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ORIGINAL RESEARCH

# Precision in Intraocular Lens Calculation for Chinese Cataract Patients with Prior History of Radial Keratotomy

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**Purpose:** To evaluate the predictive accuracy of eight traditional and contemporary intraocular lens (IOL) power calculation formulas in Chinese cataract patients with prior radial keratotomy (RK).

**Patients and Methods:** RK patients who underwent phacoemulsification with IOL implantation were retrospectively recruited. Refractive prediction errors (RPE)were calculated for eight formulas: Haigis-L, Shammas, Barrett True-K, Camellin Calossi Camellin (CCC), Kane, EVO, Pearl-DGS, and Jin-AI. The study compared RPE, mean absolute error (MAE), median absolute error (MedAE), and percentages of eyes achieving prediction errors within ±0.25, ±0.50, ±0.75, ±1.0, and ±2.0 diopters.

**Results:** This retrospective study analyzed 34 eyes from 21 patients with prior RK surgery. The superior performing IOL power calculation formulas were Jin-AI (MAE = 0.64 D, MedAE = 0.49 D), Barrett True-K (MAE = 0.58 D, MedAE = 0.535 D), and EVO (MAE=0.59 D, MedAE = 0.538 D). These three formulas demonstrated comparable accuracy, with 47.1%, 44.1%, and 44.1% of eyes achieving prediction errors within ±0.50 D, respectively. The Haigis-L and Pearl-DGS formulas exhibited significantly higher prediction errors in eyes with more than 12 RK incisions.

**Conclusion:** The Jin-AI, Barrett True-K, and EVO formulas demonstrated superior accuracy for IOL power calculation in Chinese cataract patients with prior RK. The Jin-AI formula, a novel artificial intelligence-based formula derived from Chinese individuals, presents a promising option for post-RK IOL calculation, while external validation studies across diverse ethnic groups are essential.

**Keywords:** radial keratotomy, cataract, IOL power calculation, refractive prediction errors

## Introduction

Radial keratotomy (RK) emerged as a novel refractive surgical technique in the 1980s and early 1990s, gaining widespread adoption globally. However, excimer laser surgeries rapidly superseded RK due to its compromised safety profile and associated complications.[1] Epidemiological data reveal that approximately 10% of practicing ophthalmologists performed several hundred thousand RK procedures in the United States alone.[2,3] As these patients age, they increasingly develop cataracts, creating a growing population of post-RK eyes requiring cataract extraction and intraocular lens (IOL) implantation.

Accurate IOL power calculation remains fundamental to achieving optimal postoperative visual outcomes.[4] Despite significant advances in biometric measurements and IOL formulas, selecting appropriate IOL power for cataract patients

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with prior RK presents substantial challenges. The distinctive effects of radial corneal incisions induce irregular astigmatism, central corneal flattening, and the discrepancy between anterior corneal curvature and total corneal power, creating three primary complications for IOL power calculation. First, postoperative refraction demonstrates instability characterized by early hyperopic shift and diurnal variations.[5,6] Second, instrument errors arise from asymmetric changes in corneal curvature between anterior and posterior surfaces.[5,6] Third, formula errors occur due to estimated lens position (ELP) inaccuracies, representing another significant source of calculation error.[7] These changes frequently lead to hyperopic surprises in IOL calculation for post-RK eyes.

Over the past two decades, numerous online IOL calculators have been developed to minimize formula errors, with several recent studies comparing formula accuracy.[8–12] However, no consensus has emerged from these investigations, and studies from Chinese populations remain limited. Given the increasing expectations of post-RK patients undergoing cataract surgery, advances in this field are critically needed. This study compares the accuracy of eight different IOL power calculation formulas in Northern Chinese cataract patients with prior RK. The eight selected IOL formulas encompass a broad spectrum of algorithmic generations and design philosophies: 1) a traditional theoretical formula (Haigis-L); 2) modern hybrid formulas that combine optical theory with regression or AI, considered current or next-generation standards (Barrett True-K, EVO, Kane, Pearl-DGS, and Jin-AI); and 3) formulas specifically designed for eyes after refractive surgery (Shammas and CCC). This selection allows for a comprehensive evaluation across different technological paradigms.

## Materials and Methods

This retrospective case series analyzed patients with a history of RK who underwent uneventful phacoemulsification cataract surgery at Tianjin Eye Hospital between January 2022 and April 2025. This study was approved by the Medical Ethics Committees of Tianjin Eye Hospital (KY-2025036) and was conducted adhering to the tenets of the Helsinki declaration. Informed consent was obtained from all patients prior to study commencement. Exclusion criteria included previous ocular surgery other than RK, severe complications during or after cataract surgery, incomplete medical records, or vision-threatening ocular diseases that could influence postoperative refraction (corneal diseases, glaucoma, uveitis, severe retinopathies, and amblyopia).

Patient demographics and surgical data were extracted from medical records, including age, sex, type and power of implanted IOL. Preoperative biometric measurements comprised axial length (AL), keratometry (K), anterior chamber depth (ACD, measured from epithelium to lens), lens thickness (LT), central corneal thickness (CCT), and white-to-white (WTW) corneal diameter, all obtained using IOL Master 700 (Carl Zeiss Meditec AG, Jena, Germany). All cataract surgeries were performed by a single experienced surgeon (XY Yuan) using a 2.8mm scleral limbal incision to avoid RK wounds. Monofocal aspheric IOLs were implanted in the capsular bag in all cases, specifically Akreos Adapt-AO (10 eyes, Bausch & Lomb, Rochester, NY, USA) or Tecnis ZCB00 (24 eyes, Johnson & Johnson Vision, Santa Ana, CA, USA). IOL power calculations utilized optimized constants from the IOL Con website (https://www.iolcon.org), in which the A constant of Akreos Adapt-AO is 118.5 and the A constant of Tecnis ZCB00 is 119.3.

### Formulas

Eight IOL power calculation formulas were evaluated: Haigis-L, Shammas, Barrett True-K, Camellin Calossi Camellin (CCC), Kane, EVO, Pearl-DGS, and Jin-AI. The Haigis-L formula, developed by Dr. Wolfgang in 2008 for patients with previous refractive surgery, corrects for radius error, keratometer index error, and IOL formula error on the basis of the regular Haigis formula.[13] The Shammas formula provides an alternative for IOL power calculation after myopic LASIK, particularly when refractive surgery data are unavailable.[14] Both formulas are calculated online through the American Society of Cataract and Refractive Surgery website (www.ascrs.org). The Barrett True-K formula, available at https://calc.apacrs.org, predicts ELP and IOL power using AL, K, ACD, LT, and WTW, with or without previous refractive history.[15] The CCC formula (https://3ccalculator.lasek.it/index.php), specifically designed by Camellin for IOL power calculation after refractive corneal surgery, incorporates K, ACD, AL, and desired refraction.[16] The Kane formula (https://iolformula.com) combines theoretical optics with regression and artificial intelligence (AI) components, using AL, K, ACD, LT, CCT, and biological sex for predictions.[17] The EVO formula (www.EVOiolcalculator.com) uses AL,

K, and ACD as primary predictors, with LT and CCT as optional parameters.[4] The Pearl-DGS Calculator (https://iolcalculator.escrs.org/), an AI formula, predicts theoretical internal lens position using AL, K, ACD, LT, CCT, and biological sex.[18] The Jin-AI formula, based on Chinese eyes, incorporates AL, K, ACD, and LT as learning features.[19]

## Methods of Comparison and Adjustments

Postoperative measurements were recorded during follow-up visits at 3–6 months, including uncorrected distance visual acuity, corrected distance visual acuity, manifest refraction, and IOL Master 700 assessments. Analysis and comparison of IOL power prediction accuracy followed guidelines recommended by Wang.[20] Refractive prediction error (RPE) was calculated by subtracting the predicted spherical equivalent from the actual postoperative spherical equivalent. Negative RPE values indicated myopic outcomes, while positive values represented hyperopic results. For each formula, the arithmetic mean error (AME) and corresponding standard deviation (SD) were calculated across all patients. Absolute values of arithmetic errors yielded absolute errors, from which mean absolute error (MAE) and median absolute error (MedAE) were derived. The MAE represents the average absolute difference between actual and predicted refractive outcomes and serves as a primary outcome parameter in IOL calculation studies. Since absolute errors do not follow normal Gaussian distribution and MAE is influenced by outliers, MedAE was included to mitigate extreme value effects.[21] The percentage of cases falling within ±0.25 diopters (D), ±0.50 D, ±1.00 D, and ±2.00 D was assessed to evaluate refractive outcomes for each formula.

## Statistical Analysis

Descriptive statistics, including mean, SD and range, were computed using Microsoft Excel 2016 (Microsoft Corp., Redmond, WA, USA). Data analysis was performed using the Social Sciences SPSS Statistics for Windows (version 26.0; IBM Corp., Armonk, NY, USA)), and visualizations were generated in GraphPad Prism (version 9.5.1; GraphPad Software, San Diego, CA, USA). Data normality was assessed using the Shapiro–Wilk test. Since most distributions deviated from normality ($p < 0.05$), nonparametric tests were employed. The Mann–Whitney *U*-test and Wilcoxon signed-rank test were applied for between-group and paired comparisons, respectively. Continuous variables were summarized as mean ± SD or median and range, as appropriate. Subgroup analysis based on RK incision number (<12, =12, >12) was performed. Bonferroni correction was applied for multiple comparisons. Statistical significance was defined as a two-sided p-value <0.05.

# Results

A total of 34 eyes from 21 patients were analyzed in this retrospective study. The cohort had a mean age of 58.56 ± 5.93 years, with 11 of 21 patients being female. Among the 34 eyes examined, 10 eyes (29.4%) presented fewer than 12 RK incisions, 17 eyes (50.0%) had exactly 12 RK incisions, and 7 eyes (20.6%) demonstrated more than 12 RK incisions. Additional demographic and biometric characteristics are presented in Table 1.

Table 2 presents the AME for all eight formulas. The Kane formula exhibited the highest myopic mean error (−1.04D), whereas Shammas achieved the most hyperopic outcomes (0.82D). The Kane, Pearl-DGS, CCC, Barrett True-K, and EVO formulas produced myopic arithmetic mean errors, while the remaining formulas generated hyperopic arithmetic mean errors (Figure 1A). Notably, Barrett True-K and EVO demonstrated arithmetic mean errors within 0.1 D from emmetropia.

The formula rankings of MAE from lowest to highest (Table 2) were Barrett True-K (0.58D), EVO (0.59D), Jin-AI (0.64D), CCC (0.73D), Shammas (0.89D), Pearl-DGS (0.91D), Haigis-L (0.98D), and Kane (1.12D). Figure 1B displays box and whisker plots of prediction errors for each formula, illustrating the central tendency and variability of prediction bias in post-RK eyes. Statistically significant differences in MAE were observed between multiple formula pairs: Haigis-L versus Shammas (P=0.047), Haigis-L versus Barrett True-K (P=0.08), Haigis-L versus CCC (P=0.013), Haigis-L versus EVO (P=0.001), Haigis-L versus Jin-AI (P=0.001), Barrett True-K versus Pearl-DGS (P=0.045), Kane versus EVO (P=0.01), Kane versus Jin-AI (P=0.01), EVO versus Pearl-DGS (P=0.01), and Jin-AI versus Pearl-DGS (P=0.004). No additional significant differences were identified (Figure 2). Regarding MedAE, the Jin-AI formula achieved the lowest value (0.49 D), followed by Barrett True-K (0.535 D) and EVO (0.5375 D).

**Table 1** Demographic and Ocular Characteristics of the Study Population

| Demographic | n | Percentage (%) |
|---|---|---|
| Gender (M, F) | 10, 11 | 47.6%, 52.4% |
| Eye (OD, OS) | 16, 18 | 47.1%, 52.9% |
| | Mean + SD | Range |
| Age (years) | 58.56 ± 5.93 | 49.0–71.0 |
| RK Incisions | 11.65 ± 2.44 | 8.00–16.00 |
| Axial Length (mm) | 28.31 ± 2.33 | 23.49–32.80 |
| Anterior Chamber Depth (mm) | 3.34 ± 0.56 | 1.69–4.27 |
| Lens (mm) | 4.39 ± 0.51 | 3.44–5.56 |
| Km (D) | 37.23 ± 3.92 | 27.21–43.34 |
| Central Corneal Thickness (mm) | 563.44 ± 49.55 | 382.00–620.00 |
| IOL Power Implanted | 19.93 ± 4.48 | 12–28 |
| Postoperative SE (D) | −2.06 ± 1.66 | −5.75–0.50 |

**Abbreviations**: IOL, intraocular lens; RK, Radial Keratotomy; SD, standard deviation; SE, spherical equivalent.

**Table 2** IOL Prediction Error for Each Formula in Post-RK Eyes

| Formula | AME (Mean ± SD) | MAE (Mean ± SD) | MedAE |
|---|---|---|---|
| Haigis-L | 0.72 ± 0.98 | 0.98 ± 0.70 | 0.7075 |
| Shammas | 0.82 ± 0.67 | 0.89 ± 0.57 | 0.8875 |
| Barrett True K | –0.08 ± 0.72 | 0.58 ± 0.43 | 0.535 |
| CCC | –0.26 ± 0.83 | 0.73 ± 0.45 | 0.625 |
| Kane | –1.04 ± 0.83 | 1.12 ± 0.71 | 1.1125 |
| EVO | –0.08 ± 0.69 | 0.59 ± 0.35 | 0.5375 |
| Pearl-DGS | –0.45 ± 1.00 | 0.91 ± 0.59 | 0.9 |
| Jin-AI Cal | 0.12 ± 0.84 | 0.64 ± 0.56 | 0.49 |

**Notes**: More negative arithmetic errors indicate myopic shift, and a lower MedAE indicates higher predictive accuracy.
**Abbreviations**: AME, arithmetic mean prediction error; CCC, Camellin Calossi Camellin; MAE, mean absolute prediction errors; MedAE, median absolute errors; SD, standard deviation.

Prediction accuracy assessment involved calculating the cumulative proportion of eyes achieving RPE within ±0.25 D, ±0.50 D, ±0.75 D, ±1.0 D, and ±2.0 D for each formula (Table 3). The percentage of eyes with RPE within ±0.50 D ranged from 33.5% (Kane) to 57.1% (Jin-AI). Barrett True-K and EVO formulas demonstrated comparable accuracy, with 54.1% of eyes achieving outcomes within ±0.50 D. These metrics are presented as line charts (Figure 3A) and stacked bar charts (Figure 3B). Barrett True-K, EVO, and Jin-AI demonstrated superior accuracy, particularly within the ±0.50 D and ±1.00 D ranges.

Subgroup analysis was conducted based on RK incision number, stratifying the cohort into three groups: fewer than 12 incisions, exactly 12 incisions, and more than 12 incisions. Table 4 demonstrates the influence of RK incision number on MAE for each formula. Formulas including Haigis-L and Pearl-DGS exhibited significantly higher prediction errors in eyes with more than 12 incisions (Figure 4).

## Discussion

Accurate IOL power calculation represents a fundamental requirement for successful cataract surgery and optimal visual outcomes.[22] Despite significant advances in tomographic devices and IOL formulas, achieving appropriate IOL power in

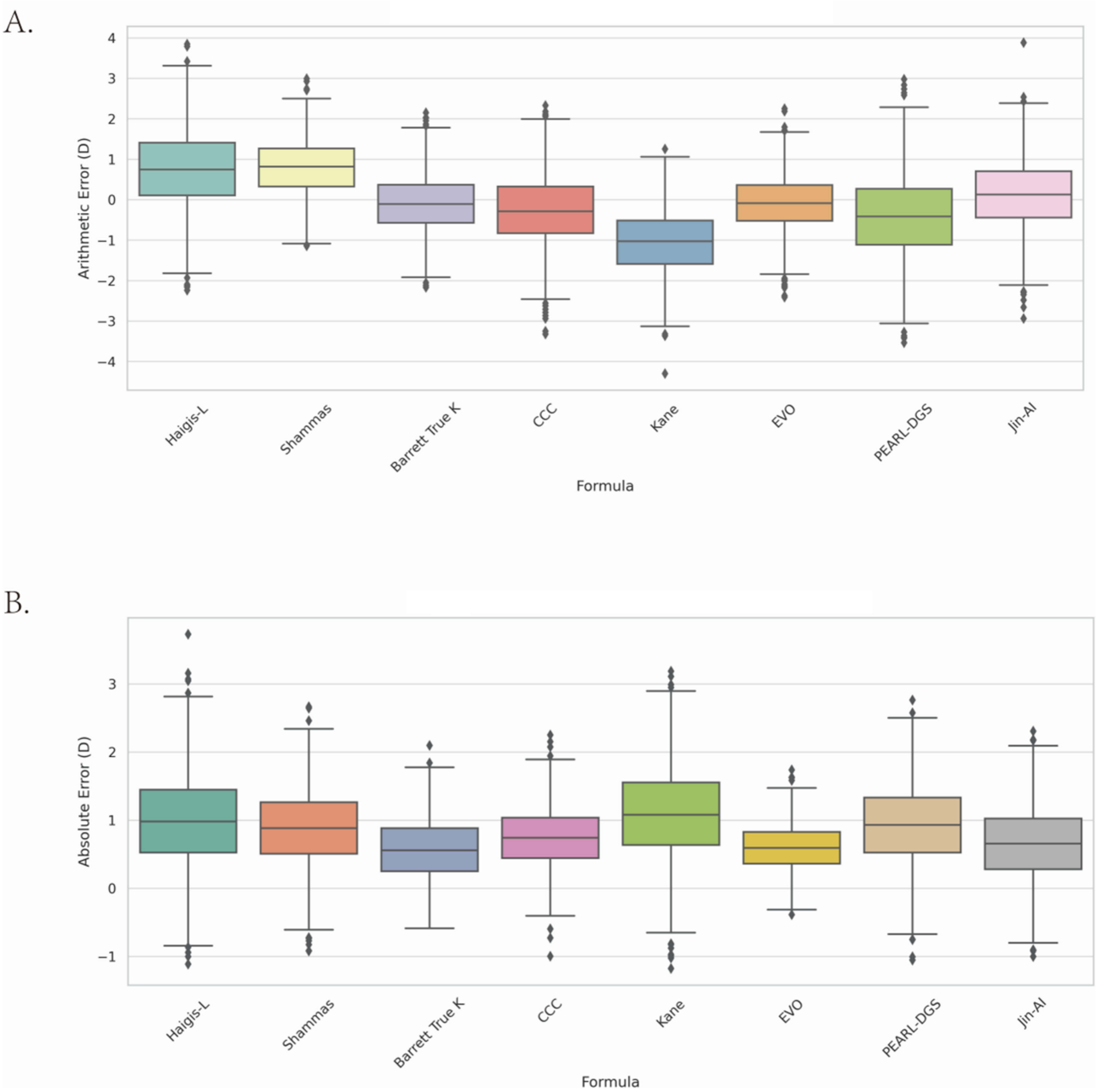



**Figure 1** (**A**) This simulated boxplot visualizes arithmetic refractive prediction errors for 8 IOL formulas, reconstructed from mean ± SD data. Each box represents the interquartile range (IQR), and dots represent outliers. Positive values indicate a myopic prediction bias, while negative values reflect a hyperopic shift. (**B**) Boxplot showing the distribution of absolute refractive prediction errors for 8 IOL power calculation formulas in eyes with prior RK. The horizontal line inside each box indicates the median absolute error (MedAE). A lower and more compact distribution suggests better predictive performance.

patients with prior RK surgery remains a substantial challenge for ophthalmologists worldwide. This study evaluated the predictive accuracy of eight different IOL power calculation formulas in post-RK Chinese eyes. To our knowledge, this represents the first investigation to incorporate the Jin-AI formula, a novel AI-powered formula based on Chinese eyes, when assessing the accuracy of traditional and contemporary IOL power calculation formulas in Chinese cataract patients with prior RK.

The percentage of patients achieving RPE within ±0.50 D holds particular clinical significance. A recent multicenter study from China evaluated eight formulas in 1443 eyes of virgin cataract patients and demonstrated that the percentage of eyes with RPE within ±0.50 D ranged from 73.6% to 84.9%.[19] However, formula accuracy declined substantially in


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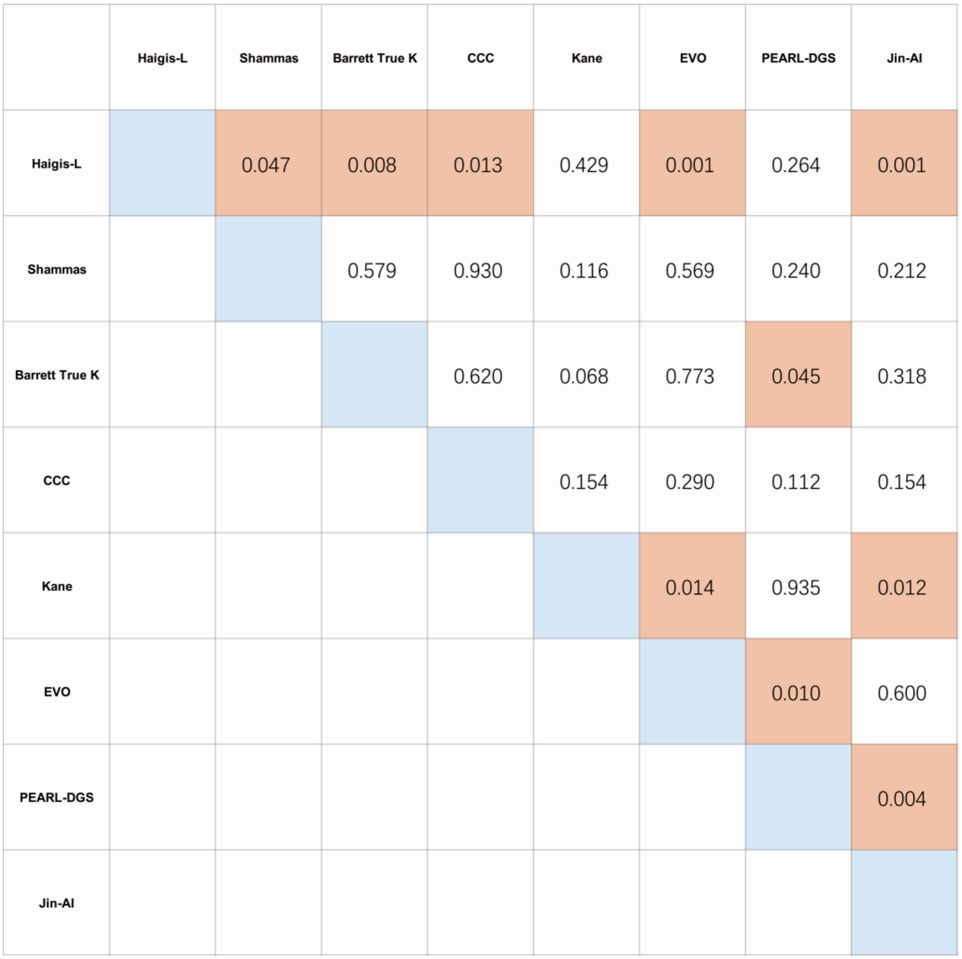



**Figure 2** A 1:1 statistical comparison of each formula in mean absolute error. Values in gray-shaded boxes indicate statistical significance.

cataract patients with prior RK. In our study, the Jin-AI formula demonstrated the highest accuracy, achieving only 47.1% of eyes within ±0.50 D of the target refraction. Additionally, Jin-AI achieved the lowest median absolute error (0.49 D) among all eight traditional and contemporary formulas. The Jin-AI formula, initially reported by Jin, represents a hybrid AI-powered IOL calculation method trained on Chinese eyes, combining a multilayer neural network with

**Table 3** Percentage of Eyes within Prediction Error Thresholds for Each IOL Formula

| Formula | % ±0.25 D | % ±0.50 D | % ±0.75 D | % ±1 D | % ±2 D |
|---|---|---|---|---|---|
| Haigis-L | 11.80% | 35.30% | 50.00% | 52.90% | 91.20% |
| Shammas | 14.70% | 32.40% | 38.20% | 64.70% | 97.10% |
| Barrett True K | 26.50% | 44.10% | 64.70% | 85.30% | 100.00% |
| Kane | 11.80% | 23.50% | 41.20% | 44.10% | 91.20% |
| EVO | 23.50% | 44.10% | 58.80% | 91.20% | 100.00% |
| CCC | 14.70% | 26.50% | 58.80% | 79.40% | 100.00% |
| Pearl-DGS | 23.50% | 29.40% | 44.10% | 52.90% | 100.00% |
| Jin-AI Cal | 17.60% | 47.10% | 70.60% | 85.30% | 94.10% |

**Notes**: The table reports the cumulative percentage of eyes achieving prediction errors within ±0.25 D, ±0.50 D, ±0.75 D, ±1.00 D, and ±2.00 D. Higher percentages at tighter thresholds (eg, ±0.50 D) indicate greater accuracy and clinical reliability.
**Abbreviation**: CCC, Camellin Calossi Camellin.

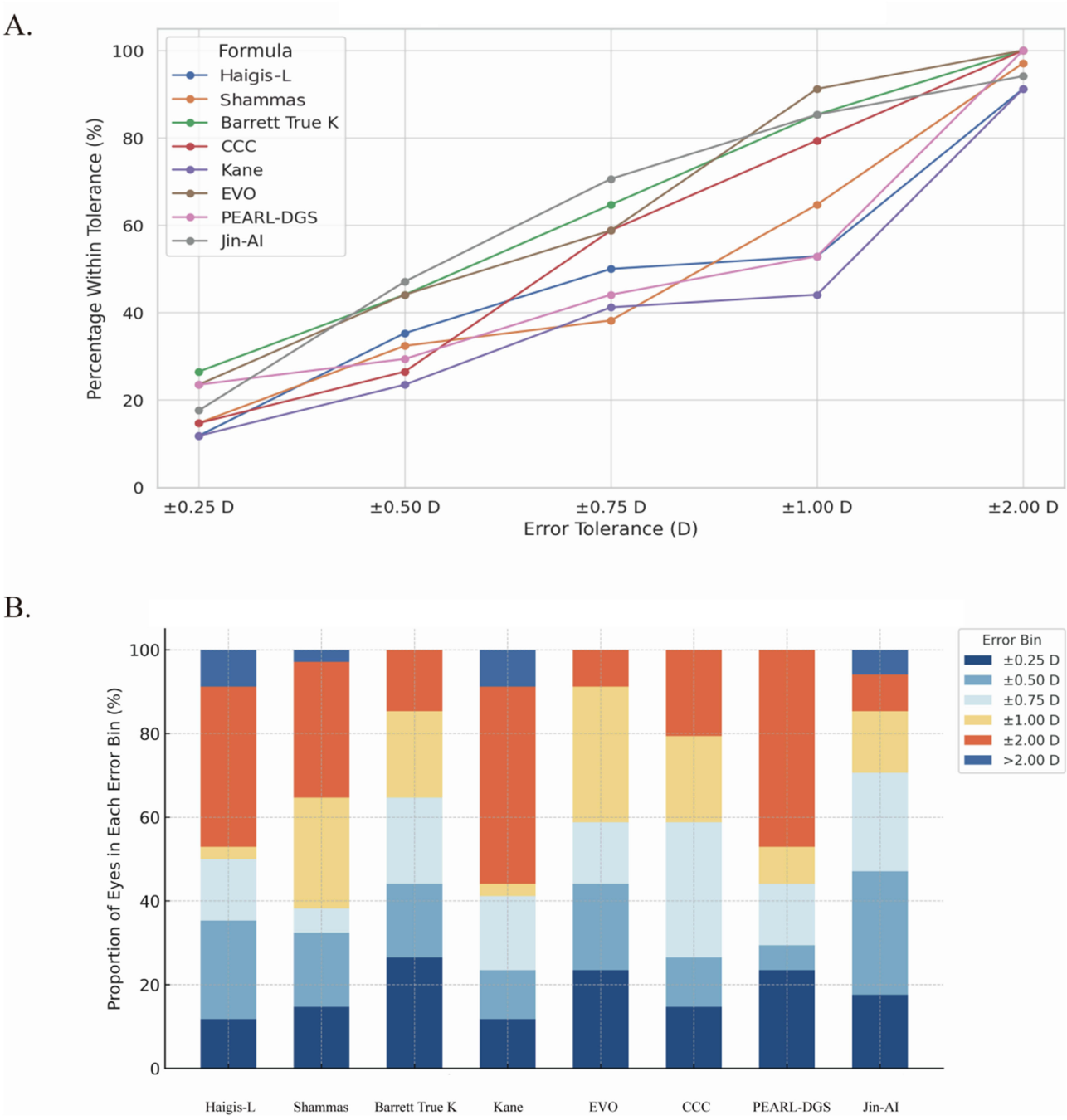



**Figure 3** (**A**) Prediction Accuracy of IOL Formulas at Different Refractive Thresholds. Line chart showing the percentage of eyes within specific refractive prediction error thresholds (±0.25 D to ±2.00 D) for 8 IOL power calculation formulas in post-RK patients. Each line represents one formula. A higher curve across tighter thresholds indicates better prediction accuracy. (**B**) Stacked bar chart illustrating the distribution of refractive prediction errors across six error bins (±0.25 D, ±0.50 D, ±0.75 D, ±1.00 D, ±2.00 D, and >2.00 D) for 8 IOL power calculation formulas in post-RK eyes. Each bar represents the percentage of eyes falling within each prediction error range, with the sum of all bins equal to 100% for each formula. The chart highlights differences in accuracy and extreme outlier rates across formulas. Formulas with taller bars in the lower error bins (eg, Barrett True K, EVO, Jin-AI) demonstrate greater precision, while those with a substantial portion in the >2.00 D bin.

Gaussian optical theory.[19] Its operation follows a two-stage process: 1. An AI model, constructed as a neural network with three hidden layers and trained using the adaptive moment estimation optimizer on a dataset of Chinese eyes, predicts a patient-specific ELP; 2. This predicted ELP is then input into a standard thin-lens vergence calculation (Gaussian optics) to derive the final IOL power recommendation.[19] This formula provides comparable accuracy to newer IOL formulas while demonstrating superior performance compared to third-generation formulas. Their results are in good


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**Table 4** Influence of RK Incision Number on Mean Absolute Error for Each Formula

| Formula | <12 | <12 Mean±SD | 12 | 12 Mean±SD | >12 | >12 Mean±SD |
|---|---|---|---|---|---|---|
| Haigis-L | 10 | 0.57±0.31 | 17 | 0.90±0.52 | 7 | 1.77±0.90 |
| Shammas | 10 | 0.90±0.60 | 17 | 0.81±0.61 | 7 | 1.07±0.47 |
| Barrett True K | 10 | 0.64±0.41 | 17 | 0.45±0.40 | 7 | 0.81±0.46 |
| CCC | 10 | 0.52±0.43 | 17 | 0.79±0.40 | 7 | 0.88±0.55 |
| Kane | 10 | 0.92±0.58 | 17 | 1.12±0.68 | 7 | 1.42±0.94 |
| EVO | 10 | 0.59±0.45 | 17 | 0.55±0.34 | 7 | 0.67±0.25 |
| Pearl-DGS | 10 | 0.60±0.62 | 17 | 0.93±0.54 | 7 | 1.32±0.44 |
| Jin-AI | 10 | 0.58±0.35 | 17 | 0.55±0.34 | 7 | 0.92±1.05 |

**Notes**: Absolute refractive prediction errors (Mean ± SD) stratified by the number of RK incisions: <12, =12, and >12. Increased incision numbers were associated with reduced prediction accuracy for some formulas (eg, Haigis-L, Pearl-DGS).
**Abbreviations**: CCC, Camellin Calossi Camellin; SD, standard deviation.

agreement with our data. Given that current widely-used IOL formulas are based on Caucasian eye data, significant anatomical differences exist between Chinese and Caucasian populations. Jin[23] and Wang[24] observed that Chinese populations demonstrate significantly lower corneal keratometric index and shallower ACD than the Caucasians. Steeper horizontal keratometry and longer AL in Chinese were also reported compared to Caucasian eyes.[25,26] These biometric parameter disparities induce clinically significant variations in IOL power calculation outcomes, necessitating ethnic-specific optimization. The Jin-AI formula presents a promising option for IOL power calculation in Chinese eyes.

In our study, Barrett True-K achieved an impressive MedAE of 0.535 D, the lowest MAE (0.58 D), and the highest percentage of eyes (26.5%) with RPE within ±0.25 D among the eight formulas in cataract patients with prior RK, demonstrating superior accuracy. Several studies support these findings. Curado[27] analyzed 52 eyes from 34 patients with cataract and prior RK, investigating the predictive accuracy of seven IOL power methods. They demonstrated that Barrett True-K (MedAE = 0.34 D) achieved a high level of accuracy compared to Holladay 2 (MedAE = 0.44 D), Hoffer

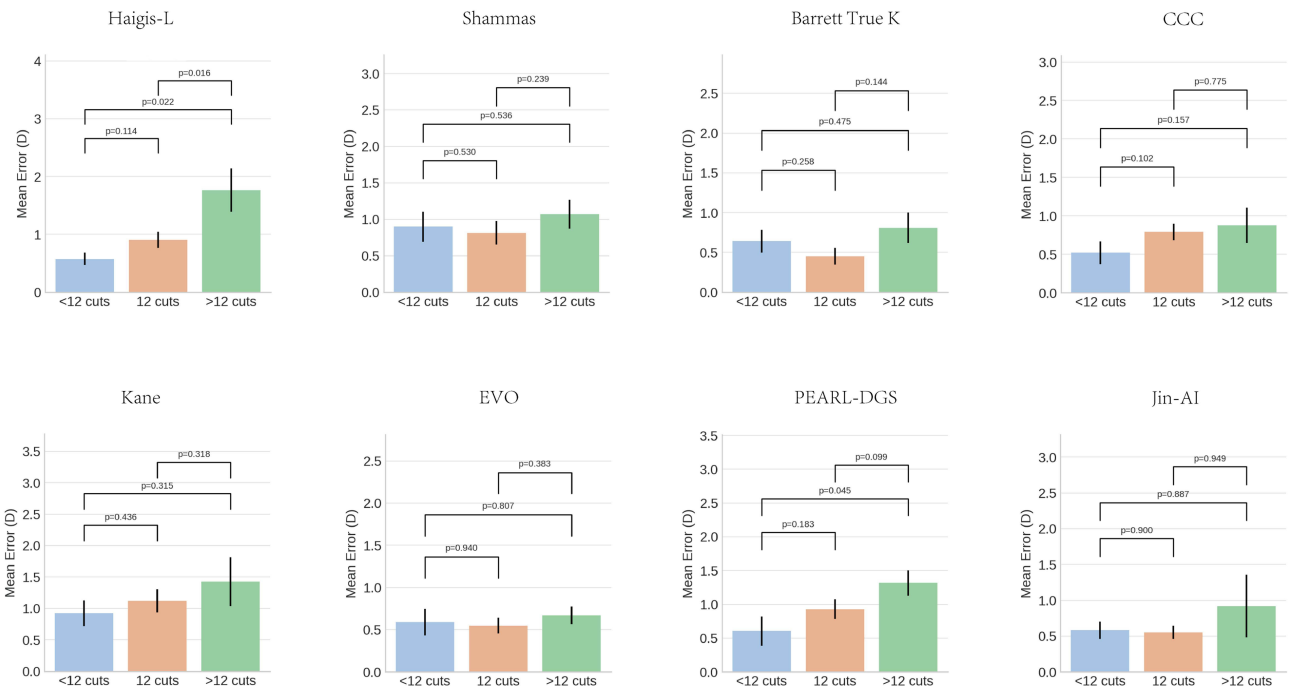



**Figure 4** Comparison of Mean Absolute Refractive Prediction Errors Among Different RK Incision Groups for Each IOL Formula. Bar charts illustrate the mean absolute prediction errors (Mean ± SD) of each IOL calculation formula, stratified by RK incision number: <12, =12, and >12 cuts. Statistical significance between groups was assessed using the Mann–Whitney *U*-test, and p-values are shown above the comparisons. Formulas such as Haigis-L and Pearl-DGS demonstrated significantly higher prediction errors in eyes with >12 incisions.


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Q (MedAE = 0.51 D), ORA (MedAE = 0.53 D), Haigis (MedAE = 0.54 D), SRK/T (MedAE = 0.54 D), and Holladay 1 (MedAE = 0.57 D). Turnbull and Barrett[28] reported results from 52 eyes of 34 patients with sequential RK and cataract surgery. Among methods not requiring refractive history, Barrett True-K exhibited superior performance with the lowest MedAE and highest percentage of eyes (69.2%) achieving refractive prediction error within ±0.50 D when compared to Double-K Holladay 1, Potvin-Hill, Haigis, and Haigis with −0.50 D offset. A similar Chinese study[10] comparing three formulas (Barrett True-K, Holladay 1 Double-K, Haigis) demonstrated that Barrett True-K achieved the lowest MedAE and highest percentage of eyes within 0.5 D (0.62 D and 46.8%, respectively). However, several studies report divergent findings.[29,30] Guo[29] reviewed 27 cataract patients after RK and indicated that Barrett True-K demonstrated the largest median absolute error (0.670 D), followed by Kane (0.585 D) and VRF formula (0.580 D), which differed significantly from our results. This discrepancy likely reflects differences in ocular biometric parameters, postoperative follow-up timing, and manifest refraction measurement protocols.

The EVO formula demonstrated comparable accuracy to Barrett True-K in our study. This formula achieved a MAE of 0.59 D with the lowest SD (0.35 D) and highest percentage of eyes (91.2%) achieving refractive prediction error within ± 1.0 D among the eight formulas, indicating high consistency and reliability of this method. The EVO formula maintains validated performance across diverse complex ocular conditions in clinical practice. Maroun[31] demonstrated that EVO achieved the lowest MAE and higher percentage of predictions within ±0.50 D for eyes with AL exceeding 26.0 mm compared to Hoffer Q, Holladay 1, Haigis, Barrett Universal II, Kane, Ladas Super formula, and Hill-RBF 3.0. For short eyes (AL ≤22.00 mm), EVO outperformed the special other formulas with which they were compared.[32] Although not originally designed for post-RK eyes, EVO demonstrated comparable accuracy in cataract eyes with prior RK due to its inherent stability.[11]

Camellin developed the CCC formula in 2006 by empirically adjusting two variables (K and ACD) on the basis of the Binkhorst II formula.[16] Although the formula was originally devised for IOL calculation following general refractive surgery and proved as a valid option for IOL power calculation in eyes with prior myopic laser vision correction,[33] its application following RK remains largely unexplored. A retrospective analysis was conducted on cataract patients with a history of RK by Moshirfar[11] and the results indicated CCC formula achieved 46% of eyes scoring within ± 0.50 D, 70% within ± 1 D, and 92% within ± 2 D of the target range. Our results did not entirely align with these findings, with 26.5% of eyes within ±0.50 D, 52.9% within ±1.00 D, and 100% within ±2.00 D of the target range, respectively. Further investigation of its application across different refractive surgery types is necessary to meet clinical requirements.

Increasing numbers of RK incisions proportionally induce corneal surface flattening.[34] Subgroup analysis based on RK incision number demonstrated that both Haigis-L and Pearl-DGS formulas exhibited significantly higher prediction errors in eyes with more than 12 incisions. This result is dramatically surprising as the Haigis-L formula does not utilize keratometry readings to estimate ELP, which should theoretically avoid higher error caused by flatter cornea in the post RK eyes. The Pearl-DGS formula represents a thick-lens version of the Haigis formula using AI for back-calculated lens position,[18] explaining its similar susceptibility to incision number with Haigis-L formula. Given the limited sample size of seven eyes with more than 12 incisions, this result lacks statistical power for definitive conclusions. Further investigation with large-scale multicenter data and larger subgroup analyses based on RK incision number would inform evidence-based IOL power calculation formula selection.

Several limitations should be acknowledged. First, the relatively uncommon occurrence of cataract patients with prior RK surgery resulted in a small sample size of 34 eyes, which may not fully represent the diverse population of post-RK cataract patients. Additional studies with larger sample sizes are needed to ensure data generalizability and validate these findings. Second, bilateral eye inclusion may introduce between-eye correlation effects. Third, several newer IOL formulas were excluded due to incomplete RK surgery data and technological incompatibility. Given constraints in device availability and efforts to minimize healthcare costs, all parameters were obtained using IOL Master 700, reflecting real clinical scenarios. Furthermore, as the Jin-AI formula shows promising results in our study, its performance in non-Chinese populations remains to be validated. Finally, postoperative follow-up intervals varied among patients due to the retrospective study design.

## Conclusion

Despite extensive advances in ocular biometry devices and IOL formulas, accuracy remains concerning for cataract eyes with prior RK surgery. In this Chinese cohort, Jin-AI, Barrett True-K, and EVO formulas demonstrated clinically acceptable and comparable accuracy for IOL power calculation in cataract patients with prior RK. The Jin-AI formula, a novel AI-based formula derived from Chinese individuals, presents a promising option for post-RK IOL calculation. Its real-world accuracy requires further independent validation in larger, prospective, and multi-ethnic populations.

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## Disclosure

The authors report no conflicts of interest in this work.

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