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ORIGINAL RESEARCH

Evaluation of Sum of Segments Biometry in Modern Intraocular Lens Power Calculation Formulas for Long Eyes

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Purpose: To evaluate the sum of segments (SOS) biometry in modern intraocular lens power (IOL) calculation formulas for long eyes.

Methods: This was a retrospective case series that included 177 eyes from 177 patients with axial length (AL) ≥ 24.5 mm. Preoperative AL measurements were performed using the ARGOS (Alcon, Inc). This study used 2 formulas: the Barrett Universal II (BUII) and the Barrett true axial length (BTAL). Other formulas were included: Cooke K6, EVO 2.0, and PEARL DGS.

Results: The Barrett Universal II formula exhibited the most significant myopic mean prediction error at −0.15 ± 0.27 D, with the Cooke K6, PEARL-DGS, and EVO 2.0 formulas following. In terms of hyperopic mean prediction error, the PEARL-DGSsos formula recorded the highest value at 0.19 ± 0.32 D, succeeded by the EVO 2.0sos, Cooke K6sos, and BTAL formulas. The EVO 2.0, PEARL-DGS, Barrett Universal II, and Cooke K6 formulas demonstrated the lowest mean and median absolute errors, with BTAL, EVO 2.0sos, Cooke K6sos, and PEARL-DGSsos formulas trailing behind. The median absolute errors (MedAE) for EVO 2.0, PEARL-DGS, and Barrett Universal II were recorded at 0.13, 0.15, and 0.16 D, respectively.

Conclusion: BUII formula showed myopic shift with SOS biometry which increases with longer eyes. Using SOS option in Cooke K6, EVO 2.0, and PEARL-DGS formulas leads to a hyperopic shift in the mean prediction error which is undesirable. Using ALsos in those formulas without choosing the option of SOS yields a mean prediction error towards the myopic side which might be more desirable. All included formulas performed well with ALsos with most of the cases within + 1 D of intended refraction.

Keywords: biometry, sum of segments, ARGOS, long eyes, IOL power calculation

Introduction

Accurate Measurement of the axial length (AL) is important for intraocular lens (IOL) power calculation. Errors in AL measurements result in significant postoperative refractive errors.[1] Measurement inaccuracy in AL and ACD can contribute to 36% and 42% errors in IOL power calculation.[2,3] Optical biometry has become the gold standard in AL measurements with high reproducibility and accuracy.[4,5]

Most of the currently available optical biometers use single refractive index to measure the total AL then convert the optical path length to geometrical distance. ARGOS (Alcon Laboratories, Inc.) is a new swept light-source equipped optical biometer with 1060 nm wavelength infrared light that allows better penetration for dense cataracts. ARGOS uses sum of segments biometry to measure the AL. It is the only optical biometer that uses a segmental refractive index instead of the composite one used by most of the other devices. It uses a different refractive index for each ocular segment (cornea 1.376, aqueous humor 1.336, lens 1.410 and vitreous). This sum of segments method resulted in longer AL in short eyes and shorter AL in long eyes. This may be explained by the relative large proportion of the lens thickness in short AL and the relative large proportion of the vitreous cavity in the long AL. In long eyes, shorter AL yields higher

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power of the IOL thus avoiding hyperopic error.[6–10] Traditionally, it was recommended that the ophthalmic surgeon choose an IOL that leaves a residual myopic refractive error to avoid hyperopic surprise. To reduce the possibility of a hyperopic refractive error, some authors proposed preoperative AL correction factors.[11]

Nowadays, there are some IOL power calculation formulas that allow the option of choosing the input of a sum of segments AL (ALsos). The following formulas are available online: Cooke K6, EVO 2.0, and PEARL-DGS formulas. (Available at: https://iolcalculator.escrs.org/). Barrett formula has a new update that is included in the ARGOS, which is the Barrett true AL (BTAL) formula. BTAL is expected to reduce the refractive prediction error in eyes measured using ARGOS biometer. Still, few articles address the results of such new formulas that allow the use of ALsos in IOL power calculation.[12,13]

The purpose was to evaluate sum of segments method using newer formulas to calculate the IOL power in long eyes.

Material and Methods

The current study was a case series (retrospective). There were 177 eyes from 177 patients in the study. The inclusion criteria for the age were above 18 years of age, cataractous patients, and AL ≥ 24.5 mm. The included patients underwent a standard, uneventful, phacoemulsification with a foldable IOL implantation (Akreos Adapt AO, Bausch + Lomb, USA). The patients were invited for a concluding follow-up appointment and provided their written consent. The study received approval from ethics committee at the Alexandria University. The framework adheres to the principles outlined in the Declaration of Helsinki. Exclusion of the candidates was based on the presence of any intraoperative complications that affected the IOL position, patients with previous corneal refractive surgery, or poor visual acuity hindering adequate postoperative refraction. The review of patients' data was done (from January 2021 to October 2024). Patients' data was recorded including age and gender, together with their biometric data.

Preoperative axial length (AL) measurements were conducted using ARGOS biometer, which is a state-of-the-art swept-source optical coherence tomography (SS-OCT) device. This biometer employs a sum of segments approach for biometry, incorporating a segmental refractive index. The average of three high-quality scans was documented. All patients underwent standard phacoemulsification surgery without complications, followed by the implantation of the foldable IOL. Postoperative refraction was performed after 1 month.

Different possible calculations were done using different IOL power formulas. The current study used two ARGOS formulas: Barrett Universal II (BUII) and BTAL. Other formulas that were used: Cooke K6, PEARL DGS, and EVO 2.0, which are available online on the website (https://iolcalculator.escrs.org/). The last 3 formulas available at the ESCRS online IOL calculator were used with (Cooke $K6_{sos}$,[14] PEARL-DGS_{sos}[15] and EVO 2.0_{sos}[16]) and without choosing the option of ARGOS ALsos. The initial A-constant used was 118.4 for most formulas. For the 2 Barrett formulas, the initial Lens Factor (LF) was 1.62. These lens constants were updated from the online IOL constants library IOLCon available at https://iolcon.org/index.php and (https://iolcalculator.escrs.org/).

The primary outcome included mean absolute prediction error, median absolute prediction error, and the proportion of eyes that achieved 0.25, 0.5 D, 1 D and 2 D from intended refraction.

The analysis of data was conducted utilizing (version 26.0; SPSS Inc., Chicago, IL, USA). The normality of the dataset was assessed through the Kolmogorov–Smirnov test. The Wilcoxon signed-rank test for paired samples was applied to evaluate the medians within the same group. The Cochran Q test was employed to analyze the number of cases falling within the targeted refraction range. Differences were deemed statistically significant when the corresponding p value was less than 0.05.

Results

This study included 177 eyes from 177 patients. The mean age was 51.7 ± 7.5 years (range from 40 to 67 years). The study included 100 males and 77 females. Table 1 shows the demographic and biometric data of the included patients (n = 177).

Table 2 presents the arithmetic mean prediction errors associated with the formulas analyzed. The results of the ANOVA indicated a statistically significant difference ($p < 0.05$). Among the formulas, the Barrett Universal II exhibited the most substantial myopic mean prediction error (−0.15 ± 0.27 D), followed by the Cooke K6, PEARL-DGS, and EVO 2.0 formulas. In terms of hyperopic mean prediction error, the PEARL-DGSsos formula recorded the highest value (0.19

Table 1 Demographic and Biometric Data of the Included Patients (n=177)

	Mean ± SD (range) (n = 177)
Age (years)	51.7 ± 7.5 (40–67)
Sex (Male: Female)	100: 77
Axial length (mm)	28.31 ± 1.92 (25.10–31.66)
Average Keratometry (D)	43.87 ± 0.99 (42.10–44.95)
Anterior chamber depth (mm)	3.40 ± 0.34 (2.90–4.42)
White to white diameter (mm)	12.27 ± 0.42 (11.70–13.00)
Lens thickness (mm)	4.37 ± 0.30 (3.70–5.10)
Central corneal thickness (microns)	545 ± 18.5 (505–608)

Table 2 The Outcome of Different Formulas Among the Included Eyes (n=177)

(n=177)	**Mean Arithmetic Error ± SD (range) (D)**	**Mean Absolute Error ± SD (range) (D)**	**Median Absolute Error (D)**	**Cases Within ± 0.25 D (%ge)**	**Cases Within ± 0.5 D (%ge)**	**Cases Within ± 1.0 D (%ge)**
Barrett Universal II	−0.15 ± 0.27 (−1.10–0.46)	0.22 ± 0.21 (0.00–1.10)	0.16	67.80%	91.53%	98.31%
Barrett true axial length	0.10 ± 0.31 (−1.10–0.72)	0.26 ± 0.21 (0.01–1.10)	0.21	55.93%	88.14%	98.31%
Cooke K6	−0.04 ± 0.36 (−1.15–0.66)	0.26 ± 0.25 (0.01–1.15)	0.19	61.02%	84.75%	98.31%
Cooke K6$_{sos}$	0.12 ± 0.35 (−1.02–0.84)	0.30 ± 0.23 (0.01–1.02)	0.26	47.46%	84.75%	98.31%
EVO 2.0	−0.02 ± 0.32 (−1.11–0.61)	0.22 ± 0.23 (0.00–1.11)	0.13	66.10%	88.14%	98.31%
EVO 2.0$_{sos}$	0.14 ± 0.32 (−0.92–0.80)	0.28 ± 0.22 (0.01–0.92)	0.21	55.93%	81.36%	100%
PEARL-DGS	−0.08 ± 0.33 (−1.16–0.64)	0.23 ± 0.24 (0.00–1.16)	0.15	69.49%	88.14%	98.31%
PEARL-DGS$_{sos}$	0.19 ± 0.32 (−0.87–0.81)	0.31 ± 0.20 (0.03–0.87)	0.26	45.76%	81.36%	100%

Abbreviation: SOS, sum of segments.

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± 0.32 D), with the EVO 2.0sos, Cooke K6sos, and BTAL formulas following. The mean and median absolute errors (MAE and MedAE) for the various formulas are detailed in Table 2. Additionally, Table 2 and Figure 1 illustrate the distribution of cases within ± 0.25 D, ± 0.5 D, and ± 1.0 D of the intended refraction. Friedman's ANOVA test confirmed statistically significant differences ($p < 0.05$). A chi-square test was employed to evaluate the number of cases that fell within the specified refraction range, yielding statistically significant results ($p < 0.05$). The EVO 2.0, PEARL-DGS, Barrett Universal II, and Cooke K6 formulas demonstrated the lowest mean and median absolute errors, followed by the BTAL, EVO 2.0sos, Cooke K6sos, and PEARL-DGSsos formulas. The median absolute errors (MedAE) for the EVO 2.0, PEARL-DGS, and Barrett Universal II were recorded as 0.13, 0.15, and 0.16 D, respectively.

PEARL-DGS formula had the largest number of cases within ± 0.25 D of the intended refraction (69.49%), followed by BUII (67.80%) then EVO 2.0 (66.10%) and Cooke K6 (61.02%). $\text{PEARL-DGS}_{\text{sos}}$ formula had the least cases within ±

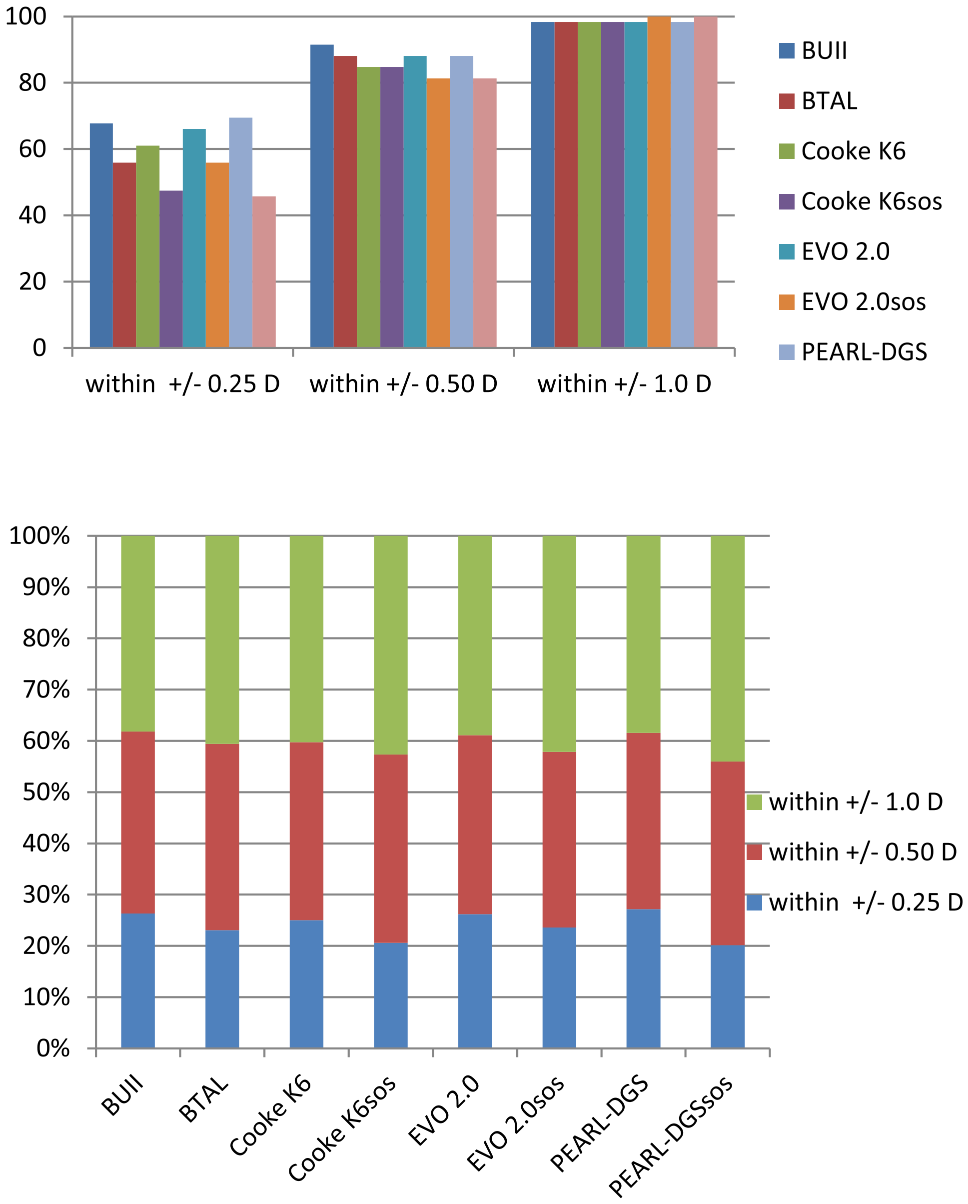

Figure 1 Percentage of overall cases within the intended refraction.

0.25 D of the intended refraction (45.76%) followed by Cooke K6$_{sos}$ (47.46%). EVO 2.0$_{sos}$ and PEARL-DGS$_{sos}$ formulas had 100% of cases within ± 1.0 D of the intended refraction. The rest of the included formulas had 98.31% of cases within ± 1.0 D of the intended refraction.

Subgroup analysis of eyes with ≥ AL 28 mm (99 eyes) was performed. The mean AL was 29.75 ± 2.20 mm (range 28.05 to 31.66 mm). Table 3 shows the mean and median absolute errors for the included formulas for eyes ≥ 28 mm AL. Table 3 shows the number of cases within the intended refraction for eyes ≥ 28 mm AL. The Barrett Universal II formula showed the highest myopic mean prediction error (−0.20 ± 0.28 D). The Cooke K6$_{sos}$ and PEARL-DGS$_{sos}$ formulas showed the highest hyperopic mean prediction error (0.23 ± 0.34 D and 0.22 ± 0.34 D respectively). The MAE and MedAE for the various formulas are shown in Table 3 for eyes ≥ 28 mm. Table 3 and Figure 2 display the number of cases within ± 0.25 D, ± 0.5 D, and ± 1.0 D of the intended refraction for eyes longer than 28 mm. The Friedman's ANOVA test showed statistically significant differences ($p < 0.05$). The chi-square test was utilized to analyze the number of cases falling within the targeted refraction range; the results indicated a statistically significant difference ($p < 0.05$). PEARL-DGS formula showed the lowest mean and median absolute errors, followed by BUII and EVO 2.0 formulas. The median absolute error (MedAE) for PEARL-DGS, BUII, and EVO 2.0 was 0.16, 0.21, and 0.21 D respectively. PEARL-DGS formula had the highest cases within ± 0.25 D of the intended refraction (66.67%), followed by BUII (63.64%) then EVO 2.0 (60.61%). PEARL-DGS$_{sos}$ formula had the least cases within ± 0.25 D of the intended refraction (33.33%) followed by Cooke K6$_{sos}$ (36.36%). For eyes ≥ 28 mm, all of the included formulas had 100% of cases within ± 1.0 D of the intended refraction except for BUII, EVO 2.0, and PEARL-DGS formulas (had 96.97% of cases within ± 1.0 D of the intended refraction). All of the included formulas had 100% of cases within ± 2.0 D of the intended refraction for eyes ≥ 28 mm.

Table 3 The Outcome of Different Formulas Among the Eyes ≥ 28 mm Axial Length (n=99)

(n=99)	Mean Arithmetic Error ± SD (range) (D)	Mean Absolute Error ± SD (range) (D)	Median Absolute Error (D)	Cases Within ± 0.25 D (%ge)	Cases Within ± 0.5 D (%ge)	Cases Within ± 1.0 D (%ge)
Barrett Universal II	−0.20 ± 0.28 (−1.10–0.22)	0.26 ± 0.23 (0.02–1.10)	0.21	63.64%	87.88%	96.97%
Barrett true axial length	0.18 ± 0.33 (−0.92–0.80)	0.29 ± 0.22 (0.01–0.92)	0.25	42.42%	81.82%	100%
Cooke K6	0.05 ± 0.34 (−0.98–0.66)	0.26 ± 0.22 (0.01–0.98)	0.23	54.55%	84.85%	100%
Cooke K6$_{sos}$	0.23 ± 0.34 (−0.82–0.84)	0.35 ± 0.21 (0.08–0.84)	0.31	36.36%	81.82%	100%
EVO 2.0	−0.03 ± 0.34 (−1.11–0.58)	0.25 ± 0.23 (0.01–1.11)	0.21	60.61%	87.88%	96.97%
EVO 2.0$_{sos}$	0.18 ± 0.34 (−0.92–0.80)	0.32 ± 0.22 (0.01–0.92)	0.27	42.42%	81.82%	100%
PEARL-DGS	−0.11 ± 0.33 (−1.16–0.42)	0.24 ± 0.25 (0.00–1.16)	0.16	66.67%	90.91%	96.97%
PEARL-DGS$_{sos}$	0.22 ± 0.34 (−0.87–0.76)	0.35 ± 0.20 (0.09–0.87)	0.31	33.33%	78.79%	100%

Abbreviation: SOS, sum of segments.

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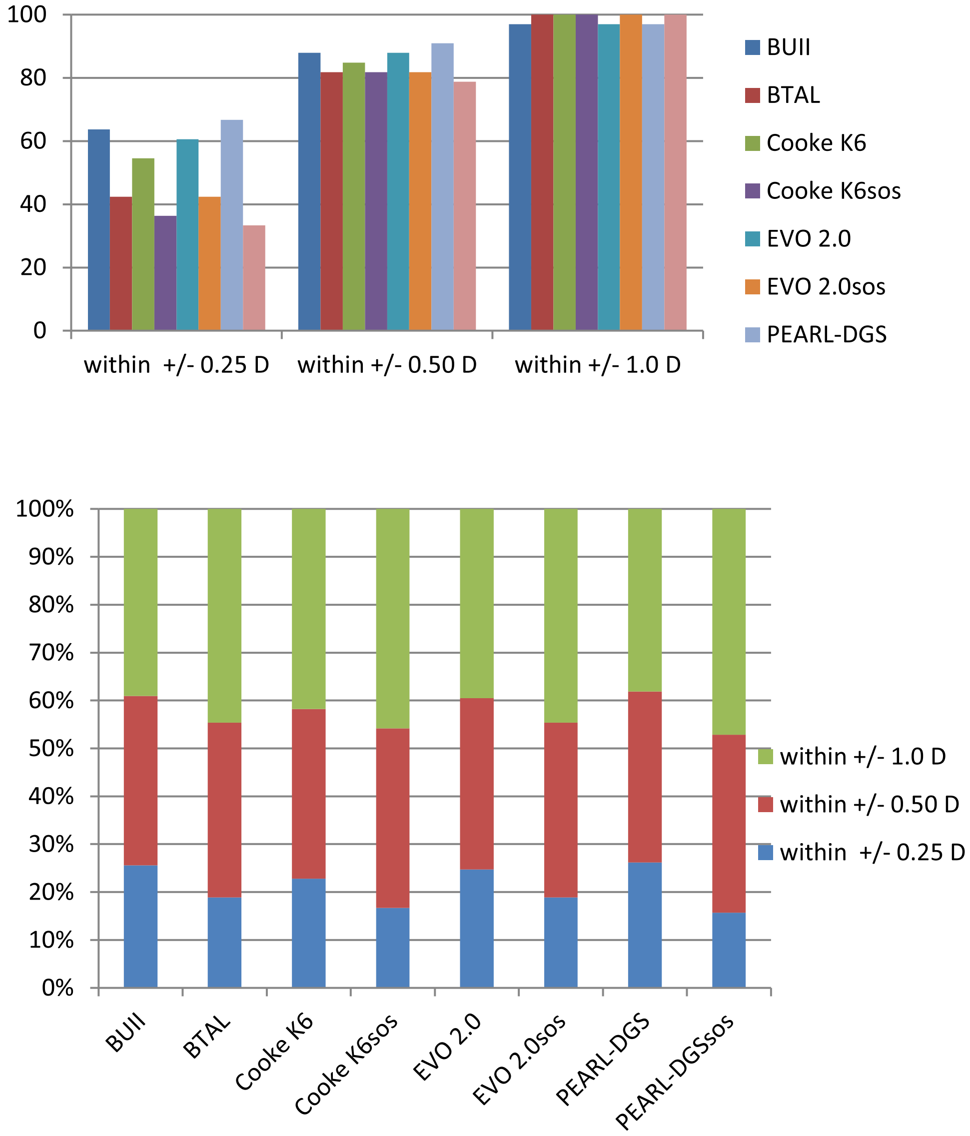

Figure 2 Percentage of cases ≥ 28 mm within the intended refraction.

Discussion

ARGOS optical biometer provides a different measure of the AL that uses sum of segments biometry or a segmental refractive index instead of the composite one used by most of the other devices. This resulted in a shorter AL in long eyes which lead to a higher IOL power. This is comparable to Wang-Koch axial length adjustment in long eyes that results in using shorter axial length in the IOL power calculation formula.[17] Cooke modified AL (CMAL) method closely approximates sum of segments AL.[14] The authors in the current study used the cutoffs for long eyes of 24.50 mm as reported by Shammas and Jabre.[18]

Not all the newer IOL power calculation formulas have the option of using sum of segments axial length. Cooke K6, EVO 2.0, and PEARL-DGS formulas have the option to choose the use of ALsos. Those formulas are available online at their own sites and at the online ESCRS IOL calculator website.[14–16] Barrett Universal II formula has a modified version that is installed in the ARGOS biometer which uses the ALsos (named BTAL formula). The current study covers the aspect of comparing the accuracy of using ALsos in the abovementioned formulas with and without choosing the option of sum of segments. The authors back calculated the predicted outcome of multiple formulas and compared it with the actual postoperative refraction. The IOL constants used were those actually applied in practice to assess the outcome using those constants in real practice situations.

In the present investigation, it was observed that the BUII formula exhibited the highest mean arithmetic error in myopic predictions, followed by the other formulas that did not incorporate the SOS option. The inclusion of the SOS option resulted in a more hyperopic outcome across all formulas, including BTAL. This finding indicates that when the objective is to achieve myopia, it is advisable to avoid selecting the SOS option, even when utilizing axial length measurements obtained from ARGOS. It is important to note that a hyperopic shift is generally considered an unfavorable result. Kato et al evaluated the precision of the BTAL and EVO formulas by employing a segmental refractive index, comparing them to the traditional BUII formula. Their findings revealed significant differences in mean arithmetic error among the three formulas, with BUII yielding 0.01 ± 0.32 D, BTAL 0.04 ± 0.32 D, and EVO 0.09 ± 0.32 D ($P < 0.0001$). Furthermore, in a subgroup analysis of patients with an ultra-long axial length exceeding 28 mm, the mean arithmetic error was notably different among the three formulas, with BUII showing −0.16 ± 0.34 D, BTAL 0.18 ± 0.33 D, and EVO 0.16 ± 0.32 D ($P < 0.0001$). These results align with the subgroup analysis conducted in the current study, where the BUII formula demonstrated a myopic outcome, in contrast to the hyperopic results produced by BTAL and EVO 2.0sos.

In the present investigation, all formulas demonstrated commendable performance, with nearly all cases falling within ±1 D of the targeted refraction. The EVO 2.0, PEARL-DGS, and BUII formulas exhibited the lowest median absolute error (MedAE) across the entire cohort as well as within the subgroup of eyes with an axial length (AL) of 28 mm or greater. Notably, the implementation of the SOS option in these formulas resulted in an increase in MedAE. Shammas et al conducted an analysis of the precision of several contemporary intraocular lens (IOL) power formulas utilizing SOS biometry, including BUII, BTAL, K6, EVO, and PEARL-DGS. The authors categorized long eyes into two distinct groups: those with an AL exceeding 24.5 mm and those classified as very long, with an AL of 25.0 mm or more. Their findings indicated a MedAE of 0.25 D for long eyes and 0.23 D for very long eyes with the BUII formula, 0.23 D and 0.24 D with BTAL, 0.25 D and 0.18 D with Cooke K6, 0.24 D and 0.22 D with EVO, and 0.25 D for both categories with PEARL-DGS. The current study reported a similar MedAE for long eyes. This minor discrepancy holds limited clinical significance, particularly given the availability of low power IOLs in 1.0 D increments. The observed difference may be attributed to the higher average AL in this study, which included a greater number of eyes with lengths exceeding 28 mm.

Miyamoto et al[12] conducted a study to assess the precision of the BTAL formula, involving 356 Japanese eyes with a mean axial length (AL) of 23.84 ± 1.16 mm. The mean absolute errors (MAEs) for BTAL and BUII were found to be 0.225 ± 0.179 D and 0.219 ± 0.168 D, respectively. These findings are comparable to the MAEs reported in the current investigation, which were 0.26 ± 0.21 D for BTAL and 0.22 ± 0.21 D for BUII, despite the differences in mean AL between the two studies. Additionally, Blehm et al[19] indicated that the predictability of ARGOS measurements and the BUII formula in longer eyes fitted with extended depth of focus intraocular lenses (IOLs) was notably high, with a low prediction error of 0.24 ± 0.20 D. In their study, 89% of eyes with a mean AL exceeding 24.5 mm (mean AL of 25.12 ± 0.57 mm) achieved a manifest refraction spherical equivalent (MRSE) within ± 0.5 D. The current study corroborated these findings, revealing that 91.53% of all cases and 87.88% of cases in the subgroup with long eyes (AL > 28 mm) were within +0.50 D of the intended refraction using the BUII formula. Both Blehm et al[19] and the present study reported a similar median absolute error (MedAE) for the BUII, which was 0.16 D.

Cione et al[11] investigated the IOL power calculation formulas in long eyes (AL ≥ 26.0 mm), measured by the gold standard optical biometers IOLMaster 500 and 700 (Carl Zeiss, Meditec), to find the best AL adjustment for each IOL power calculation formula. For AL between 26 to 28 mm, T2 formula gave best outcome when used with unadjusted AL (BUII and EVO 2.0 with unadjusted AL represented a valid alternative). For AL > 28, EVO 2.0 with a corrected AL yielded the best results.

Blehm et al[20] conducted a comparative study on the refractive predictability of ARGOS measurements using the BUII and BTAL formulas, involving a substantial cohort of 445 eyes with varying axial lengths (AL), specifically long (> 24.5 mm), medium, and short AL eyes. Among these, 92 eyes were classified as long, with a mean AL of 25.39 ± 0.91 mm. The authors reported a hyperopic mean arithmetic error of 0.21 ± 0.48 D for the BUII formula and 0.20 ± 0.48 D for the BTAL formula. Additionally, the mean absolute error (MAE) was found to be 0.34 ± 0.38 D for BUII and 0.36

± 0.33 D for BTAL. Notably, their findings diverged slightly from our own, particularly regarding the hyperopic mean arithmetic error associated with BUII. This discrepancy may be attributed to differences in the mean AL of the eyes included in both studies. Furthermore, the authors acknowledged the inclusion of both eyes from certain patients, which could potentially introduce bias into the results. They also noted that the data were sourced from a single site, which may limit the generalizability of the findings to other surgical practices.

The current study showed some points of strength, including the large proportion of long eye of 28 mm or more. This study reported the outcome of the IOL power formulas with and without the option of SOS even with the use of ALsos. A point of strength and weakness in the same time is the use of lens constants without further optimization; the authors' point of view that they needed to report the actual real practice results with the already used constants available at the ARGOS machine and IOLCon website. In fact, when evaluating specific subgroups of eyes (eg long eyes), it would be more appropriate to rely on the optimized constants of the entire population; In the clinical setting, no one uses separate constants for short and medium eyes. Another potential limitation was the lack of comparison with other new formulas including Kane and Hill RBF 3.0 and the retrospective nature of the study. The authors only chose to compare formulas that had an option of SOS to try the effect on the outcome with and without this option. To further enhance the precision of refractive cataract surgery, advancements in IOL manufacturing technology, such as providing 0.25-D steps, would be helpful to improve postoperative patient satisfaction. The authors recommends prospective studies to validate the results, integration of SOS formulas into new biometers, and diving deeper into the impact of unoptimized constants.

Conclusions

In conclusion, Barrett Universal II formula showed myopic shift with sum of segments (SOS) biometry which increases with longer eyes. Using SOS option in Cooke K6, EVO 2.0, and PEARL-DGS formulas leads to a hyperopic shift in the mean refractive prediction error which is undesirable. Using ALsos in those formulas without choosing the option of SOS yields a mean prediction error towards the myopic side which might be more desirable. All included formulas performed well with ALsos with most of the cases within ± 1 D of intended refraction.

Abbreviations

ACD, anterior chamber depth; APE, absolute prediction error; AL, axial length; ALsos, 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; SE, spherical equivalent; SOS, sum of segments; SS-OCT, swept-source optical coherence tomography.

Data Sharing Statement

Available upon request from the authors.

Ethics and Consent to Participate

This study was approved by the local ethics committee of the Faculty of Medicine, Alexandria University, Egypt. The tenets of the Declaration of Helsinki were followed for this study. All the included patients were recalled for the final follow-up visit and signed an informed consent form.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

References

1. McEwan JR, Massengill RK, Friedel SD. Effect of keratometer and axial length measurement errors on primary implant power calculations. *J Cataract Refract Surg*. 1990;16(1):61–70. doi:10.1016/S0886-3350(13)80876-0
2. Stopyra W. Analysis of accuracy of twelve intraocular lens power calculation formulas for eyes with axial hyperopia. *Saudi J Ophthalmol*. 2023;37(2):125–130. doi:10.4103/sjopt.sjopt_64_22
3. Stopyra W. The exactness of intraocular lens power calculation formulas for short eyes and correlation between method accuracy and eyeball axial length. *Ceska a Slovenska Oftalmologie*. 2022;78(5):236–240. doi:10.31348/2022/24
4. Pathak M, Sahu V, Kumar A, Kaur K, Gurnani B. Current concepts and recent updates of optical biometry-a comprehensive review. *Clin Ophthalmol*. 2024;31:1191–1206. doi:10.2147/OPTH.S464538
5. Shin MC, Chung SY, Hwang HS, Han KE. Comparison of two optical biometers. *Optometry Vision Sci*. 2016;93(3):259–265. doi:10.1097/OPX.0000000000000799
6. Gjerdrum B, Gundersen KG, Nilsen C, Gundersen M, Jensen P. Refractive predictability and biometry agreement of a combined swept source optical coherence and reflectometry biometer compared to an optical low coherence reflectometry biometer and an SS-OCT biometer. *Clin Ophthalmol*. 2023;31:1439–1452. doi:10.2147/OPTH.S408685
7. John Shammas H, Shammas MC. Biometry measurements using a new large coherence length swept-source optical coherence tomography: clinical experience with the argos biometer. In: *InIntraocular Lens Calculations*. Cham: Springer International Publishing; 2024:313–320.
8. Nemeth G, Modis L. Ocular measurements of a swept-source biometer: repeatability data and comparison with an optical low-coherence interferometry biometer. *J Cataract Refract Surg*. 2019;45(6):789–797. doi:10.1016/j.jcrs.2018.12.018
9. Galzignato A, Lupardi E, Hoffer KJ, Barboni P, Schiano-Lomoriello D, Savini G. Repeatability of new optical biometer and agreement with 2 validated optical biometers, all based on SS-OCT. *J Cataract Refract Surg*. 2023;49(1):5–10. doi:10.1097/j.jcrs.0000000000001023
10. Multack S, Plummer N, Smits G, Hall B. Randomized trial comparing prediction accuracy of two swept source optical coherence tomography biometers. *Clin Ophthalmol*. 2023;31:2423–2428. doi:10.2147/OPTH.S407538
11. Cione F, De Bernardo M, Di Paola I, Caputo A, Graziano M, Rosa N. IOL power calculation in long eyes: selection of the best axial length adjustement factor using the most common formulas. *Heliyon*. 2024;10(17):e36609. doi:10.1016/j.heliyon.2024.e36609
12. Miyamoto S, Kamiya K. Accuracy validation of the new Barrett true axial length formula and the optimized lens factor using sum-of-segment biometry. *J Clin Med*. 2024;13(16):4639. doi:10.3390/jcm13164639
13. Barrett GD. An improved universal theoretical formula for intraocular lens power prediction. *J Cataract Refract Surg*. 1993;19(6):713–720. doi:10.1016/S0886-3350(13)80339-2
14. Cooke DL, Cooke TL. Approximating sum of segments axial length from a traditional optical low-coherence reflectometry measurement. *J Cataract Refract Surg*. 2019;45(3):351–354. doi:10.1016/j.jcrs.2018.12.026
15. Debellemanière G, Dubois M, Gauvin M, et al. The PEARL-DGS formula: the development of an open-source machine learning–based thick IOL calculation formula. *Am J Ophthalmol*. 2021;232:58–69. doi:10.1016/j.ajo.2021.05.004
16. Yeo TK. Emmetropia Verifying Optical (EVO) Formula. In: *Intraocular Lens Calculations*. Cham: Springer International Publishing; 2024:617–623.
17. Wang L, Holladay JT, Koch DD. Wang-Koch axial length adjustment for the Holladay 2 formula in long eyes. *J Cataract Refract Surg*. 2018;44(10):1291–1292. doi:10.1016/j.jcrs.2018.06.057
18. Shammas HJ, Jabre JF. Validating e-norms methodology in ophthalmic biometry. *BMJ Open Ophthalmol*. 2020;5(1):e000500. doi:10.1136/bmjophth-2020-000500
19. Blehm C, Hall B. Refractive predictability of a swept source optical coherence tomography biometer in long and short eyes implanted with extended depth of focus intraocular lenses. *Clin Ophthalmol*. 2023;31:3525–3530. doi:10.2147/OPTH.S430535
20. Blehm C, Balest Z, Blehm AC, Hall B. Refractive predictability of two intraocular lens power formulas in long, medium, and short eyes using a swept source optical coherence tomography biometer. *Clin Ophthalmol*. 2024;31:2531–2537. doi:10.2147/OPTH.S470158