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ORIGINAL RESEARCH

Refractive Predictability of a Swept Source Optical Coherence Tomography Biometer in Long and Short Eyes Implanted with Extended Depth of Focus Intraocular Lenses

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Purpose: To determine the refractive predictability of Argos (Movu, a Santec company) measurements and the Barrett Universal II formula in long and short eyes implanted with an extended depth of focus (EDOF) intraocular lens (IOL).

Methods: This retrospective, non-interventional study included 86 eyes (55 long and 31 short) of 55 patients. Preoperative biometry was performed using the Argos. Preoperative IOL power formulas were the preprogrammed Barrett Universal II (BUII). Data were collected for refractive outcomes, postoperative prediction error (directional and absolute), and monocular corrected distance visual acuity (CDVA, Snellen).

Results: The mean absolute prediction error for BUII was 0.27 ± 0.26 D overall, 0.24 ± 0.20 D in long eyes, and 0.33 ± 0.33 D in short eyes. Overall, the percentage of eyes with ≤ 0.5 D prediction error was 84% for BUII. In long eyes, the percentage of eyes with ≤ 0.5 D prediction error was 90% for BUII. In short eyes, the percentage of eyes with ≤ 0.5 D prediction error was 74% for BUII. The percentage of eyes with ≤ 0.5 D of MRSE was 89% for long eyes and 94% for short eyes. Visual acuities were excellent in both long and short eyes, with > 90% of eyes 20/25 or better in each group.

Conclusion: The prediction error of Argos using BUII was low in long and short eyes at one month after EDOF IOL implantation.

Plain Language Summary: An intraocular lens (IOL) is an artificial lens that can be implanted in the eye to replace a natural lens that has become opaque. The power of the IOL must be carefully chosen for clear vision after implantation. Cataract surgeons use devices called biometers to measure the eye and calculate the most appropriate IOL power to implant. A novel biometer is available that may offer good accuracy, for predicting the IOL power, in eyes that are longer or shorter than average. The purpose of this study was to determine the refractive predictability of this biometer in long and short eyes implanted with an extended depth of focus (EDOF) IOL. The results of this study suggest that the refractive predictability was excellent in long and short eyes at one month after EDOF IOL implantation, resulting in great vision postoperatively.

Keywords: Argos, biometry, SS-OCT

Introduction

The success of cataract surgery and intraocular lens (IOL) implantation can be measured by the postoperative refractive outcomes. Both patients and surgeons have high expectations for clear vision after surgery, and good refractive outcomes are key for clear vision. This is especially true with presbyopia-correcting lenses such as trifocals or extended depth of focus (EDOF) IOLs.[1]

Hitting the refractive target is influenced by accurate and precise preoperative measurements of the eye. Optical biometry is the standard of care to determine anterior chamber depth (ACD), axial length (AL), and keratometry (K).

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Currently available optical biometers include those based on partial coherence interferometry (PCI),[2] optical low coherence reflectometry (OLCR),[3] optical low coherence interferometry (OLCI),[4] and swept-source optical coherence tomography (SS-OCT).[5,6]

Refractive accuracy is also influenced by the IOL power formula used. Many optical biometers are available preprogrammed with the latest generation IOL power formulas, and these newer IOL formulas are reported to result in excellent refractive outcomes.[7–9] However, it can still be challenging to achieve the refractive target in eyes with long (≥ 24.5 mm) or short (≤ 22.5 mm) axial lengths.

The Argos (Movu, a Santec company) is an SS-OCT biometer that measures the eye utilizing a wavelength of 1060 nm.[10] Rather than using one refractive index for the entire eye, the Argos uses refractive indices of 1.376 for the cornea, 1.410 for the lens, and 1.336 for the aqueous and vitreous, and a sum of these segments to determine the axial length.[11,12] This allows for adjustments to the axial length calculation based on variability in the lengths of each segment. This sum-of-segments approach has been reported to result in excellent refractive outcomes compared to using a single refractive index.[13–15] In addition, Shammas et al[12] observed good refractive outcomes with the Argos in long and short eyes with a monofocal IOL. However, to date, there is minimal data on the refractive and visual outcomes of the Argos in long and short eyes with presbyopia correcting IOLs.

The purpose of this study was to determine the refractive predictability of Argos measurements in long and short eyes implanted with an EDOF IOL.

Methods

This was a non-interventional retrospective chart review of visual and refractive outcomes in long (≥ 24.5 mm) and short (≤ 22.5 mm) eyes using an SS-OCT biometer (Argos). An institutional review board reviewed the study (Salus IRB; approval CB-22-001). The IRB granted a waiver of informed consent as this was a non-interventional retrospective chart review of anonymized data. All data were maintained with confidentiality. This study followed the tenets of the Declaration of Helsinki, International Harmonization (ICH) guidelines, and Good Clinical Practice (GCP). There was no requirement to register this study in a clinical trials database (such as clinicaltrials.gov) as this was a retrospective chart review.

Charts were reviewed from subjects who had cataract surgery between December 2021 and January 2023. Eligible charts were those from adults who had previous uncomplicated cataract surgery with corrected distance visual acuity (CDVA) of 20/30 or better following implantation with AcrySof Vivity IOLs (Alcon Vision, LLC; toric and non-toric), and axial lengths ≤ 22.5 mm or ≥ 24.5 mm where biometry and IOL calculations were performed with the ARGOS SS-OCT device. Charts were excluded from subjects that had ocular pathology noted in patient chart, moderate-severe corneal or retinal pathology, severe dry eye disease, history of corneal refractive surgery, irregular astigmatism, or corneal astigmatism greater than 4.00 D.

Preoperative and ≥ 1 month postoperative data were collected. Visual acuities were collected in Snellen and converted to logMAR for analysis. Preoperative biometry was performed using the Argos biometer. The Barrett Universal II formula (BUII) was used with all eyes, and all eyes were targeted for plano or first minus. Using the data collected with the Argos, spherical equivalent predictions using the Barrett True Axial Length formula (BTAL) were back-calculated for exploratory analyses. Microincision phacoemulsification was performed by a single experienced surgeon (CB) in all eyes. The ORA System with Verifeye+ (Alcon Vision, LLC) was used intraoperatively, though the final implanted IOL was based on surgeon discretion. The primary endpoint was the mean absolute prediction error in long and short eyes. Secondary endpoints included the percentage of eyes within 0.50 D of predicted postoperative spherical equivalent in long and short eyes and postoperative CDVA in long and short eyes. Exploratory endpoints included median absolute prediction error in long and short eyes, mean and median absolute prediction error in long and short eyes using back-calculations with the Barrett True Axial Length formula, and the percentage of eyes within 0.50 D of predicted postoperative spherical equivalent in long and short eyes using back-calculations with the Barrett True Axial Length formula. Absolute prediction error was calculated as the absolute difference between predicted spherical equivalent and the postoperative manifest refraction spherical equivalent.

All statistical analyses were performed using the statistical software R version 4.2.2 (The R Foundation for Statistical Computing, Vienna, Austria). The study was intended to be descriptive in nature. A total sample size of 80 was considered sufficient to characterize the performance of the Argos in long and short eyes.

Results

The chart review identified 86 eyes (55 long and 31 short) of 55 patients that were eligible based on the inclusion and exclusion criteria above. Table 1 summarizes the preoperative and patient demographics.

A summary of the absolute prediction error for the BUII formula is shown in Table 2. Overall, mean absolute prediction error was 0.27 ± 0.26 D and the percentage of eyes with prediction error ≤ 0.5 D was 84%. In long eyes, mean absolute prediction error was 0.24 ± 0.20 D and the percentage of eyes with prediction error ≤ 0.5 D was 90%. In short eyes, mean absolute prediction error was 0.33 ± 0.33 D and the percentage of eyes with prediction error ≤ 0.5 D was 74%.

Table 3 summarizes the postoperative refractive outcomes using the BUII formula. The refractive outcomes were excellent in both long and short eyes. The percentage of eyes with ≤ 0.5 D of residual cylinder was 90% for long eyes and 74% for short eyes. The percentage of eyes with ≤ 0.5 D of MRSE was 89% for long eyes and 94% for short eyes.

Postoperative monocular CDVA for long and short eyes is summarized in Figure 1. Visual acuities were similarly excellent in both long and short eyes, with > 90% of eyes 20/25 or better in each group.

Absolute prediction error for the BTAL formula was back-calculated for exploratory analyses. A summary is shown in Table 4. Overall, mean absolute prediction error was 0.28 ± 0.27 D, and the percentage of eyes with prediction error ≤ 0.5 D was 85%. In long eyes, mean absolute prediction error was 0.26 ± 0.26 D, and the percentage of eyes with prediction error ≤ 0.5 D was 84%. In short eyes, mean absolute prediction error was 0.31 ± 0.28 D, and the percentage of eyes with prediction error ≤ 0.5 D was 87%.

Table 1 Preoperative and Demographic Data

Baseline Factor	Long Eyes (≥ 24.5mm)	Short Eyes (≤ 22.5mm)
Number of Eyes	55	31
Gender (number of eyes)		
Female	21 (38)	22 (71)
Male	34 (62)	9 (29)
WTW (mm)	12.25 ± 0.52 (11.16 to 13.46)	11.72 ± 0.39 (11.16 to 12.50)
Axial Length (mm)	25.12 ± 0.57 (24.50 to 27.42)	22.21 ± 0.24 (21.55 to 22.50)
Average K (D)	43.56 ± 1.43 (40.20 to 47.78)	45.36 ± 1.10 (43.39 to 47.66)
Cylinder (D)	1.07 ± 0.86 (0.22 to 3.96)	0.85 ± 0.54 (0.18 to 2.39)
Lens Model (n)		
DAT015	25 (45.4)	8 (25.8)
DAT315	16 (29.1)	18 (58.1)
DAT415	5 (9.1)	1 (3.2)
DAT515	4 (7.3)	2 (6.4)
DAT615	5 (9.1)	2 (6.4)

Note: Data presented as mean ± SD (range) or n (%).
Abbreviations: D, diopters; SD, standard deviation; WTW, white to white.

Table 2 Absolute Prediction Error for the BUII Formula

Group	n	Mean ± SD (Range) D	Median (D)	0–0.25 D (%)	0.26–0.50 D (%)	0.51–0.75 D (%)	0.76–1.00 D (%)	> 1D (%)
Overall	86	0.27 ± 0.26 (0.01 to 1.67)	0.17	56.98	26.74	12.79	2.33	1.16
Long	55	0.24 ± 0.20 (0.01 to 0.82)	0.16	62.82	27.27	7.27	3.64	0.00
Short	31	0.33 ± 0.33 (0.01 to 1.67)	0.27	48.39	25.81	22.58	0.00	3.23

Abbreviations: BUII, Barrett Universal II; D, diopters; SD, standard deviation.

Table 3 Refractive Outcomes in Long (n=55) and Short Eyes (n=31) Using the BUII Formula

Group	Refractive Outcome (D)	Mean ± SD (Range) D	0–0.25 D (%)	0.26–0.50 D (%)	0.51–0.75 D (%)	0.76–1.00 D (%)	> 1D (%)
Long (n=55)	Sphere	−0.30 ± 0.32 (−1.25 to 0.25)	62.82	23.64	9.09	3.64	1.82
	Cylinder	0.27 ± 0.34 (0.00 to 1.25)	66.45	23.64	5.45	0.00	5.45
	MRSE	−0.16 ± 0.30 (−1.12 to 0.75)	74.55	14.55	9.09	0.00	1.82
Short (n=31)	Sphere	−0.19 ± 0.41 (−1.00 to 1.00)	58.06	25.81	9.68	6.45	0.00
	Cylinder	0.34 ± 0.39 (0.00 to 1.25)	61.29	12.90	12.90	9.68	3.23
	MRSE	−0.02 ± 0.43 (−0.50 to 1.50)	58.06	35.48	3.23	0.00	3.23

Abbreviations: BUII, Barrett Universal II; D, diopters; MRSE, manifest refraction spherical equivalent; SD, standard deviation.

Discussion

Achieving the refractive target following cataract surgery is crucial for good postoperative visual outcomes. The UK National Health Service (NHS) released benchmark standards in 2009 of 55% and 85% of patients to be within 0.5 D and 1.0 D of the predicted refraction, respectively.[16] It has been estimated that refractive outcomes are within 0.5 D of target refraction in only 73% of eyes.[17] Refractive accuracy is influenced by the accuracy and precision of the preoperative biometry measurements, and also by the IOL power formula selected. In long eyes, missing the refractive target often leaves residual hyperopia.[18,19] In short eyes, small changes in the final position of the implanted IOL can have large effects on the residual refractive error compared to average or long eyes.[20] In this study, we determined the predictive accuracy of the BUII and BTAL formulas, which were available preprogrammed on the Argos biometer, in long and short eyes that were implanted with an EDOF IOL.

We used the cutoffs for long (24.50 mm) and short eyes (22.50 mm) reported by Shammas and Jabre,[21] although axial lengths of exactly 22.50 and 24.50 mm were included in the short eye and long eye groups, respectively, in our study. For long eyes, the percentage of eyes with prediction error ≤ 0.5 D was 90% for BUII and 84% for BTAL. Shammas et al[12] also reported on the refractive outcomes using the Argos in long and short eyes using a variety of IOL power formulas (including BUII and BTAL) after implantation with a monofocal IOL. The authors observed that the percentage of long eyes with prediction error ≤ 0.5 D was approximately 86% for BUII and 85% for BTAL (n=155). In another study, Shammas et al[13] reported that the percentage of long eyes (defined as axial length ≥ 25 mm) with prediction error ≤ 0.5 D was approximately 91% using the Argos and the BUII formula (n=57). Yang et al[6] observed that the percentage of long eyes (defined as axial length ≥ 26 mm) with prediction error ≤ 0.5 D was approximately 82% using the Argos and the Haigis formula (n=12). In addition, Omoto et al[22] reported that the percentage of long eyes (defined as axial length ≥

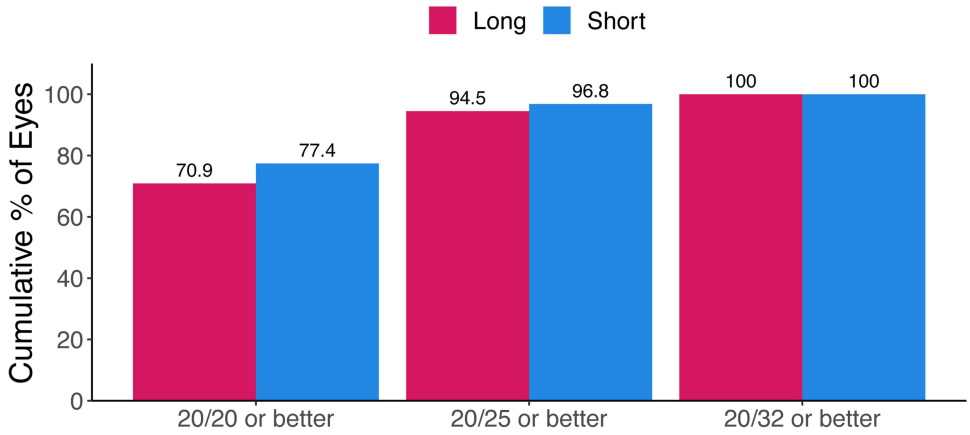

Figure 1 Cumulative postoperative monocular CDVA between groups.

Table 4 Absolute Prediction Error for the BTAL Formula

Group	n	Mean ± SD (Range) D	Median (D)	0–0.25 D (%)	0.26–0.50 D (%)	0.51–0.75 D (%)	0.76–1.00 D (%)	> 1D (%)
Overall	86	0.28 ± 0.27 (0.00 to 1.39)	0.21	56.98	27.91	10.47	2.33	2.33
Long	55	0.26 ± 0.26 (0 to 1.24)	0.16	65.45	18.18	10.91	3.64	1.82
Short	31	0.31 ± 0.28 (0.01 to 1.39)	0.28	41.94	45.16	9.68	0.00	3.23

Abbreviations: BTAL, Barrett True Axial Length; D, diopters; SD, standard deviation.

26 mm) with ≤ 0.5 D prediction error was approximately 70% using the Argos and the BUII formula (n=30). The outcomes reported in other studies are similar to those reported in our study, though the differences could be due to the differences in sample size, A-constant optimization, or surgical technique. The results of our study and other studies suggest that using the Argos with the BUII or BTAL formulas in long eyes results in excellent refractive outcomes.

For short eyes, we observed that the percentage of eyes with prediction error ≤ 0.5 D was 74% for BUII and 87% for BTAL. Shammas et al[12] reported that the percentage of short eyes with prediction error ≤ 0.5 D was approximately 71% for BUII and 72% for BTAL (n=120). Yang et al[6] observed that the percentage of short eyes with prediction error ≤ 0.5 D was approximately 71% using the Argos and the Haigis formula (n=12). Shammas et al[13] reported that the percentage of short eyes (defined as axial length < 22 mm) with prediction error ≤ 0.5 D was approximately 72% using the Argos and the BUII formula (n=43). These reported percentages in other studies are less than those reported in our study, though the differences are likely due to differences in sample size and definition of short eyes. The results of our study and other studies suggest that using the Argos with the BUII or BTAL formulas in short eyes results in good refractive outcomes, however this remains a challenge compared to long eyes.

A limitation of this study was the sample size. The study was intended to be descriptive, and we did not power the study to be able to perform statistical comparisons between the BUII and BTAL formulas. However, our results suggest that both formulas perform well in long and short eyes. Another limitation of this study was the retrospective design. A randomized and prospective study designed to compare IOL power formulas would be better, however, given that such a study may require at least 400 eyes,[12,13] a retrospective study offers significant cost and time advantages.

In conclusion, the prediction error of Argos using BUII was low in long and short eyes at one month after EDOF IOL implantation.

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Disclosure

Brad Hall reports that he has received consulting fees from Ace Vision Group outside the submitted work. The authors report no other conflict of interest for this work.

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