org.

Intraoperative wavefront aberrometry

The Optiwave Refractive Analysis (ORA, Alcon Lab, Fort Worth, TX, USA) is an intraoperative wavefront aberrometer developed to calculate IOL power based on aphakic refraction obtained intraoperatively, after the cataract has been removed.[19] Based on the aphakic spherical equivalent and the axial length, keratometry, and corneal diameter measured preoperatively, the ORA system calculates the optimal IOL power using infrared light and Talbot–Moiré interferometry. A proprietary algorithm is used to estimate ELP.

Postoperative intraocular lens adjustment

The light-adjustable lens (LAL; RxSight, Inc., Pasadena, CA, USA) is the first US Food and Drug Administration (FDA)-approved IOL that can be customized after cataract surgery. After the postoperative refraction has stabilized, the LAL enables residual spherical and cylindrical errors to be corrected or adjusted.[20-22] When the LAL is exposed to the targeted ultraviolet light, a photoinitiator is activated, resulting in selective polymerization of macromers in the lens. The unpolymerized macromers then diffuse to the treated area, producing a predictable shape change that alters the refractive power of the lens. Once the targeted refraction is achieved, the shape of the lens is locked in by irradiating.[20]

Perfect Lens (Perfect Lens, LLC, Irvine, CA, USA) is another technology under development for IOL power modification *in situ*.[23] With this technology, a

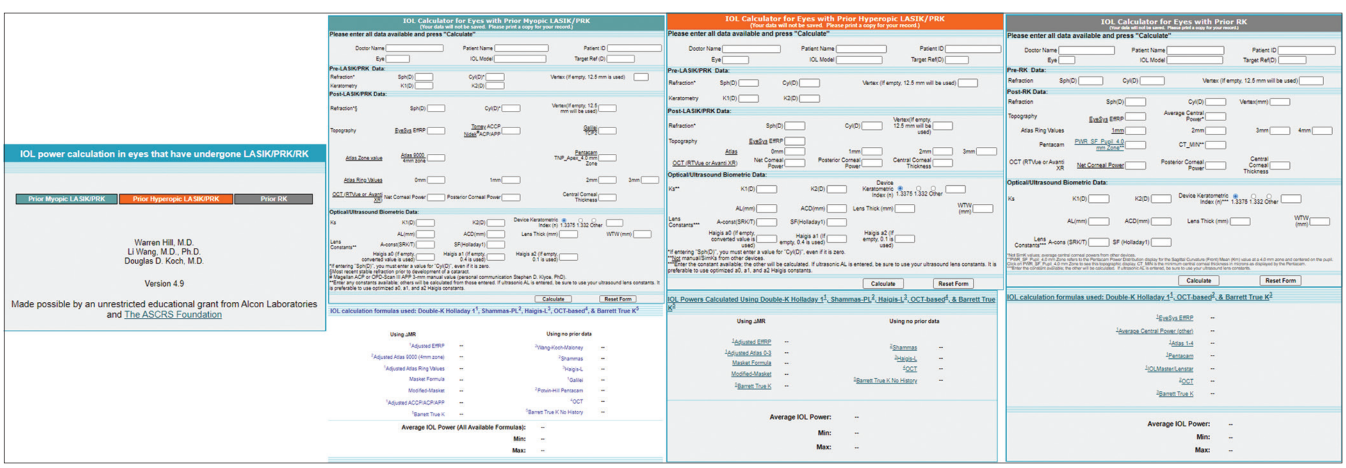

Figure 1: Postrefractive intraocular lens calculator at the American Society of Cataract and refractive surgery (www.ascrs.org)

femtosecond laser is used to increase the hydrophilicity and thus the refractive index and refractive characteristics of defined zones within a standard IOL. The lens utilizes a phase-wrapping technique for power adjustment, which is based on a theoretically perfect Fresnel lens. Using the femtosecond laser, spherical power, asphericity, toricity, and multifocality are modified by changing the relative heights and profiles of the concentric refractive zones.

Another company named Clerio (Clerio Vision, Rochester, NY, USA) is also working on the technology of laser-induced refractive index correction. This technology is investigated on altering contact lenses, corneal power, and IOL power.

Outcomes Achievable with Current Approaches

Myopic-LASIK/photorefractive keratectomy eyes

Various studies have reported wide ranges of outcomes.[16-18,24-43] The key outcomes are summarized as follows:

- The best outcomes in most studies do not exceed 85% accuracy of refractive prediction errors within ± 0.5 D of the target refraction and usually are below 75%
- Using the ASCRS postrefractive IOL calculator, methods using a combination of historical and current data reported accuracy within ± 0.5 D of the target refraction in 52%–85% of eyes, methods using no prior data produced accuracy of 43.1% to 85%, and the average value yielded an accuracy of 45% to 72%
- The total keratometry from IOLMaster 700 produced 57%–75% of eyes within ± 0.50 of target refraction. Using the OKULIX ray tracing, 41.7% of eyes had refractive prediction error within ± 0.5 D.

Hyperopic-LASIK/photorefractive keratectomy eyes

In general, accuracy of the IOL formulas for posthyperopic LASIK/PRK eyes tend to be slightly lower than that for postmyopic LASIK/PRK eyes, with none reaching 80% with 0.5 D of the target.[18,44-48] The key outcomes are summarized as follows:

- Using the ASCRS postrefractive IOL calculator, methods using a combination of surgically induced changes in refraction and current measurements produced accuracy of prediction errors ± 0.5 D in 47.6%–71.9% of eyes, methods using no prior data yielded accuracy of 38.1%–73.4%, and the average value produced an accuracy of 47.6%–66.7%
- Using the total keratometry values from the IOLMaster 700, standard Haigis, Barrett True K No History, and Haigis-L formulas produced 56.3%, 50.0%, and 46.9% of eyes within ± 0.50 of target refraction, respectively.

Radial keratotomy eyes

In post-RK eyes, lower accuracy was reported compared to eyes following myopic or hyperopic LASIK/PRK.[48-54] The key outcomes are summarized as follows:

- Using the ASCRS postrefractive IOL calculator, the percentage of eyes within 0.5 D of target ranged from 29% to 62%
- The Barrett True K[History], True K[Partial History], and True K[No History] produced 76.6%, 75%, and 69.2% of eyes within ± 0.5 D of refractive prediction error, respectively
- The Haigis, double-K Holladay 1, and Potvin–Hill methods produced 37% to 69.2% of eyes within ± 0.5 D of the target refraction.

Small-incision lenticule extraction eyes

In the peer-reviewed literature, there are no studies reporting refractive outcomes and IOL power calculation accuracy in eyes with previous SMILE and subsequent cataract surgery. We are aware of two studies in which the accuracy of theoretical IOL power calculations was assessed using the SMILE-induced refractive changes as the gold standard:

- In 204 eyes that underwent myopic SMILE, Lazaridis *et al*.[55] evaluated the predictability of IOL power calculation by comparing the changes in spherical equivalent induced by SMILE and the differences in predicted refraction with virtual implantation of the same IOL before and 3 months after the SMILE. They investigated the ray tracing (OKULIX) program, Haigis-L, and a few standard IOL power calculation formulas for normal eyes without prior corneal refractive surgery. The percentages of eyes within 0.5 D of the target refraction were 81.9% using ray tracing, 53.4% using Haigis-L, 35.3% using Haigis, 25.5% using Hoffer Q, 6.4% using Holladay 1, and 2.9% using SRK/T formula
- In another study of 54 eyes that underwent myopic SMILE, based on ocular biometric measurements before and 6 months after SMILE, Zhu *et al*.[56] compared the prediction accuracy of Barrett True-K, Holladay 1, Haigis, and SRK/T formulas. The percentages of eyes within 0.5 D of target refraction were 81.5%–88.9% using Barrett True-K, 7.4%–40.7% using Holladay 1, 44.4%–85.2% using Haigis, and 7.4%–33.3% using SRK/T.

Intraoperative wavefront aberrometry

- In 246 myopic LASIK/PRK eyes, Ianchulev *et al*.[19] reported that ORA achieved an accuracy of ± 0.5 D in 67%
- Fram *et al*.[26] reported that the ORA produced 74% to 75% of eyes with refractive prediction errors within ± 0.5.

Postoperative intraocular lens adjustment

- Light-adjustable lens: Excellent refractive accuracy was achieved with the light-adjustable lens in patients with a history of myopic LASIK or PRK. In 34 eyes of 21 cataract patients with previous myopic corneal refractive surgery, Brierley *et al*.[22] reported 74% of eyes within ±0.25 D of target, 97% of eyes within ± 0.50 D, and 100% within ±1.00 D.
- Refractive index modification: Sahler *et al*.[23] investigated *in vitro* the effectiveness of the Perfect Lens technology to create a refractive index change within a standard IOL (EC-1Y, Aaren Scientific, Inc., Ontario, CA, USA). They reported that the technology altered the power of the IOL to within ± 0.1 D of the targeted change without decreasing the optical quality of the lens. Using a femtosecond laser, Nguyen *et al*.[57] performed *in vitro* evaluation of power change in a commercially available hydrophobic acrylic blue-light-filtering IOL. They found an accurate change in dioptric power of within 0.1 D of the target without significantly affecting the optical quality of the IOL.

Intraocular Lens Type Selection

Aspheric intraocular lens

In normal unoperated corneas, corneal spherical aberration (SA) has been reported at an average of +0.28 μm for a 6.0-mm pupil.[58] To compensate for the inherent positive corneal SA in normal eyes, aspheric IOLs have been designed.

Myopic corneal refractive procedures

To correct or reduce myopia, corneal refractive procedures, such as LASIK, PRK, SMILE, and RK, flatten the central cornea and increase the positive corneal SA. The magnitude of increase in SA tends to increase with increasing amounts of myopic correction.[59] IOLs with negative SA can be used in these eyes to reduce the ocular SA.

Fernández-Vega *et al*.[60] found superior contrast sensitivity in eyes implanted with multifocal IOLs with negative asphericity, compared to another model with positive asphericity. Alfonso *et al*.[61] reported that aspherical multifocal IOLs produced better intermediate visual acuity than spherical multifocal IOLs.

Hyperopic corneal refractive procedures

Hyperopic corneal refractive procedures steepen the central cornea and induce a negative shift in corneal SA. The magnitude of decrease in SA is significantly correlated with increasing amounts of hyperopic correction.[62] In a previous study,[63] we found that there is a wide range of corneal SA values in eyes following hyperopic LASIK. The mean SA in these corneas was −0.114 μm, and the median value of optimal IOL SA was approximately 0.00 μm for a 6.0-mm pupil with defocus of 0.00 D. Therefore, as a general rule, we recommend IOLs with zero SA in these eyes.

Toric intraocular lens

In eyes with previous corneal refractive surgery, toric IOLs are effective to correct preexisting corneal astigmatism in selected cases. In our experience, ideal candidates for recommending toric IOL implantation are as follows: (1) regular bow-tie corneal astigmatism within the central 3-mm zone, (2) difference of ≤0.75 D in corneal astigmatism magnitude between two ocular biometers, and (3) difference of ≤15° in the astigmatism meridians from 2 biometers.

In 12 eyes with previous myopic LASIK and 3 eyes with hyperopic LASIK, Yesilirmak *et al*.[64] reported that 47% of eyes had postoperative astigmatism ≤0.50 D. We have reported outcomes in postrefractive eyes that meet the three criteria noted above:

- In 56 eyes with previous myopic LASIK/PRK and 19 eyes with previous hyperopic LASIK/PRK,[65] we found that 80% and 84% of eyes had postoperative refractive astigmatism of ≤0.50 D, respectively.
- In 40 eyes with previous RK, 73% of eyes had postoperative refractive astigmatism of ≤0.50 D.[66]

Multifocal and extended-depth-of-focus intraocular lens

Many studies have reported outcomes of multifocal or extended-depth-of-focus (EDOF) IOLs implanted in eyes with previous corneal refractive surgery.[67-72] A major limitations in interpreting the outcomes of all these otherwise excellent studies is that corneal topographic criteria for implantation of multifocal or EDOF IOLs were not specified. The key findings are summarized as follows:

Multifocal intraocular lens

- In post-LASIK/PRK eyes, all studies reported good corrected visual acuities, high patient satisfaction, and no explantations for poor quality of vision; 4% to 42.9% of eyes required corneal laser enhancement to treat postoperative ametropia.
- In 17 post-RK eyes, at 6 months postoperatively, 35.29% and 52.94% of eyes had distance-corrected visual acuity (DCVA) of ≥20/20 and ≥20/25, respectively; 29.41% and 64.71% of eyes had distance-corrected near-visual acuity of ≥20/20 and ≥20/25, respectively; 52.94% had lost one line of DCVA; and 29% of eyes were within ± 0.50 D of the target refraction.[73] The authors thus conclude that multifocal IOL implantation following RK did not result in good visual outcomes.

Extended-depth-of-focus intraocular lens

- In 187 virgin eyes and 28 eyes with prior refractive surgery, 79% and 77% of eyes had a refractive error within ± 0.5 D, 56.8% and 28.6% (P = 0.01) achieved 20/20 uncorrected distance visual acuity (UDVA), 79.5% and 85.7% of eyes had UDVA of ≥20/25, and 4.8% and 3.6% required refractive surgery enhancement.[78] There was no significant difference between the virgin and postrefractive eye groups in the postoperative subjective visual function score
- In 71 eyes with previous myopic LASIK, 61.6% of eyes had postoperative refraction within ± 0.5 D[74]
- In patients with previous myopic LASIK, Ferreira *et al*.[75] compared the clinical outcomes with implantation of a monofocal or an EDOF IOL. They found that the EDOF IOLs provided visual quality comparable to those achieved with the monofocal IOL.

Small-aperture intraocular lens

Small-aperture optics offer a new approach to reduce the optical impact of ametropia and higher-order aberrations. Ang[76] reported that both contralateral and bilateral implantation of an IC-8 IOL (Acufocus, Irvine, CA, USA) in normal eyes provide excellent visual acuity across all distances, and bilateral implantation can be successful based on careful patient selection and optimization of refractive targets.

In 17 eyes with severe corneal irregularities due to keratoconus, previous penetrating keratoplasty, RK, or scarring after ocular trauma, at 3 months following the IC-8 implantation, Shajari *et al*.[77] reported that uncorrected distance, intermediate, and near visual acuity improved significantly, and the overall life quality analyses reported less difficulty with activities under reduced optical phenomena conditions.

Barnett *et al*.[78] reported a case of implantation of the IC-8 IOL in the nondominant eye of a patient with bilateral previous RK. The dominant eye had a monofocal IOL. For the nondominant eye, an IC-8 with the highest available power was used, and then a planned secondary piggyback sulcus IOL implantation was performed to achieve the expected residual refractive error. Postoperatively, the UDVA was − 0.10 logMAR in both eyes, and the patient did not require spectacles for near, intermediate, or distance vision.

Conclusions

In eyes with previous corneal refractive surgery, challenges in IOL power calculations are primarily contributed by difficulties in obtaining accurate corneal refractive power and in predicting the ELP. To improve the accuracy of IOL power calculation in these eyes, many formulas and approaches have been proposed. The ASCRS postrefractive IOL power calculator is a helpful tool that incorporates many commonly used methods (www.ascrs.org). The number of visits to this calculator is over a million per year, and we continually update this calculator as more accurate formulas emerge.

Despite the wide range of approaches and formulas, IOL power calculations are less accurate in these eyes compared to eyes with virgin corneas. Best outcomes in most studies do not exceed 85% accuracy within ± 0.5 D of target refraction, and most are below 75%. It is more difficult in RK eyes due to the anterior and posterior corneal irregularities induced by the RK incisions and the hyperopic shift over time. Our recommendation is to obtain IOL calculations using as many approaches as possible and select the IOL power based on the consensus of multiple methods. We place more weight on the newer formulas, such as the Barrett True K No History and OCT-based IOL formulas. Careful patient consultation is advisable to warn patients of the lower accuracy of IOL power calculations.

We use IOLs with negative SA in eyes with previous myopic corneal refractive surgery and IOLs with zero SA in eyes with prior hyperopic refractive procedures. Our study demonstrates that toric IOLs are effective in correcting preexisting corneal astigmatism in selected eyes that meet the three criteria noted above. Studies have reported that implantation of multifocal IOLs and EDOF IOLs can have successful outcomes in patients with prior corneal refractive surgery. We consider EDOF IOLs primarily for eyes whose corneas have variation of <1 D in corneal power along meridians within the central 3-mm zone on the axial topographic map.

Advances in this area are crucial for meeting the increasing expectations of these patients undergoing cataract surgery. The Holy Grail might be the postoperative adjustable IOLs, which show promise and could become a standard option as these technologies advance.

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Conflicts of interest

Dr. Wang is a consultant for Carl Zeiss Meditec and Alcon Laboratories. Dr. Koch is a consultant for Alcon, Carl Zeiss Meditec, and Johnson and Johnson Vision.

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