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Studying the added effect of sum-of-segments biometry to modern intraocular lens power calculation formulas for short eyes

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Abstract

Purpose To study the added effect of sum-of-segments (SOS) biometry to modern intraocular lens power calculation formulas for eyes with short axial length.

Methods This was a retrospective case series that included 99 eyes from 99 patients. Preoperative AXL measurements were conducted utilizing the ARGOS biometer (Alcon, Inc., Fort Worth, TX). The following formulas were used: Barrett Universal II (BUII), Cooke K6, EVO 2.0, and PEARL-DGS formulas. Additionally, the Barrett formula has been updated and is now incorporated into the ARGOS biometer, introducing the Barrett true axial length (BTAL) formula.

Results EVO 2.0_{SOS} and PEARL-DGS_{SOS} formulas had the highest cases within ± 0.25 D of the intended refraction (45.45% and 42.42%, respectively). The PEARL-DGS_{SOS} was the only formula to show a myopic mean prediction error (-0.25 ± 0.36 D). The Cooke K6 formula showed the highest hyperopic mean prediction error (0.55 ± 0.35 D), followed by EVO 2.0, Cooke $K6_{SOS}$, and BUII formulas. BTAL had mean prediction error of 0.15 ± 0.47 which is less hyperopic than BUII (0.43 ± 0.39 D). Subgroup analysis of eyes with AXL 21 mm or shorter (*n* = 57) was done. Again, the PEARL-DGS_{SOS} formula showed the only myopic mean prediction error (-0.23 ± 0.37 D).

Conclusion PEARL-DGS_{SOS} was the only formula to show a myopic mean prediction error. Using BTAL and SOS option in Cooke K6, EVO 2.0, and PEARL-DGS formulas decreased the undesirable hyperopic shift in the mean prediction error. This effect was more evident in shorter eyes ≤ 21.0 mm.

Keywords Biometry, Sum-of-segments, ARGOS, Eyes with short axial length, IOL power calculation

Introduction

Accurate assessment of the axial length (AXL) is crucial for calculating the power of intraocular lenses (IOLs). Mistakes in measuring AXL can lead to notable refractive errors after surgery [1]. Optical biometry has established itself as the preferred method for AXL measurements, offering exceptional reproducibility and precision [2–4].

Most of the optical biometers currently on the market employ a composite refractive index for the entire axial length (AXL) to transform optical path length into geometrical distance. The ARGOS (Alcon Laboratories, Inc., Fort Worth, TX) is an optical biometer featuring a swept light source that operates at an infrared wavelength of 1060 nm, allowing for higher acquisition rates

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in cases of denser cataracts. Unlike the majority of other devices, ARGOS utilizes a sum-of-segments approach for AXL measurement, applying a segment-specific refractive index instead of a composite one. It assigns distinct refractive indices for each part of the eye: cornea at 1.376, aqueous humor at 1.336, lens at 1.410, and vitreous at 1.336. This sum-of-segments technique has led to longer AXL measurements in shorter eyes, while resulting in shorter AXL measurements in longer eyes. This could be attributed to the significantly larger percentage of contribution of lens thickness to the AXL in shorter eyes and the comparatively larger percentage of the vitreous cavity in longer AXL. In shorter eyes, a longer AXL results in a lower power of the intraocular lens (IOL), this can lead to hyperopic errors [4–8]. It is worth mentioning that the AXL measurement error can contribute to inaccuracy in IOL power in 36% of cases [9, 10].

Currently, several intraocular lens (IOL) power calculation formulas provide the option to utilize a sum-of-segments axial length (AXLsos) as input. The online IOL calculator from the European Society of Cataract and Refractive Surgery (ESCRS) features some of these formulas, including the Cooke K6 [11], EVO 2.0, and PEARL-DGS formulas (accessible at: https://iolcalculator.escrs.org/). Additionally, the Barrett formula has been updated and is now incorporated into the ARGOS biometer, introducing the Barrett true axial length (BTAL) formula. This new formula has resolved the concerns regarding the accuracy of conventional Barrett Universal II formula calculated using the ARGOS anterior chamber depth, therefore aims to minimize refractive prediction errors in eyes measured with the ARGOS biometer [12, 13]. However, there is a scarcity of literature discussing the outcomes of these novel formulas that permit the use of AXLsos in IOL power calculations.

The aim of this study was to study the added effect of sum-of-segments biometry to modern intraocular lens power calculation formulas for eyes with short axial length.

Material and methods

This was a retrospective case series that included 99 eyes from 99 patients. The included patients were older than 18 years of age, phakic patients with cataract and AXL less than or equal 22.0 mm. The patients included in this study underwent a standard and uneventful phacoemulsification procedure, followed by the implantation of a hydrophobic single-piece acrylic intraocular lens (Alcon AcrySof model SA60AT), within the capsular bag. Following the procedure, the patients were scheduled for a final follow-up appointment and provided their written consent to participate in the research. Exclusion criteria for the study included patients who experienced intraoperative complications that could compromise postoperative biometric measurements, those with inadequate visual acuity that would impede proper postoperative refraction, and individuals with other ocular conditions affecting biometric assessments, such as corneal scarring or lens dislocation. A review of the medical records of the patients, spanning from January 2021 to October 2024, was conducted. Demographic information, including age and sex, was documented, along with biometric parameters such as axial length (AXL), keratometric readings (K), anterior chamber depth (ACD), lens thickness, central corneal thickness, and white-to-white diameter.

Preoperative AXL measurements were conducted utilizing the ARGOS biometer (Alcon, Inc., Fort Worth, TX), an advanced swept-source optical coherence tomography (SS-OCT) biometer operating at a wavelength of 1060 nm. This device employs sum-of-segments biometry along with a segmental refractive index. The mean of three high-quality scans was documented. All patients underwent standard phacoemulsification without complications, followed by the implantation of a foldable hydrophobic acrylic IOL, and were monitored in the postoperative period. At 4 to 6 weeks after surgery, manifest refraction was assessed. The refractive error was subsequently converted to spherical equivalent (SE) and recorded, calculated as SE = spherical power + (cylinder power/2).

The results of various IOL power calculation formulas were analyzed in this study. Two integrated formulas from ARGOS were employed: Barrett Universal II (BUII) and BTAL. Additionally, the following formulas were utilized: Cooke K6 [11], EVO 2.0, and PEARL DGS, all of which can be accessed through the ESCRS IOL calculator website (https://iolcalculator.escrs.org/). The last three formulas available on the ESCRS online IOL calculator were applied both with (Cooke K6sos, EVO 2.0sos, and PEARL-DGSsos) and without the selection of the ARGOS AXLsos option. The Cooke K6 formula employs the general vergence formula, thereby mitigating some limitations associated with thick-lens, ray-tracing, and artificial intelligence formulas; it is also accessible online at (https://cookeformula.com/) [14]. The PEARL-DGS formula, which stands for Postoperative Spherical Equivalent prediction using Artificial intelligence and Linear algorithms, was developed by Debellemanière, Gatinel, and Saad. This thick lens formula utilizes artificial intelligence to estimate the distance between the posterior corneal surface and the anterior IOL surface (theoretical internal lens position) and is available online at www.iolsolver.com [15]. EVO (Emmetropia Verifying Optical) 2.0 is a contemporary thick-lens formula based on the theory of emmetropization, which can also be found online at https://www.evoiolcalculator.com/calculator.aspx [16]. The initial A-constant for most formulas was set at 118.8, while for the BUII and BTAL formulas, the initial Lens Factor (LF) was 1.74. These lens constants were updated from the ARGOS biometer and the online site of "User group for Laser Interference Biometry" (ULIB), available at http://ocusoft.de/ulib/c1.htm.

Refractive prediction error (PE) was determined by calculating the difference in spherical equivalent between the value predicted by the formula and the actual value measured 4 to 6 weeks after surgery. The absolute prediction error (APE) was derived by converting the PE into an absolute figure. The main outcomes assessed included the median absolute prediction error, the mean absolute prediction error, and the percentage of cases falling within 0.25, 0.5 D, 1 D, and 2 D of the desired refraction.

Data analysis was performed using the Social Sciences SPSS Statistics for Windows (version 26.0; SPSS Inc., Chicago, IL, USA). The quantitative data were described in terms of their range, median, mean, and standard deviation. The normality of the dataset was evaluated using the Kolmogorov–Smirnov test. Friedman's ANOVA test was utilized to compare different means. The Wilcoxon signed-rank test for paired samples was used to assess the medians within the same group. Additionally, the Cochran's Q test was applied to examine the distribution of cases within the specified refraction range. Statistical significance was established when the p value was less than 0.05, 95% confidence interval. Eyetemis web-based analysis software) was used to double check the results of spherical equivalent prediction errors [17].

Results

This study included 99 eyes from 99 patients. The mean age was 53.7 ± 7.1 years (range from 43 to 69 years). The study included 50 males and 49 females. Table 1 shows the demographic and biometric data of the included patients ($n = 99$).

Table 1 Demographic and biometric data of the included patients ($n = 99$)

	Mean ± SD (range) ($n = 99$)
Age (years)	53.7 ± 7.1 (43 – 69)
Sex (Male: Female)	50: 49
Axial length (mm)	20.89 ± 0.67 (19.80 – 21.98)
Average Keratometry (D)	46.17 ± 0.89 (44.00 – 47.50)
Anterior chamber depth (mm)	2.75 ± 0.40 (2.10 – 3.62)
White to white diameter (mm)	11.27 ± 0.40 (10.70 – 11.90)
Lens thickness (mm)	4.67 ± 0.40 (3.70 – 5.10)
Central corneal thickness (microns)	525 ± 17.5 (495 – 585)

Table 2 lists the arithmetic mean prediction errors of the included formulas. The ANOVA showed that the difference was statistically significant ($p = 0.017$). The PEARL-DGS$_{sos}$ was the only formula to show a myopic mean prediction error (−0.25 ± 0.36 D). The Cooke K6 formula showed the highest hyperopic mean prediction error (0.55 ± 0.35 D), followed by EVO 2.0, Cooke K6$_{sos}$, and BUII formulas. The mean and median absolute errors (MAE and MedAE) for the various formulas are shown in Table 2. Table 2 displays the number of cases within ± 0.25 D, ± 0.5 D, and ± 1.0 D of the target refraction. The Friedman's ANOVA test showed statistically significant differences ($p = 0.014$). Post-hoc analysis showed statistically significant differences between PEARL-DGS and PEARL-DGSsos, Cooke K6 and Cooke K6sos, BUII and BTAL, and EVO 2.0 and EVO 2.0sos. The Cochran's Q test was used to analyze the number of cases falling within the targeted refraction range; the results indicated a statistically significant difference ($p < 0.05$). EVO 2.0$_{sos}$ and PEARL-DGS$_{sos}$ formulas showed the least mean and median absolute errors. The median absolute error (MedAE) for EVO 2.0$_{sos}$ and PEARL-DGS$_{sos}$ was 0.29 and 0.31 D respectively.

EVO 2.0$_{sos}$ and PEARL-DGS$_{sos}$ formulas had the highest cases within ± 0.25 D of the intended refraction (45.45% and 42.42%, respectively). Cooke K6 formula had the least cases within ± 0.25 D of the intended refraction (15.50%). EVO 2.0$_{sos}$, Cooke K6$_{sos,}$ and PEARL-DGS$_{sos}$ formulas had 100% of cases within ± 1.0 D of the intended refraction. Cooke K6 formula had the least cases within ± 1.0 D of the intended refraction (87.88%). All of the included formulas had 100% of cases within ± 2.0 D of the target refraction.

Subgroup analysis of eyes with AXL 21 mm or shorter ($n = 57$) was done. The mean AXL was 20.41 ± 0.40 mm (range 19.80 to 21.00 mm). Table 3 shows the mean and median absolute errors for the included formulas for eyes ≤ 21 mm AXL. Table 3 also displays the number of cases within ± 0.25 D, ± 0.5 D, and ± 1.0 D of the target refraction for eyes ≤ 21 mm AXL. The PEARL-DGS$_{sos}$ formula showed the only myopic mean prediction error (−0.23 ± 0.37 D). The Cooke K6 and EVO 2.0 formulas showed the highest hyperopic mean prediction error (0.58 ± 0.36 D and 0.52 ± 0.42 D respectively). The MAE and MedAE for the various formulas are shown in Table 3 for eyes ≤ 21 mm. Table 3 displays the number of cases within ± 0.25 D, ± 0.5 D, and ± 1.0

Table 2 The outcome of different formulas among the included eyes ($n=99$)

($n=99$)	Mean arithmetic error ± SD (range) (D)	Mean absolute error ± SD (range) (D)	Median absolute error (D)	eyes with a PE within ± 0.25 D	eyes with a PE within ± 0.5 D	eyes with a PE within ± 1.0 D
Barrett Universal II	0.27 ± 0.43 (−0.39 – 1.07)	0.42 ± 0.27 (0.02 – 1.07)	0.34	30.30%	60.61%	93.94%
Barrett true axial length	0.15 ± 0.47 (−0.67 – 1.00)	0.40 ± 0.29 (0.00 – 1.00)	0.40	36.36%	60.61%	96.97%
Cooke K6	0.55 ± 0.35 (−0.27 – 1.18)	0.58 ± 0.30 (0.10 – 1.18)	0.60	15.50%	36.36%	87.88%
Cooke $K6_{sos}$	0.31 ± 0.34 (−0.56 – 0.95)	0.38 ± 0.26 (0.01 – 0.95)	0.39	30.30%	72.73%	100%
EVO 2.0	0.38 ± 0.42 (−0.33 – 1.21)	0.47 ± 0.32 (0.06 – 1.21)	0.34	33.33%	57.58%	90.91%
EVO 2.0_{sos}	0.07 ± 0.39 (−0.67 – 0.80)	0.33 ± 0.22 (0.00 – 0.80)	0.29	45.45%	78.79%	100%
PEARL-DGS	0.23 ± 0.39 (−0.52 – 0.98)	0.38 ± 0.24 (0.04 – 0.98)	0.34	36.36%	66.67%	93.94%
PEARL-DGS_{sos}	−0.25 ± 0.36 (−1.02 – 0.46)	0.35 ± 0.27 (0.01 – 1.02)	0.31	42.42%	72.73%	100%

SOS sum-of-segments

Table 3 The outcome of different formulas among the eyes ≤ 21 mm axial length ($n=57$)

($n=57$)	Mean arithmetic error ± SD (range) (D)	Mean absolute error ± SD (range) (D)	Median absolute error (D)	Eyes with a PE within ± 0.25 D	Eyes with a PE within ± 0.5 D	Eyes with a PE within ± 1.0 D
Barrett Universal II	0.43 ± 0.39 (−0.38 – 1.07)	0.50 ± 0.29 (0.02 – 1.07)	0.55	21.05%	42.11%	89.47%
Barrett true axial length	0.23 ± 0.46 (−0.67 – 1.00)	0.39 ± 0.33 (0.00 – 1.00)	0.40	42.11%	57.89%	94.74%
Cooke K6	0.58 ± 0.36 (−0.27 – 1.18)	0.63 ± 0.27 (0.18 – 1.18)	0.66	5.26%	26.32%	89.47%
Cooke $K6_{sos}$	0.31 ± 0.36 (−0.56 – 0.95)	0.41 ± 0.22 (0.01 – 0.95)	0.40	15.79%	73.68%	100%
EVO 2.0	0.52 ± 0.42 (−0.33 – 1.21)	0.58 ± 0.31 (0.13 – 1.21)	0.60	15.79%	36.84%	84.21%
EVO 2.0_{sos}	0.16 ± 0.40 (−0.67 – 0.80)	0.35 ± 0.24 (0.00 – 0.80)	0.29	47.37%	73.68%	100%
PEARL-DGS	0.33 ± 0.39 (−0.52 – 0.98)	0.43 ± 0.26 (0.04 – 0.98)	0.44	26.32%	52.63%	89.47%
PEARL-DGS_{sos}	−0.23 ± 0.37 (−1.02 – 0.46)	0.32 ± 0.30 (0.02 – 1.02)	0.28	47.37%	84.21%	100%

SOS sum-of-segments

D of the target refraction for eyes shorter than or equal 21 mm. The Friedman's ANOVA test showed statistically significant differences ($p=0.023$). The Cochran's Q test was used to analyze the number of cases falling within the targeted refraction range; the results indicated a statistically significant difference ($p<0.05$). PEARL-DGS_{sos} and EVO 2.0_{sos} formulas showed the lowest median absolute errors (0.28 and 0.29 D, respectively). Cooke K6, EVO 2.0, and BUII had the highest MedAE (0.66, 0.60, and 0.55 D, respectively). PEARL-DGS_{sos} and EVO 2.0_{sos} formulas had the highest cases within ± 0.25 D of the intended refraction (47.37%), followed by BTAL (42.11%). Cooke K6 formula had the least cases within ± 0.25 D of the intended refraction (5.26%) followed by EVO 2.0 and Cooke $K6_{sos}$ (15.79%). For eyes ≤ 21 mm, Cooke $K6_{sos,}$ EVO $2.0_{sos,}$ and PEARL-DGS_{sos} formulas had 100% of cases within ± 1.0 D of the target refraction. All of the included formulas had

100% of cases within ± 2.0 D of the target refraction for eyes ≤ 21 mm.

Discussion

The ARGOS optical biometer provides a unique method that measures the AXL that uses a sum-of-segments concept or a segmental refractive index instead of the composite one used by most of the other optical biometers. This resulted in a longer AXL in the eyes with short axial length which lead to a lower IOL power [16]. The authors in the current study used the cutoffs for eyes with short axial length of 22.00 mm as reported by Shammas and Jabre [18].

Not all contemporary IOL power calculation formulas provide the option to utilize sum-of-segments axial length (AXLsos). The Cooke K6, EVO 2.0, and PEARL-DGS formulas do offer this option. These formulas can be accessed on their respective websites as well as on the online ESCRS IOL calculator platform. The Barrett Universal II formula features a modified version, known as the BTAL formula, which is integrated into the ARGOS biometer and employs AXLsos. This study aims to evaluate the accuracy of incorporating AXLsos in the aforementioned formulas, comparing results with and without the sum-of-segments option. The authors conducted a back-calculation of the predicted outcomes from various formulas and juxtaposed these with the actual postoperative refraction. The IOL constants utilized were those that are routinely applied in clinical practice to evaluate outcomes in real-world scenarios.

In the current study, it was noted that the PEARL-DGS_{sos} was the only formula to show a myopic mean prediction error. All the formulas without SOS correction option (Cooke K6, followed by EVO 2.0, Cooke $K6_{sos}$, and BUII formulas had hyperopic mean prediction error. By choosing SOS option or using BTAL, the outcome turned into less hyperopic which is more desirable. This suggests that when less hyperopia or myopia is desired, it is better to choose SOS option or BTAL when using an axial length measured by ARGOS. It is worth mentioned here, that hyperopic shift is an undesirable outcome. Kato et al. [19] evaluated the accuracy of BTAL and EVO formulas using segmental refractive index in comparison to the conventional BUII. They reported that the mean arithmetic error differed significantly among the 3 formulas in eyes with short axial length, BU II giving 0.32 ± 0.40 D, BTAL 0.22 ± 0.37 D, and EVO 0.10 ± 0.37 D ($P < 0.0001$). This is similar to the results of the current study, where BUII formula showed hyperopic outcome that decreased with BTAL and EVO 2.0_{sos}.

In the current study, all formulas with SOS option and BTAL performed well, with almost all the cases within ± 1 D of intended refraction. The EVO 2.0_{sos}, PEARL-DGS_{sos}, and Cooke $K6_{sos}$ formulas yielded the lowest MedAE in both the whole pool of cases and the subgroup with 21 mm or shorter AXL. Using BTAL or the SOS option in the other included formulas decreased the MedAE in a more evident way in the subgroup of short AXL ≤ 21 mm. Shammas et al. [20] analyzed the accuracy of many newer IOL power formulas using SOS biometry including BUII, BTAL, K6, EVO, and PEARL-DGS. The authors classified eyes with short axial length into 2 groups: short with an AXL ≤ 22.5 mm and very short with an AXL ≤ 22.0 mm. They reported a MedAE for short and very short eyes of 0.31 D and 0.35 D with BU II, 0.30 D and 0.32 D with BTAL, 0.26 D and 0.26 D with Cooke K6, 0.28 D and 0.33 D with EVO, and 0.27 D and 0.27 D with PEARL-DGS, respectively. The current study reported slightly higher values for MedAE for eyes with short axial length ≤ 22.0 mm. The difference could be attributed to the lower mean AXL in this study with more included eyes shorter than 21 mm. Their mean AXL for eyes with short axial length was (22.00 ± 0.38 mm, range from 20.75 to 22.49 mm) versus mean AXL of 20.89 ± 0.67 mm (range from 19.80 to 21.98 mm) in the current study.

Miyamoto et al. [12] aimed at verifying the accuracy of BTAL. They included 356 Japanese eyes with mean AXL 23.84 ± 1.16 mm. The MAEs for BTAL and BUII were 0.225 ± 0.179 D and 0.219 ± 0.168 D, respectively. This was less than the reported MAEs for the current study for BTAL and BUII which were 0.42 ± 0.27 D and 0.40 ± 0.29 D, respectively. This is due to the difference between the mean AXL between the 2 studies. Blehm et al. [21] reported that the predictability of ARGOS measurements and the BUII formula in eyes with short axial length implanted with an extended depth of focus IOL was moderate with a prediction error of 0.33 ± 0.33 D. The percentage of eyes in their study with ≤ 0.5 D of MRSE was 74% for eyes with short axial length ≤ 22.5 mm (mean AXL was 22.21 ± 0.24 mm). The current study showed a lower percentage of cases with ± 0.50 D of intended refraction with the BUII (60.61% in the whole cases and 42.11% in the subgroup with shorter eyes ≤ 21.0 mm). Blehm et al. [21] reported a lower MedAE for the BUII (0.27 D) than the current study (0.34 D for the whole cases and 0.55 D for subgroup ≤ 21.0 mm). This is due to the shorter mean AXL in the current study and the more included cases less than 21.0 mm.

Blehm et al. [22] in another study compared the refractive predictability of ARGOS measurements with BUII and BTAL formulas in a large sample (445 eyes) of long (≥ 24.5 mm), medium, and short AXL eyes. They included 75 eyes with short axial length (≤ 22.5 mm) with mean AXL of 22.08 ± 0.45 mm. They reported a hyperopic mean arithmetic error for both BUII and BTAL of 0.34 ± 0.48 D and 0.15 ± 0.46 D, respectively. They reported MAE of 0.45 ± 0.37 D and 0.37 ± 0.31 D for BUII and BTAL, respectively. Their results were comparable to our results especially in the less hyperopic BTAL mean arithmetic error in comparison to the BUII formula despite their higher mean AXL. It was noted that both eyes from certain patients were included in the analysis, potentially introducing bias. Additionally, it was indicated that the data examined originated from a single site, which may limit its relevance to other surgeons.

It is noteworthy to mention different approaches to evaluate the accuracy of IOL power calculation formulas and to optimize the lens constants. Gatinel et al. [23] concluded that prioritizing standard deviation minimization before adjusting the mean prediction error significantly improved the precision of the selected IOL power calculation formulas, which enhanced postoperative refractive outcomes. Lagenbucher et al. [24] investigated the performance of a simple strategy for formula constant optimization. Stopyra et al. [25] used root mean square absolute error (RMSAE) as a primary outcome. Stopyra W [26] in another study used the agreement interval in Bland–Altman analysis.

The current study showed some points of strength, including a large proportion of eyes with short axial length of 21 mm or less. This study presented the results of IOL power calculation formulas, both with and without the option of the SOS even when utilizing the AXLsos measurement. A notable aspect of the study is the simultaneous strength and limitation associated with the use of lens constants without additional optimization. The authors emphasized the necessity of reporting actual clinical practice outcomes based on the constants already employed in the ARGOS machine and available on the ULIB website. Only one IOL model was investigated, this IOL is a spherical model, which is likely to generate positive spherical aberrations (the results may be slightly different with aspheric IOLS). Another possible limitation identified was the absence of comparisons with other contemporary formulas, such as Kane and Hill RBF 3.0, as well as the retrospective design of the study. The authors opted to focus solely on formulas that included the SOS option to evaluate its impact on outcomes with and without this feature. To further improve the accuracy of refractive cataract surgery, advancements in IOL manufacturing technology, such as the introduction of 0.25-D increments, would be beneficial in enhancing postoperative patient satisfaction.

Conclusions

In conclusion, PEARL-DGS$_{sos}$ was the only formula to show a myopic mean prediction error. Using BTAL and SOS option in Cooke K6, EVO 2.0, and PEARL-DGS formulas decreased the undesirable hyperopic shift in the mean prediction error. This effect was more evident in shorter eyes ≤ 21.0 mm.

Abbreviations

ACD	Anterior chamber depth
APE	Absolute prediction error
AXL	Axial length
AXLsos	Sum-of-segments axial length
BTAL	Barrett true axial length formula
BUII	Barrett Universal II
D	Diopter
ESCRS	European Society of Cataract and Refractive Surgery
IOL	Intraocular lens
MAE	Mean absolute error
MedAE	Median absolute error
PE	Prediction error
RMSAE	Root mean square absolute error
SE	Spherical equivalent
SOS	Sum-of-segments
SS-OCT	Swept-source optical coherence tomography

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Authors' contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by all authors. The first draft of the manuscript was written by H. A.H. M.H.E., M.S.E., and M.S.H. commented on previous versions of the manuscript. All authors reviewed, read and approved the final manuscript.""All authors contributed to data analysis, drafting or revising the article, agreed on the journal to which the article was submitted, agreed on all the versions of the article before submission and during revision, gave final approval of the accepted version to be published and any significant changes introduced at the proofing stage, and agree to be accountable for all aspects of the work.

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Data availability

Data analysed is available upon request.

Declarations

Ethics approval and consent to participate

Authors of research involving human or animal subjects should include a statement that confirms that the study was approved (or granted exemption) by the appropriate institutional and/or national research ethics committee (including the name of the ethics committee and reference number, if available). For research involving animals, their data or biological material, authors should supply detailed information on the ethical treatment of their animals in their submission. If a study was granted exemption or did not require ethics approval, this should also be detailed in the manuscript.
This study was performed in line with the principles of the Declaration of Helsinki. This is an observational study. The Faculty of Medicine, Alexandria University Research Ethics Committee has confirmed that no ethical approval is required.
Informed consent was obtained from all individual participants included in the study.

Consent for publication

Not applicable here … "The authors affirm that human research participants provided informed consent for publication of data."

Competing interests
The authors declare no competing interests.

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