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ORIGINAL RESEARCH

Precision in IOL Calculation for Cataract Patients with Prior History of Combined RK and LASIK Histories

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Purpose: This study aimed to evaluate the accuracy of 12 intraocular lens (IOL) power calculation formulae for eyes that have undergone both radial keratotomy (RK) and laser assisted in situ keratomileusis (LASIK) surgery to determine the efficacy of various IOL calculations for this unique patient group. Currently, research on this surgical topic is limited.

Methods: In this retrospective study, 11 eyes from 7 individuals with a history of RK and LASIK who underwent cataract surgery at Hoopes Vision were analyzed. Preoperative biometric and corneal topographic measurements were performed. Subjective refraction was obtained postoperatively. Twelve different intraocular lens (IOL) power calculations were used: Barrett True K No History, Barrett True K (prior LASIK, Prior RK history), Barrett Universal 2, Camellin-Calossi-Camellin (3C), Double K-Modified Holladay, Haigis-L, Galilei, OCT, PEARL-DGS, Potvin-Hill, Panacea, and Shammas.

Results: The rankings of mean arithmetic error (MAE), from least to greatest, were as follows: 3C (0.088), Haigis-L-L (−0.508), Shammas (−0.516), OCT Average (−0.538), Barrett True K (−0.557), OCT RK (−0.563), Galilei (−0.570), IOL Master (−0.571), OCT LASIK (−0.583), Barrett True K No History (−0.597), Pearl-DGS (−0.606), Potvin-Hill SF (−0.770), Potvin-Hill TNP (−0.778), Panacea (−0.876), and Barrett Universal 2 (−1.522). The 3C formula achieved the greatest percentage of eyes within ±0.25 D of target range (91%), while Haigis-L, Shammas, Galilei, Potvin Hill, Barrett True K, IOL Master, PEARL-DGS, and OCT formulae performed similarly, achieving 45% of eyes within ±0.75D of target refraction.

Conclusion: This study demonstrates the accuracy of the lesser known 3C formula in IOL calculation, particularly for patients who have undergone both RK and LASIK. Well-known formulae, such as Haigis-L, Shammas, and Galilei, which are used by the American Society of Cataract and Refractive Surgery (ASCRS), are viable options, although 3C formulae should be considered in this patient population. Furthermore, larger studies can confirm the best IOL power formulas for post-RK and LASIK cataract patients.

Keywords: radial keratotomy, intraocular lens, laser assisted in situ keratomileusis, IOL power, IOL calculator, Barrett True K No History, Barrett True K, Barrett Universal 2, Camellin-Calossi-Camellin, double K-modified Holladay, Haigis-L, Galilei, OCT, PEARL-DGS, Potvin-Hill, Panacea, Shammas

Introduction

Radial keratotomy (RK) emerged as a prominent refractive surgery technique in the 1980s, primarily for the treatment of myopia. However, the procedure was phased out by the late 1990s due to postoperative complications and safety concerns.[1] Ophthalmologists subsequently witnessed advancements, notably the advent of excimer laser surgeries such as laser assisted in situ keratomileusis (LASIK), which superseded RK in popularity, safety, and efficacy. Many patients with post-refractive effects following surgery seek enhancement LASIK procedures to address residual RK-related refractive error.[2]

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As patients with RK require cataract surgery, surgeons must calculate the appropriate power for intraocular lenses (IOLs). This complication arises because of the distinctive effect of radial corneal incisions from RK, which results in a more pronounced flattening of the anterior corneal curvature than that of the posterior curvature.[3] This difference in curvature commonly overestimates corneal power and consequently contributes to refractive errors in patients.

A range of online IOL calculators have been developed over the past two decades to address this issue. However, these calculators incorporate different refractive indices, resulting in varying IOL powers. Many surgeons have reported the primary challenge of cataract in patients with prior refractive surgery is the appropriate IOL formulae[4] use. In light of the scarcity of studies addressing the accuracy of IOL calculators among cataract patients with both RK and LASIK, our study aimed to evaluate the precision and reliability of various IOL calculators to address this specific cohort of patients. To our knowledge, only two studies have addressed this concern,[5,6] but with a limitation of only using Barrett True K No History and Barrett True K (with Prior RK or LASIK history) formulae. Thus, despite the small sample size, this study – which analyzes 12 online formulae – may provide valuable information regarding refractive care for patients with RK and LASIK. We hope to contribute pivotal insights that will not only enhance the clinical decision-making process for surgeons, but also advance the overall quality of care provided to cataract patients with a multifaceted refractive surgery history.

Methods

Study Group

This was a retrospective case series of seven de-identified patients (11 eyes) with previous RK and LASIK for myopia who underwent cataract surgery from 2017 to 2023 at Hoopes Vision, Draper, UT, USA. Four patients underwent bilateral cataract surgery, while 2 patients underwent unilateral cataract surgery. Seven of the 11 eyes had 6 RK incisions, 3 had 8 RK incisions, and 1 had 4 RK incisions. Additionally, 4 eyes had 4 AK incisions and 1 eye had 2 AK incisions. Informed consent was obtained from patients prior to performing all procedures. This study was approved by the Biomedical Research Alliance of New York (BRANY) Institutional Review Board (#A20-12-547-823), adhered to the Declaration of Helsinki, and was approved by the Hoopes Vision Ethics Committee. The exclusion criteria were glaucoma, history of congenital ocular abnormalities, previous corneal disease, retinal abnormalities, trauma to the eye, and perioperative or postoperative complications.

Surgical Procedure

All surgeries were performed by one surgeon (MM), using a temporal incision. The surgeon selected an IOL power based on a targeted refraction derived from the average suggested formula power. All patients received either ZCBOO or MX60E lenses. Among ZCBOO, nine eyes received conventional lenses and two eyes received toric lenses. A manual 2.4 clear corneal incision was created for patients with fewer than 8 RK incisions. For those with 8 or more RK incisions, the surgeon performed a 2.4 mm scleral tunnel incision. Duovisc (Alcon) was used. The surgeon performed a continuous curvilinear capsulorhexis ranging from 5.0 to 5.55 mm in size. Phacoemulsification, either in a horizontal chop or divide-and-conquer fashion, was performed using the Infiniti Vision System (Alcon Laboratories, Inc., Fort Worth, TX, USA). There were no complications related to the capsulotomy, and all wounds were confirmed to be self-sealing.

Preoperative measurements of flat/steep keratometry, flat/steep axis, aqueous chamber depth, axial length, lens thickness, AD central corneal thickness, and white-to-white were obtained using Zeiss IOLMaster 700 version 1.90.12.05 (Carl Zeiss Meditec AG., Jena, Germany) and Lenstar 900 version i9.6.3.0 (Haag-Streit, Köniz, Switzerland). In cases with biometric data from both Lenstar and IOLMaster, the values were averaged to obtain the most accurate data. Corneal topography was measured using the OCULUS Pentacam HR (OCULUS Inc., Wetzlar, Germany), Galilei G4 ColorZ (Zeimer Ophthalmic Systems Inc., Brugg, Switzerland), or Optovue by Avanti for comprehensive wide-field OCT imaging.

Postoperative measurements of the patients' uncorrected visual acuity, best corrected visual acuity, sphere, cylinder, and axis were obtained for an average of 5 months.

There were 12 IOL formulas:

Barrett True K

Barrett True K utilized the Barrett Universal 2 formula (https://calc.apacrs.org/barrett_universal2105/), but included previous refractive history, incorporating either prior RK or LASIK. Barrett predicted the effective lens position and IOL power using axial length, keratometry, anterior chamber depth, lens thickness, and white-to-white distance.[7] Barrett True K could be completed with or without history.

Camellin Calossi Camellin (3C)

Camellin-Calossi-Camellin (3C) formula (https://3ccalculator.lasek.it/index.php), designed by Camellin et al, incorporated keratometry, previous refractive surgery information, anterior chamber depth, axial length, and desired refraction to calculate IOL.[8]

Galilei

Galilei formula, incorporated in ASCRS, utilized the average total corneal power (TCP) for the central 4 mm diameter of the cornea to calculate the IOL. TCP represented the average of corneal power for every detected point in a selected region of interest.[9]

Haigis-L

Haigis-L formula was developed by Dr Wolfgang Haigis-L at the University of Wurzburg Eye Hospital to account for effective lens position, or the actual distance of the lens from the cornea, and the individual geometry of each lens model. It utilized three constants (a_0, a_1 and a_2) to set both the position and shape of a power prediction curve.[10]

The Double K-Modified Holladay

The Double K-Modified Holladay optical biometry machine utilized a modified version of the Holladay 1 formula (Double K Modified Holladay) in which a preoperative K of 43.86 D and a postoperative mean K was used from IOLMaster or Lenstar.[11] Lens implant power was calculated using axial length.

OCT-Based

OCT-Based calculator utilized optical coherence tomography (OCT) to calculate based on cornea, IOL and retina. It was designed to not be biased by previous laser correction, by Tang et al.[12] It utilized keratometry, axial length, anterior chamber depth (ACD), lens thickness, and white-to-white.

Pearl DGS Calculator

(https://iolcalculator.escrs.org/) predicted theoretical internal lens position using artificial intelligence. It incorporated keratometry, axial length, ACD, lens thickness, central corneal thickness, white-to-white, and biological sex into its calculation.[13]

Panacea Calculator

(www.panaceaioltoriccalculator.com) factored axial length, lens thickness, ACD, mean keratometry, anterior and posterior curvature values of asphericity (Q) at 6 mm, and posterior: anterior ratio of R_m to calculate IOL.[14]

Potvin-Hill

Calculator utilized Pentacam's formula by incorporating anterior segment tomography, induced astigmatism, and target refraction to calculate IOL based on total corneal refractive power (TCRP).[15]

Shammas

Formula, also incorporated into ASCRS, was a no-history method of intraocular lens power calculation for cataract surgery after myopic LASIK.[16]

Several of these formulae required an A constant and SF constant for calculations. These values were obtained using the lens' manufacturer suggestions. The TECNIS ZCBOO monofocal lens and TECNIS ZCT Toric lens had an A-constant of 119.3 and SF of 1.96.[16] The enVista enhanced MX60E lens had an A-constant of 119.1 and SF of 1.85.[17]

Calculations

The average predicted IOL power was obtained using these calculators. In addition to those listed above, 2 new averages were created using a combination of values. The calculator titled "OCT-based average" combined the provided IOL power values from the OCT prior LASIK calculator and OCT prior RK calculator. As the Camellin-Calossi-Camellin (3C) RK and LASIK formulae yielded the same results, no separate 3C averages were required. The IOL refraction prediction error (RPE) was calculated by subtracting the predicted IOL power from the implanted IOL power. A positive RPE indicated a hyperopic patient, whereas a negative RPE indicated a myopic patient.

Data Analysis

The results were collected and analyzed using IBM SPSS Statistics software and Microsoft Excel. The Shapiro–Wilk test was used to assess data normality. Each IOL formula was compared with the other formulae, and p-values were calculated using the Friedman test to determine significance. Subsequently, a Wilcoxon signed-rank test with Bonferroni correction was used to compare significant formula pairs. Statistical significance was set at $p \leq 0.05$, and the confidence interval was set at 95%.

The following data was collected using the published method of Wang et al[18]

1. Mean arithmetic prediction error: A positive mean arithmetic IOL PE indicated underestimation of IOL power by the formula, whereas a negative mean arithmetic IOL PE indicated overestimation of IOL power.
2. Mean absolute prediction error.
3. Variance: A smaller variance confirmed greater consistency in the given formula. By adjusting for the mean IOL prediction error, a better refractive outcome could be expected.
4. Percentage of eyes within a certain RPE: This was calculated assuming 1.00 diopter (D) of IOL prediction error produced 0.70 D of refractive error at the spectacle plane. The percentages of eyes with refractive errors of ±0.25, ±0.50, ± 0.75, ±I.0, and ±2.0 diopters were measured for each formula.

Cochran's Q test was performed to determine the significance of the 3C calculator's ability to calculate IOL within 0.25, 0.5, 0.75, 1, and 2 diopters (D) of the inserted IOL power.

Results

This study included 11 eyes from 7 patients, 4 being bilateral cases, and 3 unilateral cases (demographic characteristics are shown in Table 1). This data set was not normally distributed.

The formulas with the greatest to least mean arithmetic errors (Table 2) were as follows: 3C (0.088), Haigis-L (−0.508), Shammas (−0.516), OCT Average (−0.538), Barrett True K (−0.557), OCT RK (−0.563), Galilei (−0.570), Double K-Modified Holladay (−0.571), OCT LASIK (−0.583), Barrett True K No History (−0.597), Pearl-DGS (−0.606), Potvin-Hill SF (−0.770), Potvin-Hill TNP (−0.778), Panacea (−0.876), and Barrett Universal 2 (−1.522). The positive values observed only in the 3C formula indicated that this formula slightly underestimated IOL power, whereas all other formulae slightly overestimated IOL power.

The formulas with the least to greatest mean absolute error (Table 2) were as follows: 3C (0.088), Haigis-L-L (0.867), Potvin-Hill TNP (0.884), Potvin-Hill SF (0.896), Double K-Modified Holladay (0.907), OCT Average (0.925), Barrett True K (0.934), Pearl-DGS (0.953), OCT LASIK (0.953), Galilei (0.955), Barrett True K No History (0.960), Shammas (0.967), OCT RK (0.986), Panacea (1.25), and Barrett Universal 2 (2.39). This indicates that the 3C formula had the least difference between the actual IOL power and predicted IOL power, whereas Barrett Universal 2 had the greatest difference between the actual and predicted IOL power.

The formula with the least to greatest variance (Table 3) are 3C (0.077), Potvin-Hill TNP 4.0 (0.173), Potvin-Hill SF (0.175), Haigis-L-L (0.197), Barrett True K (0.205), Galilei (0.225), OCT LASIK (0.235), OCT Average (0.240), OCT RK (0.244), Barrett True K No History (0.252), Shammas (0.256), Double K-Modified Holladay (0.262), Pearl-DGS (0.264), Panacea (0.74) and Barrett Universal 2 (1.455). Lesser variance demonstrated better consistency in IOL predictions, and the 3C formula indicated the highest consistency among the IOL predictions. Greater variance demonstrated poorer consistency in IOL predictions, as seen with Barrett Universal 2.

The 3C formula accurately captured most IOLs of the eyes within 0.25 diopters (91%). The 3C formula also performed the best overall for all diopter ranges, from 0.25 to 2D. The Barrett Universal 2 formula performed the

Table 1 Demographics of Patient Population

Demographic	n	Percentage (%)
Gender (M, F)	4, 7	40, 60
Eye (OD, OS)	6, 5	50, 50
	Mean + SD	**Range**
Age	69.2 ± 5.1	59–73
RK Incisions	6.4	4–8
AK Incisions	1.6	0–4
Pre-operative BCVA (LogMAR)	0.12 ± 0.11	0–0.40
Post-operative BCVA (LogMAR)	0.03 ± 0.05	0–0.097
Axial Length	25.21 ± 1.09	23.6–27.0
Anterior Chamber Depth	3.35	2.92–3.73
Lens Thickness	4.44 ± 0.44	4.02–5.62
K1 (flat)	37.84	31.56–42.75
K2 (steep)	39.34 ± 2.73	34.51–43.92
IOL Power Implanted	24.3 ± 3.1	19.5–26.5
20/20 BCVA Preoperatively	9.1%	
20/20 BCVA Postoperatively	72.7%	

Abbreviations: RK, Radial Keratotomy, AK, Astigmatic Keratotomy, BCVA, Best Corrected Visual Acuity.

Table 2 IOL Prediction Error for Each Calculator

IOL Prediction Error			
Calculator	**Arithmetic (Mean ± SD)**	**Absolute (Mean ± SD)**	**Variance (D2)**
CCC Lasik	0.088 ± 0.28	0.088 ± 0.28	0.077
CCC RK	0.088 ± 0.28	0.088 ± 0.28	0.077
Haigis-L	−0.508 ± 0.86	0.867 ± 0.44	0.197
Shammas	−0.516 ± 0.99	0.967 ± 0.51	0.256
OCT Average	−0.538 ± 0.93	0.925 ± 0.49	0.240
Galilei	−0.570 ± 0.94	0.955 ± 0.47	0.225
Barrett True K	−0.557 ± 0.91	0.938 ± 0.45	0.205
OCT RK	−0.563 ±.99	0.986 ± 0.49	0.244
IOL MASTER	−0.571 ± 0.90	0.906525 ± 0.51	0.262
OCT LASIK	−0.583 ± 0.93	0.953 ± 0.49	0.235
Barrett No History	−0.597 ± 0.94	0.960 ± 0.50	0.252
PEARL- DGS	−0.606 ± 0.93	0.953 ± 0.51	0.264

(*Continued*)

Table 2 (Continued).

IOL Prediction Error			
Calculator	**Arithmetic (Mean ± SD)**	**Absolute (Mean ± SD)**	**Variance (D2)**
Pentacam SF	−0.770 ± 0.62	0.896 ± 0.42	0.175
Pentacam TNP	−0.778 ± 0.66	0.884 ± 0.42	0.173
Panacea	−0.876 ± 1.28	1.25 ± 0.86	0.741
Barrett Universal 2	−1.522 ± 2.29	2.39 ± 1.21	1.455

Abbreviations: CCC, Camellin-Calossi-Camellin, OCT, Optical Coherence Tomography, LASIK, Laser-Assisted in Situ Keratomileusis, RK, Radial Keratotomy, IOL, Intraocular Lens, TNP, True Net Power.

Table 3 Accuracy of Calculators

Formula Name	% ±0.25 D	% ±0.50 D	% ±0.75 D	% ±1 D	% ±2 D
CCC LASIK	91.00	91.00	91.00	100.00	100.00
CCC RK/LASIK	91.00	91.00	91.00	100.00	100.00
Potvin Hill TNP 4.0 mm	25.00	37.50	37.50	62.50	112.50
Haigas	20.00	40.00	40.00	60.00	110.00
Shammas	20.00	30.00	40.00	60.00	110.00
Galilei	20.00	30.00	40.00	50.00	110.00
Barrett No History	20.00	30.00	40.00	50.00	110.00
Barrett True K	20.00	30.00	40.00	50.00	110.00
IOLMaster	20.00	40.00	40.00	60.00	110.00
OCT-based Average	20.00	30.00	40.00	60.00	110.00
Pearl-DGS	20.00	40.00	40.00	50.00	110.00
Potvin Hill SF 3.00	12.50	37.50	37.50	75.00	112.50
OCT-based LASIK	10.00	40.00	40.00	60.00	110.00
OCT-based RK	10.00	30.00	40.00	40.00	110.00
Panacea	10.00	30.00	40.00	50.00	90.00
BARRET Universal 2	0.00	0.00	10.00	20.00	60.00

Abbreviations: CCC, Camellin-Calossi-Camellin, OCT, Optical Coherence Tomography, LASIK, Laser-Assisted in Situ Keratomileusis, RK, Radial Keratotomy, IOL, Intraocular Lens, TNP, True Net Power.

poorest, with only 50% of eyes having a refractive power within 2 diopters of the predicted IOL power. Figure 1 shows the accuracy of each formula for capturing IOL within 0.25, 0.5, 0.75, and 2D.

Discussion

The scarcity of studies investigating the combined impact of RK and LASIK surgeries on patients was evident in the course of this study. A meticulous literature review yielded only five papers that covered this subject, underscoring the

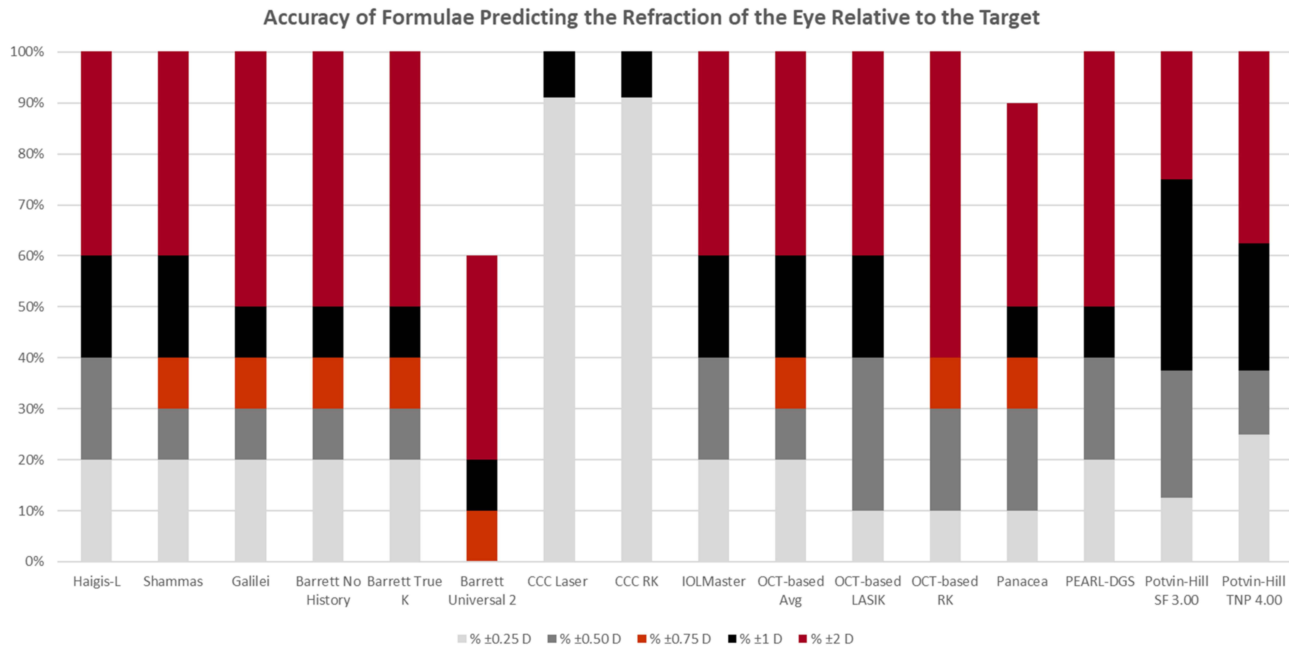

Figure 1 Accuracy of Formulae Predicting the Refraction of the Eye Relative to the Target.
Abbreviations: CCC, Camellin-Calossi-Camellin; OCT, Optical Coherence Tomography; LASIK, Laser-Assisted in Situ Keratomileusis; RK, Radial Keratotomy; IOL, Intraocular Lens; TNP, True Net Power.

lack of comprehensive information in this patient population. Two of these papers were case reports, both of which cited the challenge of calculating the IOL in patients undergoing successive refractive surgeries.[19,20] The third paper was a consultation in the Journal of Cataract and Refractive Surgery (JCRS) asking the professional community which formula to utilize in this unique patient.[21] Physicians' responses varied but included 3C, Panacea, Barrett Universal II, and Holladay. This consultation exemplified the absence of standardization as each surgeon responded with a different calculator. The fourth paper was a JCRS case report from 2020 analyzing IOL power calculations in 3 patients with RK and LASIK, which found Barrett True K No History to be the most accurate.[5] This led to the fifth paper, a JCRS report in 2022, which expanded on Barrett Formulae but focused on Barrett History (post-RK and post- LASIK) in 10 eyes with sequential RK and LASIK, thus similar to this study but without the analysis of a great variety of formulae.[6]

This study aimed to address a lack in the existing literature on patients with cataracts who underwent both RK and LASIK. The primary objective of this investigation was to conduct a comparative analysis of formulae derived from various IOL calculation platforms, including Haigis-L, Galilei, Shammas, Panacea, Barrett, Camellin-Callosi-Camellin, Double K-Modified Holladay, Potvin-Hill, Pearl, and OCT. These were selected based on available patient data collected at the time of surgery as well as a literature review of the most frequently used formulae by cataract surgeons.

Among the 12 formulae evaluated, the 3C calculator exhibited the highest performance and accuracy in predicting IOL power. This reflects previous literature findings, in which researchers found the Camellin-Calossi formula was "a good option for calculating IOL powers in eyes that have undergone various corneal ablative surgeries".[22] The Cochran Q test found the 3C formula to be statistically significant in all diopters ($p<0.001$). This success may be attributed to the incorporation of K1 and K2, axial length, anterior chamber depth, and IOL constant. As previously reported by Saiki et al, the greater the number of parameters required for computation, the higher the likelihood of encountering biometric measurement inaccuracies, which leads to less accurate postoperative outcomes.[23] This can best be seen when comparing 3C to another calculator such as the ASCRS IOL calculator which requires more parameters including – but not limited to – white, lens thickness, pre/post-surgery sphere and cylinder, and central corneal thickness.

Additionally, the 3C calculator, which is a modification of the Binkhorst II formula, uniquely obtains the curvature of the posterior cornea by not using regression analysis, but rather using anterior corneal surface and pachymetry points from the 3-mm curvature zone.[8] In the JCRS Consultation, a surgeon reports their preference of 3C because of its unique incorporation of average pupil corneal power and corneal thickness map to determine corneal refractive index, which they have found to be more precise.[21] However, despite its impressive accuracy, the 3C formula remains underutilized within the refractive surgeon community. Given its demonstrated precision, there exists a compelling case for the integration of the 3C calculator into academic forums, such as the ASCRS IOL website, when considering patients with multiple refractive surgeries, with the intention of augmenting overall accuracy. Of course, no instrument is perfect and there is a risk of transcription error with the 3C calculator as it requires input from multiple data points for its calculations.

Given that Haigis-L-L, Shammas, Galilei, Potvin-Hill, Barrett True K, and OCT-based are all individual formulae that are combined on the ASCRS calculator site to provide an average IOL power, they were expected to perform similarly to one another, as shown in Table 3. It provides a reliable calculation that is precise but not necessarily the most accurate. Our findings were also reflected in the two aforementioned case reports of post-RK and LASIK patients, both of which primarily utilized ASCRS' online calculator and found that Haigis-L, Shammas, and Barrett True K were the most accurate in their IOL calculations. While formulae outside of ASCRS (such as 3C) were not analyzed in these case reports, the conclusion translates to our study, as we found Haigis-L and Shammas to be 2nd and 3rd most accurate formulae, respectively.

Conversely, the Barrett Universal 2 formula exhibited the least favorable performance ($p<0.001$). This suboptimal performance may be attributed to the formula's premise that calculations are derived from eyes without prior refractive surgeries. This likely contributed to the subsequent development of the Barrett True K Calculator, which requires refractive surgery history input to ensure accurate computation.

When comparing various calculators against one another, a few showed statistical significance such as Barrett True K No History RPE vs 3C RPE ($p = 0.0039$). OCT-based RPE vs 3C RPE ($p = 0.0117$), PEARL-DGS vs 3C RPE ($p = 0.0078$), Panacea RPE vs 3C RPE ($p = 0.0195$), Haigis-L RPE vs 3C RPE ($p = 0.0039$), Shammas RPE vs 3C RPE ($p = 0.0078$), and Galilei RPE vs 3C RPE ($p = 0.0117$). However, after correcting the p-values to account for the large number of evaluated pairs, the results were statistically insignificant. Given the small sample size, this was expected, and the lack of significance detected by the Wilcoxon Signed-Rank test does not necessarily imply the absence of actual differences but rather the need to replicate this study on a larger scale.

The current challenge is rooted in the difficulty of calculating corneal refractive power (CRP) when the P/A ratio is no longer 0.82, as seen is virgin eyes.[24] Because RK flattens the anterior surface of the eye, and often results in subepithelial scarring over the incision site, IOL power calculations are often underestimated, as most of these formulae are based on the optic model of an eye, thus not accounting for changes in P/A ratio. Given the fact that each eye's P/A ratio depends on the magnitude of surgical correction, "there is no single keratometric index that can be accurate" in all post-surgical eyes.[25] This leads to the divergence of clinical preferences among ophthalmologists for calculating IOL in these complex scenarios. Given the variations in treatment and calculation approaches, it is necessary to standardize (as much as possible) the complexities of RK and LASIK into a singular formula. A potential solution could be a centralized platform where refractive surgeons input their post-RK and LASIK patients' refractive and IOL data, calculator used, and surgical outcomes, thereby creating a more expansive dataset and demonstrating the precision of IOL calculations for patients with a history of both refractive surgeries.

It is worth acknowledging that the future clinical relevance of such a calculator may be questioned considering the waning prevalence of RK procedures since the mid-1990s. Nevertheless, despite this impending decline in post-RK cases, an IOL calculator that accommodates both RK and LASIK histories is valuable and is needed by refractive surgeons **today**. As the population of RK recipients ages and requires cataract surgery, their care deserves transparency and accuracy, which can be achieved using evidence-based literature.

This study has some limitations, including a small sample size and a relatively short postoperative evaluation period. With such a limited sample size of 11 eyes from 7 patients, this study lacks the ability to accurately capture all qualities of the post-RK, post-LASIK cataract patients. Additionally, because long-term refractive implications beyond the 1-year postoperative assessment are difficult to ascertain, this study does not provide the full picture of patients' refractive outcomes. While this study attempted to be as comprehensive as possible, there are some formulae that were not included due to technological incompatibility, such as Ray Tracing. However, future studies will benefit from the incorporation of Ray Tracing as there is evidence it increases IOL power calculation in post-refractive eyes[26] Finally, this study did not focus on patient comorbidities or time between RK/LASIK and cataract surgery. These variables may be confounding and have an impact on corneal curvature, which was not addressed in this study. Thus, the academic community of cornea specialists will greatly benefit from a more comprehensive study of this post-RK, post-LASIK cataract patient population, which can adjust for confounding variables, selection bias, and sample size.

Conclusion

Our findings indicate that refractive surgeons continue to struggle to achieve accurate IOL calculations for cataract patients who have undergone both RK and LASIK procedures. Among the formulae tested, the Camellin-Calossi-Camellin formula was the most accurate method for calculating IOL power in post-RK and LASIK patients. These results are briefly reflected in the literature, yet this formula is not widely known. Despite its relatively limited use within the refractive surgery community, the demonstrated accuracy of this formula in our study underscores its potential utility and warrants further research on 3C calculator capabilities. This study also found that Barrett Universal 2 underperformed significantly, which is reflected in the literature and led to the subsequent development of Barrett True K IOL calculators. Based on these results, we recommend consideration for use of the 3C formula when confronted with cataract patients with a similar refractive surgery history. Additionally, we recommend the standardization of IOL calculations in post-refractive cataract patients. The academic community will benefit from further studies to confirm these results on a larger scale.

Disclosure

The authors report no conflicts of interest in this work.

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