



Intraocular Lens Calculation for Phacoemulsification in Eyes with Previous Corneal Refractive Surgeries

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ABSTRACT:

Background: This review addresses the complexities of intraocular lens (IOL) power calculation for phacoemulsification procedures in patients with a history of corneal refractive surgery and evaluates available methodologies to improve calculation accuracy.

Review: During phacoemulsification with IOL implantation in eyes previously treated with LASIK, PRK, or RK, refractive surprises frequently occur due to three key factors: i) the modified anterior-posterior corneal surface relationship renders conventional keratometric indices unreliable; ii) corneal curvature measurements are obtained outside the central optical zone; and iii) effective lens position estimation becomes compromised when based on post-refractive surgery corneal parameters. Several computational methods are currently available to achieve superior refractive outcomes during phacoemulsification in these challenging cases, even without access to preoperative corneal data (such as original corneal power values and surgically induced refractive changes). This review details the most accurate calculation techniques validated through our clinical studies.

Conclusions: IOL power determination for phacoemulsification in eyes with prior myopic corneal refractive surgery can be successfully performed using various computational approaches that provide reasonably accurate results, with 60-70% of cases achieving prediction errors within 0.50 diopters.

1. Introduction

IOL Power Calculation After Corneal Refractive Surgery

Background

Determining intraocular lens (IOL) power for phacoemulsification procedures in eyes that have undergone previous corneal refractive surgery is one of the most difficult challenges faced by ophthalmologists worldwide. Even in healthy eyes receiving standard phacoemulsification, IOL power calculations can be inaccurate. Around 20-25% of these cases have refractive

prediction errors greater than 0.5 diopters (D) despite using modern formulas and advanced biometric instruments [1]. The margin of error increases significantly when phacoemulsification is done on corneas that have had any form of refractive surgery, especially when traditional IOL calculation methods are used [2].

Over the last 15 years, extensive research by various investigators has led to the creation of more than 30 different methods to tackle this computational challenge. Recent clinical studies show that successful refractive outcomes can be achieved during phacoemulsification



when the right calculation techniques are used [3]. The difficulty of stabilizing refractive error after phacoemulsification cataract surgery and understanding the preoperative factors involved has been studied in depth. This highlights the importance of using proper IOL power calculation methods [1,9].

This review aims to: 1) clarify the specific reasons why IOL power calculation for phacoemulsification becomes complicated after corneal refractive surgery, and 2) suggest the calculation methods that have shown the highest accuracy for phacoemulsification in eyes that have had refractive surgery.

Why does IOL power calculation for phacoemulsification present difficulties after corneal refractive surgery?

Excimer laser procedures

Patients preparing for phacoemulsification with a history of photorefractive keratectomy (PRK) or laser in situ keratomileusis (LASIK) face three main challenges in determining accurate IOL power. The first issue, known as the "keratometric index error" [2, 3], occurs when keratometric instruments and corneal topography devices cannot provide the precise diopter measurements needed for IOL power formulas during phacoemulsification planning. This problem arises because these devices use a fixed, artificial keratometric index of refraction (usually 1.3375) to convert measured anterior corneal radius into keratometric diopters, based on the paraxial formula:

$$P = (n-1)/r$$

where P represents corneal power (in D), n is the keratometric index of refraction, and r is the anterior corneal surface curvature radius (in meters). This conventional value of 1.3375, established in the 1800s, was set so that a 7.5 mm corneal radius would equal 45 D of corneal power [6].

For planning phacoemulsification, keratometric devices assess anterior corneal curvature while the keratometric index acts as a theoretical single refractive element simulating both corneal surfaces. This setup assumes a steady anterior-to-posterior corneal curvature relationship. While this assumption holds true for normal eyes undergoing standard phacoemulsification, refractive surgery changes anterior corneal shape while

keeping the posterior surface intact. This disrupts the balance and weakens the conventional keratometric index for phacoemulsification calculations [2].

As a result, after myopic treatments, keratometric measurements often overestimate corneal power, which leads to underestimating IOL power during phacoemulsification planning and results in postoperative hyperopia [2,6,7,8]. Conversely, after hyperopic treatments, corneal power is underestimated, leading to overestimated IOL power calculations and a risk of postoperative myopia [11]. Generally, larger refractive corrections result in greater calculation errors in phacoemulsification planning.

Research indicates that after myopic excimer surgeries, the keratometric index should be reduced based on the magnitude of correction to achieve accurate corneal power measurements for IOL calculations [6]. This keratometric index issue can also be addressed by measuring both corneal surfaces using advanced imaging techniques such as Scheimpflug technology or optical coherence tomography, though this requires specially calibrated formula constants for phacoemulsification.

The second complication, referred to as "radius error" or "instrument error" [2, 3], arises because most instruments estimate central corneal curvature through paracentral measurements. After myopic ablations, these devices may report steeper central curvatures than what actually exists, which negatively affects phacoemulsification IOL calculations. Various researchers have found that central corneal curvature measurements more accurately reflect surgical refractive changes [2]. They suggest using central topographic values instead of simulated keratometry (SimK) for corneal power calculations in post-excimer phacoemulsification [8]. This consideration is especially important for small or off-center treatments, where curvature measurements may lie outside the treatment zone and differ from visual axis measurements. When optical zones are 6 mm or larger, radius error is less significant for phacoemulsification calculations [2].

The third complication concerns third-generation IOL formulas (Hoffer Q, Holladay 1, and SRK/T) that use corneal power to predict effective lens position (ELP) in phacoemulsification planning. Following myopic LASIK or PRK, lower postoperative corneal power leads to ELP underestimation, which compounds IOL power



underestimation in the calculations. Hyperopic surgery creates the opposite issue. Dr. Jaime Aramberry addressed this by developing the Double-K methodology, which uses dual K-values for phacoemulsification IOL calculations: pre-surgical K for ELP determination and post-surgical K for the vergence formula that establishes the final IOL power [2]. Some formulas, like Haigis', do not face this complication as they calculate ELP independently of corneal power in phacoemulsification planning [3].

A potential fourth complication is the changes in corneal asphericity caused by laser ablation. Since corneal asphericity impacts IOL calculations in untreated eyes [3], this factor likely becomes more significant after excimer procedures for phacoemulsification planning, although limited research exists on this topic.

Incisional procedures

Incisional approaches like radial keratotomy (RK) preserve corneal tissue. Traditionally, it was understood that RK creates similar flattening across both corneal surfaces. This was thought to maintain the keratometric index validity (1.3375) for phacoemulsification calculations [2]. However, Scheimpflug imaging has shown that after RK, the posterior surface flattens more than the anterior surface. This reduces the accuracy of the keratometric index for phacoemulsification IOL calculations [2]. Additionally, the typically narrow (3.0 mm) optical zones increase the chance of radius error in phacoemulsification planning. This can lead to overestimating corneal power, underestimating IOL power, and causing hyperopic outcomes [2].

Moreover, unpredictability in calculations after RK may worsen due to corneal structure changes that happen after incisional procedures. Phacoemulsification techniques can temporarily disturb keratorefractive incisions, bringing back immediate post-keratorefractive conditions [2]. This instability may increase central flattening and peripheral steepening. While these conditions usually stabilize, sometimes they result in ongoing flattening that can affect phacoemulsification results.

Methods for IOL Power Calculation in Phacoemulsification Following LASIK and PRK

The growing number of patients who have had LASIK or PRK surgery and now need phacoemulsification, along

with higher refractive expectations, has led to the development of over 30 IOL calculation methods for these cases in the last 15 years [3]. While this wide range of techniques can improve the chances of successful phacoemulsification outcomes, it may also confuse surgeons who are unsure which method to use for their patients. Many comparative studies of these methods [2, 3, 7] have improved our ability to recommend the best techniques for individual phacoemulsification patients based on available preoperative and postoperative data. After a thorough analysis of the PubMed database, we looked at all publications on IOL power calculation for phacoemulsification following myopic refractive procedures.

Through a series of clinical studies, we found the methods that produced the most accurate results for phacoemulsification procedures [3]. Below is a detailed description of these techniques and their clinical outcomes. Clinical Refractive outcomes of IOL power calculation in eyes with historical data and without historical data were tabulated in **Table no. 1 and Table no. 2.**

When preoperative keratometry and/or refractive change data are accessible

Seitz/Speicher's approach

This methodology depends on preoperative keratometry data and does not require knowledge of the refractive change for phacoemulsification IOL calculations [3,6]. The method assumes that total corneal dioptric power (P), measured through keratometry, can be determined by combining the anterior (Pa) and posterior (Pp) corneal surface powers:

$$P = Pa + Pp = (n2-n1)/r1 + (n3-n2)/r2$$

where n1 represents air's refractive index (= 1), n2 signifies corneal refractive index (= 1.376), and n3 denotes aqueous humor's refractive index (= 1.336). Both before and after surgery, anterior corneal surface power (Pa) can be calculated by multiplying corneal power by 1.114 (equivalent to 376/337.5) for phacoemulsification planning [3]. Therefore:

$$Pa = SimK \times 1.114$$

Understanding anterior corneal surface power enables calculation of posterior corneal surface power (Pp)



before surgery using: $P_p = P_a - P = (\text{SimK} \times 1.114) - \text{SimK}$

Following LASIK or PRK, anterior corneal surface power can be combined with posterior corneal surface power (presumed unchanged) for phacoemulsification IOL calculations: $P = \text{postop } P_a + P_p = \text{postop } \text{SimK} \times 1.114 + (\text{preop } \text{SimK} \times 1.114 - \text{preop } \text{SimK})$

This approach has demonstrated exceptional results when paired with the Double-K SRK/T formula for phacoemulsification procedures [3]. The primary benefit is that it eliminates the need for perioperative refractive data, requiring only preoperative K readings for accurate phacoemulsification IOL calculations.

When preoperative corneal power data is unavailable, this method can still be implemented using Savini's modification, employing a mean value of -4.98 diopters (D) for posterior corneal surface power (Seitz/Speicher/Savini's approach) [3]. In such cases, the unknown preoperative K must still be incorporated into the Double-K formula for phacoemulsification calculations, with several estimation options: using an average value (e.g., 43.50 D), calculating preoperative K by adding refractive change at the corneal plane to modified postoperative K values, or deriving it from posterior corneal surface parameters [3].

Savini's methodology and alternative formulas for keratometric index recalculation

As we discussed earlier, the standard keratometric index of 1.3375, which is used to convert the anterior corneal curvature to diopters, becomes unreliable after LASIK or PRK for phacoemulsification planning. Research shows that this index needs to be reduced in proportion to the increase in myopic correction for accurate phacoemulsification IOL calculations [3]:

$$\text{Post-refractive surgery index of refraction} = 1.338 + 0.0009856 \times \text{SIRC}$$

Where SIRC = surgical induced refractive change.

After calculating the keratometric index, you can find corneal power using $P = (n-1)/R$ for phacoemulsification planning [3]. This method has been shown to be effective when combined with the Double-K SRK/T formula for phacoemulsification procedures [3].

Similar methods have been developed by Camellin and Calossi [6] and others, who created their own formulas for calculating the post-refractive surgery keratometric index (n_{post}) in phacoemulsification calculations:

$$\text{Camellin: } n_{\text{post}} = 1.3319 + 0.00113 \times \text{refractive change [6]}$$

Masket's formula (for eyes with previous myopic and hyperopic treatments)

IOL power for phacoemulsification is first calculated as if the eye had not undergone LASIK or PRK. The IOL power determined using either Single-K SRK/T for myopic cases or Single-K Hoffer Q for hyperopic cases is then adjusted with this formula:

$$\text{IOL power adjustment} = \text{SIRC} \times (-0.326) + 0.101.$$

This calculated value is added to standard IOL power calculations for phacoemulsification patients with prior myopic laser correction. It is subtracted for those with prior hyperopic laser correction [2]. Multiple studies have confirmed this method's accuracy for phacoemulsification procedures, though it may lead to slightly hyperopic outcomes [3].

Barrett True-K formula

The mathematical foundation of this method has not been published. Current knowledge suggests that keratometry is modified, the Barrett Universal II formula is used, and a Double-K solution is applied for phacoemulsification calculations. The refractive change caused by PRK/LASIK is necessary for this version of the formula. However, since it is available on the Asia-Pacific Association of Cataract & Refractive Surgeons (www.apacrs.org) and American Society of Cataract and Refractive Surgery (www.ascrs.org) websites, several studies have shown its reliability in achieving accurate refractive results for phacoemulsification [3]. It is now considered one of the most trustworthy options for phacoemulsification following both myopic and hyperopic PRK/LASIK procedures.

2.Methods

Methods for IOL Power Calculation in Phacoemulsification When Historical Data is Unavailable



Shammas-PL formula

The Shammas-PL method eliminates both keratometric and radius errors by employing posterior corneal curvature measurements to estimate effective lens position for phacoemulsification procedures [3]. Multiple studies have documented favorable outcomes not only in phacoemulsification cases lacking historical data but also in those with available perioperative information [3]. A specialized version (Shammas-PHL formula) has been developed for phacoemulsification in eyes with previous hyperopic LASIK [11]. For these cases, corneal power calculation follows:

$$\text{Corneal power} = 1.0457 \times K_{\text{post}} - 1.9538$$

Maloney's approach

Maloney's technique, as documented by Wang and colleagues in their comparative analysis [8], closely resembles the Seitz/Speicher/Savini method, utilizing a mean value of -4.98 D for posterior corneal power in phacoemulsification calculations [3]. The primary distinction involves topographic value selection, where Maloney's method employs the single power at the axial map center rather than SimK for phacoemulsification planning. Additionally, Maloney utilized a mean power of -4.9D instead of -4.98D.

Consequently, corneal power according to Maloney's method for phacoemulsification reads: $K = \text{measured } K \times 1.114 - 4.90$

Wang et al. recommended using a modified value of -6.1 D for posterior corneal power and subsequently revised it to -5.59 D for phacoemulsification calculations [8].

Haigis-L formula

This formula is included in the IOLMaster (Zeiss, Germany) for planning phacoemulsification. It improves on the standard Haigis formula by predicting the effective lens position (ELP) from the anterior chamber depth instead of preoperative corneal curvature [3]. The Haigis-L formula uses a correlation curve to correct for radius and keratometric index errors in the keratometry module of the IOLMaster for phacoemulsification procedures. The formula offers different corrections for past myopic and hyperopic excimer laser surgery, with excellent outcomes reported [3].

Barrett True-K no history formula

This Barrett formula variant has been specifically developed for phacoemulsification without historical data and is accessible through the same websites as the "historical" version. Although the formula remains unpublished, clinical results for phacoemulsification have been excellent [3].

Gaussian optics formula

The Gaussian optics formula (GOF) calculates total corneal power from both corneal surface curvature radii and their separation distance for phacoemulsification planning. The keratometric index becomes unnecessary. The formula is:

$$P = (n_1 - n_0)/r_1 + (n_2 - n_1)/r_2 - (d/n_1) \times [(n_1 - n_0)/r_1] \times [(n_2 - n_1)/r_2]$$

where:

- n_0 = air refractive index (= 1.000)
- n_1 = corneal refractive index (= 1.376)
- n_2 = aqueous humor refractive index (= 1.336)
- r_1 = anterior corneal surface curvature radius (in meters)
- r_2 = posterior corneal surface curvature radius (in meters)
- d = corneal thickness in meters

Scheimpflug cameras or anterior segment OCT are necessary to measure posterior corneal curvature for phacoemulsification calculations. Studies using these devices show that in unoperated eyes, the GOF provides corneal power that is 1.2 D lower than standard keratometry [3]. This difference requires consistent adjustments when entering GOF-derived corneal power into IOL formulas for phacoemulsification. Once finalized, results are accurate and similar to simulated keratometry in unoperated eyes [3]. Theoretically, similar outcomes should occur in post-LASIK phacoemulsification cases using Double-K formulas or the Haigis formula, although this is not yet proven. To tackle the systematic difference between GOF-calculated and standard keratometric index corneal power, Borasio et al. modified the GOF and created the BESt formula. The authors presented favorable results in their original



manuscript, but no further studies have confirmed its effectiveness for phacoemulsification [3].

Instruments that measure both corneal surface curvatures can determine corneal power through ray-tracing based on Snell's law for phacoemulsification planning. For each corneal map point, the incidence angle is calculated in relation to the anterior surface normal for incoming parallel rays. Snell's law calculates the refraction angle, which establishes the non-parallel direction of incoming rays relative to the posterior surface normal and determines the posterior surface incidence angle. A new refraction angle for the posterior surface is computed using Snell's law. This final refraction angle calculates ray intersection along the (0,0) axis, and the focal length determined from this calculates corneal power for that map point. After LASIK and PRK, corneal power calculated by this method must be entered into Double-K formulas for phacoemulsification. Since ray-tracing corneal power in unoperated eyes is about 0.5 to 0.7 D lower than keratometric index calculations, consistent adjustments are necessary [3].

The Galilei (Ziemer Ophthalmic Systems AG, Port, Switzerland), a dual Scheimpflug analyzer with Placido disc, provides Total Corneal Power. The Pentacam, a rotating Scheimpflug camera, offers Total Corneal Refractive Power. The Sirius (CSO, Firenze, Italy), a rotating Scheimpflug camera with Placido disc topographer, provides Mean Pupil Power. In unoperated eyes, these values have shown accurate refractive outcomes when used in third-generation IOL formulas for phacoemulsification [3]. Data concerning post-refractive surgery phacoemulsification eyes remains limited.

Ray-tracing can also calculate IOL power for phacoemulsification, replacing standard theoretical thin lens formulas. Ray refraction at each optical surface, from tear film to retina, is calculated using Snell's law. After corneal refractive surgery, ray-tracing offers clear advantages for phacoemulsification by avoiding three errors [2]: i) the keratometric index issue, since ray-tracing relies on actual curvature data from both corneal surfaces instead of the keratometric index, ii) the "radius problem," since ray-tracing can be calculated over any corneal diameter, and iii) the formula error, since IOL position can be estimated without depending on anterior corneal curvature. Additionally, all ray-tracing methods

estimate real geometric IOL position instead of ELP, which is a theoretical value related to the IOL's secondary principal plane and cannot be measured.

Ray-tracing requires no historical data and can factor in corneal aberrations for IOL power calculations in phacoemulsification [3]. Several studies have shown promising results with this approach in phacoemulsification after LASIK or PRK [3].

Various commercial solutions are available, such as Okulix and Phaco-Optics, which provide accurate ray-tracing and can be applied to measurements from most devices for phacoemulsification planning. Another noteworthy option is the Sirius instrument's internal software. Each software has its own algorithm for predicting IOL position for phacoemulsification.

The RTVue spectral-domain OCT offers a similar solution, calculating corneal power through the GOF and using a vergence formula for IOL power calculation in phacoemulsification. The vergence formula is similar to ray-tracing but is valid only in the paraxial limit, treating the IOL as a thin lens [3]. ELP prediction is based on a regression formula that uses preoperative measurements of anterior chamber depth, lens thickness, and axial length. For previous LASIK or PRK cases, the OCT net corneal power calculated by the GOF is changed into effective corneal power (ECP), which varies for myopic or hyperopic surgery. Results for phacoemulsification have been encouraging [3].

The aphakic refraction technique was created by Ianchulev and later modified by Mackool for phacoemulsification [2]. In this technique, phacoemulsification is done without IOL insertion. Ianchulev then used a portable autorefractor to evaluate aphakic refraction while the patient stayed reclined on the operating table. Meanwhile, Mackool recommended waiting thirty minutes, then moving the patient to an examination room to measure aphakic refraction. Finally, the patient returned to the operating room for the chosen IOL implantation during phacoemulsification. However, few have used this method.

The formulas for IOL power calculation in phacoemulsification are slightly different:

- IOL power = aphakic refraction (spherical equivalent) \times 2.01449 (Ianchulev)



- IOL power = aphakic refraction (spherical equivalent) × 1.75 (Mackool)

Both authors reported excellent results in small patient groups undergoing phacoemulsification.

Based on the aphakic refraction technique, a specific instrument (Ora System, Alcon, Fort Worth, TX) has been designed to calculate IOL power in the operating room once the crystalline lens has been extracted during phacoemulsification. The Ora System comprises an optical head that attaches directly to the surgical microscope and connects to a computer processor. When the patient is on the table during phacoemulsification, it measures intraoperative wavefront aberrometry and enables real-time IOL power calculations. Favorable results have been recently reported in two series of post-LASIK and post-PRK phacoemulsification cases [2].

IOL Power Calculation Refractive Outcomes

Table 1: Refractive outcomes of IOL power calculation in eyes with historical data

Method	Historical data		N	MedAE (D)	Mean Error (D)*	% < 0.5 D
	K	Rx			Mean ± SD	Range
Awwad [32]	Yes	Yes	30	0.36	-0.38 ± 0.51	-1.27, 0.85
Barrett True-K [33]	No	Yes	58	0.33	-0.01 ± 0.55	-0.96, 1.53
Barrett True-K [34]	No	Yes	28	0.33	0.06 ± 0.98	-2.02, 2.61
Latkany [32]	Yes	Yes	30	0.48	-0.33 ± 0.54	-1.22, 0.73
Masket [32]	Yes	Yes	30	0.34	0.22 ± 0.44	-0.67, 1.11

Method	Historical data		N	MedAE (D)	Mean Error (D)*	% < 0.5 D
Masket [33]	No	Yes	58	0.32	0.29 ± 0.79	-1.26, 1.59
Masket [34]	No	Yes	28	0.32	0.21 ± 1.07	-1.30, 3.61
Masket [30]	Yes	Yes	170	-	0.29 ± 0.79	-3.55, 4.59
Savini [32]	Yes	Yes	30	0.29	-0.01 ± 0.48	-1.03, 1.00
Seitz/Speicher [32]	Yes	Yes	30	0.42	0.14 ± 0.48	-0.94, 0.99

Table 2: Refractive outcomes of IOL power calculation in eyes with no historical data

Method	N	MedAE (D)	Mean Error (D)*	% < 0.5 D
			Mean ± SD	Range
Barrett True-K No-Hx [33]	30	0.41	-0.20 ± 0.64	-1.55, 1.28
Barrett True-K No-Hx [34]	104	0.42	-0.07 ± 0.89	-1.86, 2.65
Haigis-L [30]	170	-	-0.26 ± 1.13	-3.40, 6.34
Haigis-L [33]	58	0.58	-0.34 ± 0.74	-1.65, 2.86
Haigis-L [33]	30	0.62	-0.50 ± 0.65	-1.94, 1.03



Method	N	MedAE (D)	Mean Error (D)*	% < 0.5 D
Haigis-L [34]	104	0.39	-0.07 ± 0.88	-2.15, 2.04
Haigis-L [70]	39	0.26	–	–
OCT [34]	104	0.35	-0.20 ± 0.73	-2.10, 1.33
OCT [70]	39	0.28	–	–
Intraoperative aberrometry [70]	39	0.29	–	–
Ray-tracing [64]	21	0.25	0.13 ± 0.49	-0.85, 1.28
Shammas No-Hx [30]	170	–	-0.10 ± 1.02	-5.42, 6.16
Shammas No-Hx [30]	30	0.53	-0.34 ± 0.72	-1.75, 1.46
Shammas No-Hx [34]	104	0.48	-0.34 ± 0.94	-2.09, 2.99

Abbreviations:

- N = number of eyes
- MedAE = median absolute error
- D = diopters
- K = keratometry data available
- Rx = refractive change data available
- SD = standard deviation
- No-Hx = no history available

*Mean Error: Negative values indicate myopic outcomes, positive values indicate hyperopic outcomes

Expected results and most accurate methods for phacoemulsification

Numerous studies comparing the aforementioned methods demonstrated that all are quite accurate for phacoemulsification [3,13]. Recent advances in artificial intelligence-based IOL power calculation formulas have

shown promising results in predicting outcomes for medium-long Caucasian eyes, potentially improving accuracy in post-refractive surgery cases [13]. In most phacoemulsification cases, 60-70% of eyes can be expected to have an absolute prediction error (PE) within ± 0.5 D; when historical data are lacking, the percentage is slightly lower (50-60%) but increases up to 70% when ray-tracing or intraoperative aberrometry are used for phacoemulsification [3]. These percentages closely match those achieved in unoperated eyes undergoing phacoemulsification [1,9].

The evaluation of reliability of formulas for IOL power calculation after hyperopic refractive surgery has shown that careful formula selection is crucial for optimal outcomes [11]. Additionally, the accuracy of various IOL power calculation formulas in patients with ciliary sulcus implantation has been assessed, providing valuable insights for complex cases [10].

However, it is essential to advise patients that perfection (100% of eyes with PE < 0.50 D) is not possible in phacoemulsification, as they may be accustomed to excimer laser surgery outcomes, which are considerably more accurate than those obtained with IOL power calculation for phacoemulsification [1,9].

Methods for IOL power calculation in phacoemulsification after RK

Fewer methods are available to calculate corneal power in eyes that have undergone RK before phacoemulsification and IOL implantation. If preoperative data and postoperative refraction are known, traditional methods have been used for a long time, but their reliability may be affected by the post-RK hyperopic shift [2].

Using standard keratometric values can lead to underestimating corneal power. This can result in myopic error after IOL implantation during phacoemulsification because the keratometric index (1.3375) changes differently compared to myopic PRK and LASIK [2]. Corneal power underestimation may be balanced by radius error from the small optical zone. To reduce radius error in planning phacoemulsification, it is advisable to discard SimK values and look at more central corneal power measurements, such as the ACCP3mm of the TMS or the Effective Refractive Power (EffRP) shown in the Holladay Diagnostic



Summary of the EyeSis Corneal Analysis System [2]. These values should be used in Double-K formulas to prevent incorrect ELP prediction during phacoemulsification.

Several authors have reported excellent phacoemulsification outcomes by using the EffRP in the Holladay 2 formula [2]. Others achieved similar results by entering the ACCP3mm from TMS corneal topography into the Double-K Holladay 1 formula for phacoemulsification [2]. Alternatively, keratometry readings from the IOLMaster (Carl Zeiss, Jena, Germany), taken over a small diameter (2.5 mm), can be used in the Haigis formula for phacoemulsification, which does not have issues with ELP prediction error. This method has led to good phacoemulsification results [2].

To address both keratometric and radius errors in phacoemulsification, corneal power can be calculated through ray-tracing. However, no studies have confirmed this for phacoemulsification procedures.

When dealing with post-RK eyes and looking at refractive outcomes of IOL power calculation for phacoemulsification, surgeons should also think about ongoing corneal changes and mechanical instability that might impact long-term results. The need for refractive error stabilization after phacoemulsification cataract surgery and its related preoperative factors must be taken into account in these complex situations [1,9].

Special Considerations for Toric IOL Implantation

If astigmatism correction is necessary during phacoemulsification in post-refractive surgery eyes, assessing the postoperative rotation and refractive effectiveness of toric intraocular lenses becomes crucial [12]. The accuracy of IOL power calculation is even more important with toric IOLs because both spherical and cylindrical components must be precisely determined for the best results.

Comparative Analysis of Modern Formulas

Recent studies have shown that newer generation formulas significantly improve IOL power calculation accuracy compared to traditional methods [4,7]. Comparisons of IOL power calculation and refractive outcomes after laser refractive cataract surgery with a femtosecond laser versus conventional

phacoemulsification show promising results, particularly when appropriate calculation methods are used [7].

3. Conclusion

IOL power calculation in eyes with prior corneal refractive surgery remains a complex issue that requires careful consideration of many factors and methods. Choosing the right calculation methods depends on available historical data, the type of previous refractive surgery, and the specific details of each case. With the right method selection and application, excellent refractive outcomes can be achieved in most cases undergoing phacoemulsification after corneal refractive surgery. Ongoing research and development of new calculation methods, including those based on artificial intelligence, promise to further improve accuracy in these challenging cases [13].

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6. Consent for Publication

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