DOI: 10.4274/tjo.galenos.2021.43726
Turk J Ophthalmol 2022;52:228-236

Original Article

The Effect of Anterior Segment Depth on the Accuracy of 7 Different Intraocular Lens Calculation Formulas

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Abstract

Objectives: To evaluate the effect of anterior segment depth (ASD; sum of anterior chamber depth and lens thickness) on the accuracy of 7 intraocular lens formulas calculated in patients with axial length (AL) between 22.5 and 24.5 mm.

Materials and Methods: In this retrospective study, patients who underwent cataract surgery were divided into three groups based on their ASD measurements (Group I: ASD <7.30 mm, Group II: ASD between 7.30-7.90 mm, Group III: ASD >7.90 mm). The mean predictive error (MPE), mean absolute error (MAE), and median absolute error (MedAE) values of each group were compared. The effect of ASD on the predictive error (PE) of each lens formula was additionally tested in subgroups based on mean keratometry (K) values (Subgroup I: K <42.0 D, Subgroup II: K between 42.0-44.5 D, Subgroup III: K >44.5 D).

Results: The study included 184 eyes of 184 patients. In Group I, all formulas except Olsen OLCR and Barrett II had clinically myopic MPEs. In Group II, the MPEs of all lens formulas except Barrett II were statistically non-different from zero ($p>0.05$). In Group III, the MPEs of all lens formulas were found to be statistically hyperopic. In Group III, all formulas except Olsen OLCR were significantly shifted to more hyperopic results when compared with Groups I and II ($p<0.05$). ASD was positively correlated with the PEs of the SRK/T, Holladay I, Hoffer Q, Barrett II, Hill-RBF, and Haigis formulas. In cases with mean K greater than 42.0 D, ASD was similarly correlated with PE for all formulas except Olsen OLCR.

Conclusion: In eyes with AL between 22.5 and 24.5 mm, the predictions of lens formulas were significantly hyperopic in cases with greater ASD.

Keywords: anterior segment depth, predictive error, lens formula, axial length

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Received: 19.02.2021 **Accepted:** 24.08.2021

Cite this article as: Kesim C, Yıldız Taş A, Karslıoğlu MZ, Hasanreisoğlu M, Müftüoğlu O, Şahin A. The Effect of Anterior Segment Depth on the Accuracy of 7 Different Intraocular Lens Calculation Formulas. Turk J Ophthalmol 2022;52:228-236

Introduction

With the advent of microincisional techniques, cataract surgery has become the most commonly performed surgery worldwide. Despite groundbreaking advances in intraocular lens (IOL) calculations, 30-40% of cases still miss their predictive refractive targets by ±0.50 diopters (D) or more. This problem is largely due to uncertainty in the prediction of the effective lens position (ELP) preoperatively.[1]

Although axial length (AL) and keratometry (K) measurements are the mainstay parameters of all IOL calculation formulas, they are not directly related to ELP, which is almost synonymous with postoperative anterior chamber depth (ACD). Therefore, newer formulas use preoperative ACD and lens thickness (LT) measurements in isolation to predict ELP.[2,3,4] Unlike AL and K measurements, which are reproducible and remain steady throughout the lifetime, ACD and LT measurements may be significantly affected by conditions such as natural accommodation, pharmacologic cycloplegia, and aging.[5,6,7,8] In these conditions, the increase in LT is accompanied by an approximately equal decrease in ACD, and vice versa.[9] This would result in a relatively stable anterior segment depth (ASD; the sum of ACD and L), which might offer a stable and reliable biometric parameter comparable to AL and K, to predict ELP better than ACD or LT measurement in isolation.

Most commonly used vergence formulas (Holladay 1, SRK/T, Hoffer Q, and Haigis) predict ELP using either AL, K, or ACD measurements (Holladay 1, SRK/T, and Hoffer Q use AL and K; Haigis uses AL and ACD).[10,11,12,13] New-generation formulas seek to improve IOL calculation on different bases. While Barrett II Universal is a 5-variable vergence formula including LT and white-to-white (WTW) measurements, Olsen is based on ray-tracing and a C constant derived from ACD and LT, and Hill-Radial Basis Function (Hill-RBF) is an artificial intelligence-based formula.[3,4,14] The main purpose of this study was to assess the effect of ASD on the predictions of these IOL calculation formulas and to evaluate the postoperative predictive errors (PEs) of these formulas in eyes with different ASD.

Materials and Methods

Study participants

This study was conducted with Koç University Institutional Review Board approval (decision number: 2019.410.IRB2.131), according to the tenets of the Declaration of Helsinki.

Consecutive patients who underwent cataract surgery between July 2018 and May 2019 with AcrySof SN60WF (both Alcon Laboratories, Inc.) by experienced surgeons (A.S., O.M.) were included in this retrospective study. Inclusion criteria were: (1) no history of previous ocular surgery, (2) no ocular condition other than cataract, and (3) AL of 22.5-24.5 mm. Patients who had intraoperative or postoperative complications and with postoperative corrected distance visual acuity worse than 20/40 at 1 month were excluded.

Data Calculation and Analysis

Preoperative AL, mean K, ACD, and LT values were measured with optical low-coherence reflectometry (OLCR) (Lenstar LS900, Haag-Steit AG). Eyes were classified in three groups based on their ASD distribution: Group I included eyes with ASD lower than 7.30 mm, Group II included eyes with ASD in the 7.30-7.90 mm range, and Group III included eyes with ASD greater than 7.90 mm. Manifest refraction was performed by an experienced ophthalmologist (C.K.) at least 1 month postoperatively for each eye.

The accuracy of 4 vergence formulas (SRK/T, Holladay 1, Hoffer Q, Haigis) and 3 new-generation formulas (Olsen, Barrett II, Hill-RBF) were evaluated. User Group for Laser Interference Biometry (ULIB) lens constants were used for each IOL.[15] All formula calculations were obtained from the default software program of the OLCR device (EyeSuite, Haag-Steit AG). The formulas were not optimized to detect systemic PEs in this study population. The PE for each formula was calculated by subtracting the predicted refractive error from the actual postoperative spherical refraction; therefore, a negative PE indicated a refractive result that was more myopic than predicted by the formula. Mean predictive errors (MPE) and median absolute errors (MedAE) were noted. The possible effect of K on the correlation between ASD and PEs was additionally investigated in three subgroups based on mean K values (Subgroup I: Mean K less than 42.0 D, Subgroup II: Mean K between 42.0 and 44.5 D, Subgroup III: Mean K greater than 44.5 D).

Statistical Analysis

SPSS Statistics software (version 20.0, IBM, Armonk, NY, USA) was used for statistical analysis. Data distribution was checked for normality with Kolmogorov-Smirnov analysis. One-sample t-test was performed to evaluate whether the MPE values of lens formulas were different from zero. MPE differences between three groups were analyzed with one-way analysis of variance (ANOVA), which was followed by post-hoc t-tests with Bonferroni correction. Friedman test was performed to compare MedAEs between formulas for each group to evaluate accuracy, which was followed by Wilcoxon signed-rank test with Bonferroni correction for post-hoc analysis. Correlation analysis between biometric parameters and the PEs of the lens formulas was performed with Spearman's rho analysis. A probability less than 5% ($p<.05$) was considered statistically significant.

Results

The study included 184 eyes of 184 patients (age: 69±9 years, 116 women) who underwent cataract surgery. Table 1 shows the demographic and biometric findings in total and in the three study groups. There was no significant difference between the groups in terms of age or mean K values ($p>.05$). Figure 1 shows the mean PEs of different formulas according to

ASD range. There was an apparent relation between ASD and MPE for all formulas, showing a tendency towards hyperopic error with increasing ASD and a tendency towards myopic error with decreasing ASD. There were 29 patients were in Group I, 107 patients in Group II, and 48 patients in Group III. Although AL was statistically higher in Group III than Groups I and II (p<.05 for both), it was clinically negligible (23.23±0.48 in Group I, 23.31±0.55 in Group II, and 23.61±0.51 in Group III).

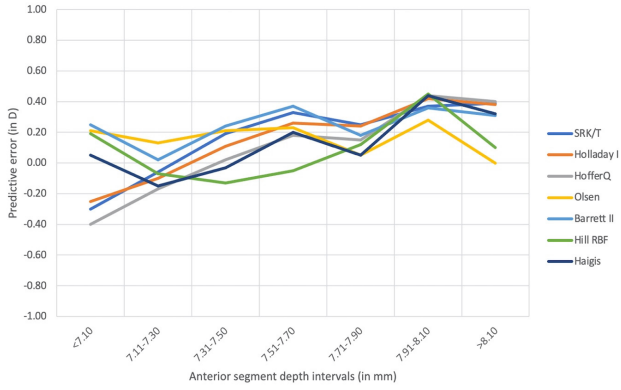

Figure 1. Line graph showing mean predictive error values (in diopters) of 7 lens formulas based on anterior segment depth intervals (in mm)

Predictive Errors of Lens Formulas

Table 2 shows the MPE values of the three groups with their one sample t-test results. MPE values nearest to zero were obtained with Haigis in Group I (-0.03±0.73 D), Hill-RBF in Group II (-0.02±0.49 D), and Olsen OLCR in Group III (0.27±0.44 D). In Group I, the Hoffer Q formula had an MPE value statistically different from zero (p=.008), while the predictions of the other formulas were statistically equivalent to postoperative refraction. In Group II, all formulas but Hill-RBF and Haigis had MPE values statistically different from zero (p<.05 for all except Hill-RBF: -0.02±0.49 D, p=.684 and Haigis: -0.03±0.46 D, p=.197). In Group III, the MPE results of all formulas were found to be statistically hyperopic (p<.05 for all). The MPE of the Olsen formula was mathematically closest to zero (0.27±0.44 D), which was still statistically different from zero. Group-related differences for all lens formulas are shown in Figure 2. One-way ANOVA showed that PE differed significantly between the three groups for all formulas except Olsen OLCR and Barrett II (p<.05 for all except Olsen: p=.896 and Barrett: p=.299). Post-hoc tests showed that all remaining 5 formulas had more hyperopic PE values in Group III eyes than in Group I eyes (p<.05 for all). In addition, the PEs of SRK/T, Holladay 1, and Hoffer Q were also more hyperopic for Group II eyes than for Group I eyes (p<.05 for all), and the PEs of Hill-RBF and Haigis were significantly more hyperopic for Group III eyes than for Group II eyes (p<.05 for all).

Table 1. Demographic and biometric data of the study

Parameter		Total (n=184)	Group I (n=30)	Group II (n=106)	Group III (n=48)	p (ANOVA)
Age	Mean ± SD	69±9	68±9	69±9	71±8	0.275
	(Range)	(48, 87)	(49, 87)	(48, 86)	(56, 85)	
AL (mm)	Mean ± SD	23.38±0.55	23.23±0.48	23.31±0.55	23.63±0.51	0.001
	(Range)	(22.50, 24.48)	(22.55, 24.32)	(22.50, 24.41)	(22.68, 24.48)	
Mean K (D)	Mean ± SD	43.58±1.42	43.57±1.34	43.40±1.42	43.96±1.41	0.072
	(Range)	(40.46, 46.25)	(41.60, 45.75)	40.46, 46.25)	(41.25, 46.12)	
CCT (µm)	Mean ± SD	544±34	548±36	542 ± 32	547±39	0.532
	(Range)	(476, 633)	(479, 633)	(477, 620)	(476, 616)	
ACD (mm)	Mean ± SD	3.09±0.33	2.93±0.28	3.07 0.33	3.22±0.32	0.001
	(Range)	(2.16, 4.04)	(2.41, 3.50)	(2.16, 3.75)	(2.38, 4.04)	
LT (mm)	Mean ± SD	4.57±0.41	4.19±0.29	4.54±0.36	4.87±0.35	<0.001
	(Range)	(3.67, 5.66)	(3.67, 4.76)	(3.71, 5.30)	(4.08, 5.66)	
IOL power (D)	Mean ± SD	22.2±1.89	22.47±1.49	22.65±1.89	21.04±1.59	<0.001
	(Range)	(17.5, 27.0)	(20.0, 25.5)	(18.0, 27.0)	(17.5, 24.5)	
ASD (mm)	Mean ± SD	7.66±0.35	7.12±0.18	7.61±0.17	8.09±0.17	<0.001
	(Range)	(6.68, 8.68)	(6.68, 7.30)	(7.31, 7.90)	(7.92, 8.68)	

AL: Axial length, K: Keratometry, CCT: Central corneal thickness, ACD: Anterior chamber depth, LT: Lens thickness, IOL: Intraocular lens, ASD: Anterior segment depth, ANOVA: Analysis of variance, SD: Standard deviation. Note the statistically significant differences in AL between Groups I and III (p=0.005) and Groups II and III (p=0.002).

The MedAEs of the formulas are shown in Table 3 and Figures 3A-C. There were no differences between the formulas' MedAE values in Groups I and II. In Group III, Hill-RBF had lower MedAE than Haigis (0.38 and 0.46 respectively, p<.007 with Bonferroni adjustment). There was no statistically significant difference between the other formulas.

Correlations Between Ocular Biometrics and Predictive Error

The results of correlation analysis between the PEs of the 7 lens calculation formulas and the ocular biometric parameters of ACD, LT, and ASD are shown in Table 4. PE was positively correlated with ACD for Hoffer Q (r=0.280, p<.01) and with LT

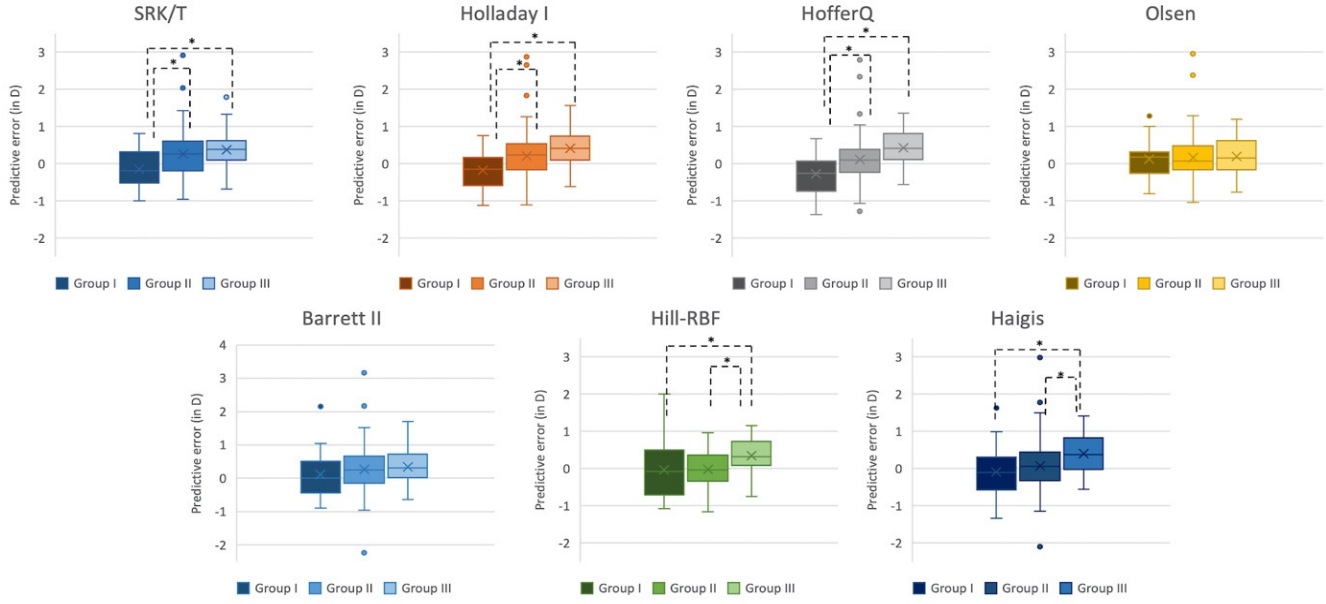

Figure 2. Box plot presentation of predictive errors (PEs) (in diopters) for 7 lens formulas. Results for Group I (anterior segment depth [ASD] <7.30 mm), Group II (ASD 7.30-7.90 mm) and Group III (ASD >7.90 mm) are given in separate box plots for each formula (outliers shown as individual dots). *Statistically significant (p<.05)

Table 2. Mean predictive errors (MPE) of 7 lens calculation formulas in the anterior segment depth (ASD) groups

Formula		Group I ASD <7.30 mm	Group II ASD 7.30-7.90 mm	Group III ASD >7.90 mm
SRK/T	MPE	-0.11±0.58	0.13±0.51	0.36±0.29
	p	0.131	<0.001	<0.001
Holladay	MPE	-0.15±0.55	0.05±0.47	0.42±0.40
	p	0.058	0.001	<0.001
Hoffer Q	MPE	-0.24±0.59	-0.04±0.45	0.45±0.43
	p	0.008	0.049	<0.001
Olsen	MPE	0.14±0.60	0.06±0.42	0.27±0.44
	p	0.197	0.008	0.008
Barrett II	MPE	0.22±0.76	0.14±0.49	0.37±0.37
	p	0.364	<0.001	<0.001
Hill-RBF	MPE	-0.03±0.76	-0.02±0.49	0.35±0.41
	p	0.868	0.684	<0.001
Haigis	MPE	-0.03±0.73	-0.03±0.46	0.45±0.44
	p	0.442	0.197	<0.001

For each formula, the first row gives MPE value (in diopters) and the second row gives the p value from one-sample t-test comparing predictive error with zero. A p value less than 0.05 was considered statistically significant.

for SRK/T (r=0.203, p<.01). ASD showed significant positive correlation with PE for 5 formulas, SRK/T (r=0.273, p<.01), Holladay 1 (r=0.347, p<.01), Hoffer Q (r=0.408, p<.01), Hill-RBF (r=0.292, p<.01), and Haigis (r=0.295, p<.04), but not for Olsen OLCR and Barrett II (r=0.011, p<.881 and r=0.119, p<.110, respectively).

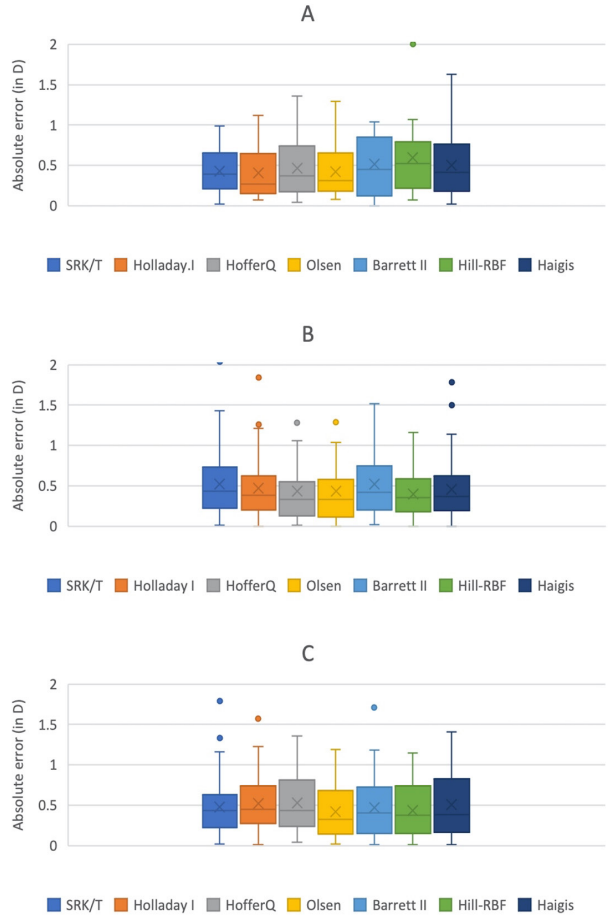

Figure 3. Box plot presentation of absolute errors (AEs) in diopters (D): A) in eyes with anterior segment depth (ASD) less than 7.30 mm, B) in eyes with ASD between 7.30 and 7.90 mm, C) in eyes with ASD greater than 7.90 mm. Outliers shown as individual dots

The effect of K on the correlation between ASD and PE is shown in Table 5. No correlation was found between ASD and the PEs of the formulas in Subgroup I except for a weak correlation for Hoffer Q (r=0.364, p=0.048). In Subgroup II, ASD was positively correlated with the PEs of SRK/T, Holladay 1, Hoffer Q, and Haigis. In Subgroup III, ASD was positively correlated with SRK/T, Holladay 1, Hoffer Q, Hill-RBF, and Haigis.

Discussion

Precise prediction of ELP remains among the unresolved challenges of current cataract surgery. As a biometric parameter that is created following the removal of the crystalline lens, ELP should either be assessed by direct intraoperative measurement of the distance between the posterior corneal surface and posterior lens capsule, or indirect preoperative prediction by lens regression formulas, the latter being the most commonly used method in clinical practice. The advent of high-resolution OLCR and optical coherence tomography (OCT) techniques enabled the incorporation of ACD and LT parameters separately to increase the precision of these formulas. Although ASD might simply be regarded as the combination of ACD and LT, this parameter could present variations that are not strictly dependent on the dimensions of ACD and LT. Therefore, ASD might have a separate effect on ELP which otherwise cannot be predicted by ACD and LT values, resulting in PEs that are detectable by ASD assessment in particular.

The current study revealed a trend towards postoperative hyperopic error in IOL predictions with increasing ASD (particularly more than 7.90 mm) and towards myopic error with decreasing ASD (particularly less than 7.30 mm), regardless of the lens formula used. The lens formulas successfully predicted IOL power when ASD was between 7.60 and 7.90 mm, giving PEs that were non-different from zero. The shift from myopia to hyperopia is shown in Table 3, with the highest rate of hyperopic results found in Group III.

Table 3. Median absolute errors (in diopters) of 7 lens calculation formulas in the anterior segment depth (ASD) groups

Formula	SRK/T	Holladay	Hoffer Q	Olsen	Barrett II	Hill-RBF	Haigis	p (Friedman's test)
Group I, ASD <7.30 mm	0.43	0.48	0.42	0.42	0.51	0.52	0.59	0.720
Group II, ASD 7.30-7.90 mm	0.39	0.37	0.31	0.27	0.34	0.36	0.28	0.155
Group III, ASD >7.90 mm	0.33	0.45	0.51	0.34	0.32	0.38	0.46	0.001

Table 4. Correlation analysis between the predictive error of 7 formulas and biometric parameters

Formulas		Parameters			
		Mean K	**ACD**	**LT**	**ASD**
SRK/T	rho	-0.313	0.028	0.203	0.273
	p	<0.001	0.701	0.006	<0.001
Holladay 1	rho	-0.107	0.165	0.162	0.347
	p	0.151	0.026	0.029	<0.001
Hoffer Q	rho	0.072	0.280	0.120	0.408
	p	0.332	<0.001	0.103	<0.001
Olsen OLCR	rho	0.007	-0.071	0.065	0.011
	p	0.924	0.346	0.388	0.881
Barrett II	rho	-0.267	-0.050	0.129	0.119
	p	<0.001	0.504	0.081	0.110
Hill-RBF	rho	-0.055	0.111	0.150	0.292
	p	0.552	0.226	0.100	0.001
Haigis	rho	0.076	0.089	0.174	0.295
	p	0.302	0.231	0.018	<0.001

K: Keratometry, ACD: Anterior chamber depth, LT: Lens thickness, ASD: Anterior segment depth. For each formula, the first row gives the Spearman's rho value and the second row gives its corresponding p value

Table 5. Correlation analysis between the predictive errors of 7 formulas and anterior segment depth (ASD) in mean keratometry (K) subgroups

Formulas		Mean K values		
		K <42.0 D	**K: 42.0-44.5 D**	**K >44.5 D**
		n=30	**n=100**	**n=54**
SRK/T	Rho:	0.313	0.304	0.378
	P:	0.092	0.002	0.005
Holladay 1	Rho:	0.342	0.321	0.454
	P:	0.065	0.001	0.001
Hoffer Q	Rho:	0.364	0.362	0.500
	P:	0.048	<0.001	<0.001
Olsen OLCR	Rho:	0.005	-0.084	0.218
	P:	0.979	0.410	0.120
Barrett II	Rho:	0.042	0.114	0.251
	P:	0.825	0.257	0.070
Hill-RBF	Rho:	0.179	0.174	0.571
	P:	0.450	0.163	<0.001
Haigis	Rho:	0.251	0.257	0.402
	P:	0.181	0.010	0.003

D: Diopters. For each formula, the first row gives the Spearman's rho value and the second row gives its corresponding p value

In our study, we also analyzed whether ASD or ACD variations were more reliable to predict hyperopic shift in the PEs of lens formulas. As shown in Table 4, ASD was strongly correlated with the PEs of 5 lens formulas, whereas ACD was only correlated with the PE of the Hoffer Q formula. The only two lens formulas that were not biased by ASD variations were Olsen OLCR and Barrett II. Our results were similar in subgroups with normal and high mean K values, showing that the effect of ASD was mostly independent from keratometric parameters.

A study conducted by Gökce et al.[16] investigated the effect of ACD on the accuracy of 8 IOL calculation formulas. They found that the PEs of the Holladay 1 and Hoffer Q formulas were myopic in eyes with ACD lower than 3.00 mm and hyperopic in those with ACD greater than 3.50 mm, whereas the results of Olsen OLCR were inversely hyperopic in shallow ACD and myopic in deeper ACD. In their study, the Holladay 2, Barrett II, and Haigis formulas had lower PEs that were non-different from zero in the same groups. They also showed that while Holladay 1, Hoffer Q, and Hill-RBF were positively correlated with ACD, Olsen OLCR was negatively correlated. In contrast, the Holladay 2, Barrett II, Haigis, and the purchased version of the Olsen formula were not correlated. With these results, they concluded that while the implanted IOLs were more posteriorly located than predicted by the Holladay 1 and Hoffer Q formulas, the inclusion of ACD in the Holladay 2, Barrett II, Haigis, and the purchased Olsen formulas improved the accuracy of ELP prediction. They also acknowledged that in their study, eyes with shallower ACD had greater LT. Thus, they concluded that it would be prudent to use lens formulas that include both ACD and LT together (Holladay 2, Barrett II, and Olsen). In our study, we showed that despite the inclusion of ACD and LT, two of these formulas (Barrett II and Olsen) still yielded significantly hyperopic PEs, which might be explained by an alteration of ASD as a whole, rather than separate ACD or LT variations. In view of these findings, we suggest that eyes with larger ASD might have more posteriorly located ELPs than the preoperative estimations of the lens formulas, which resulted in their hyperopic predictions, and ASD might be a better ocular parameter than ACD or LT alone in predicting ELP.

As mentioned above, ACD and LT measurements could vary with cycloplegic examination. The impact of these variations on IOL calculation results have been investigated in several studies.[6,7,8] By measuring with a swept-source OCT-based biometer (IOLMaster 700®), Arriola-Villalobos et al.[7] showed no effect of cycloplegia-related ACD and LT variations on the Holladay 2 and SRK/T formulas. However, Huang et al.[6] reported a significant difference between IOL calculations of the Haigis formula with and without cycloplegia when measured with Lenstar LS900®. In addition to Haigis, Ozyol et al.[8] showed a significant difference in Holladay 2 formula calculations when measured with the IOLMaster 700®. Based on these results, it should be noted that lens formulas including ACD parameters are likely to be affected by changes in ACD induced by cycloplegia. Presumably, ASD might not be affected by accommodation and cycloplegia, and thus could be a more stable and reliable biometric parameter than ACD.

Melles et al.[17] conducted a large population study evaluating the bias introduced by ocular biometric parameters in lens calculation formulas. Based on their results, they concluded that Barrett II and Olsen OLCR had the best outcomes in terms of the accuracy of postoperative spherical equivalent. They also emphasized that most of the formulas were affected by ocular biometric changes. They demonstrated that SRK/T was particularly affected by changes in mean K, whereas Hoffer Q and Olsen OLCR had significant bias with varying ACD, and Haigis was the formula most affected by LT variations. These results were the driving factors for investigating the effect of ASD on the predictions of lens formulas in our current study.

There are two recent articles in the literature which investigated the effect of ASD on ELP. Plat et al.[18] analyzed correlations between preoperatively acquired biometric parameters and postoperative actual lens position (ALP) with OLCR. They demonstrated that AL, ACD, ASD, and WTW measurements were correlated with ALP. Satou et al.[19] analyzed anterior segment anatomy with anterior segment OCT, in which they identified anterior, equatorial, and posterior surface depth of the crystalline lens preoperatively (hence anterior surface depth and posterior surface depth correspond to ACD and ASD in our study, respectively). They concluded that lens equatorial and posterior surface depth were correlated with IOL position as well as with the refractive PE of the SRK/T formula. Both studies made the assumption that including ASD (or posterior surface depth) in the lens calculation would improve ELP predictions.

The effect of ASD on vergence lens calculation formulas was first analyzed by Olsen and Hoffmann,[4] who showed that the PEs of SRK/T, Holladay I, Haigis, and Hoffer Q had bias in terms of the AL, K, and ASD, which led them to introduce the C constant into the Olsen formula in order to reduce the effect of LT (and therefore ASD) on ELP preoperatively. In the current study, we further developed this approach by including new-generation Barrett II and Hill-RBF formulas and comparing the performances of both old- and new-generation formulas in eyes grouped according to their ASD values. Our results have shown that, although both old- and new-generation formulas were affected by ASD variations, Olsen OLCR and Barrett II seemed to be the least affected formulas. This is likely because both of these formulas include ACD and LT changes in their calculations.[4,20] However, Olsen OLCR still had more hyperopic than myopic results in all groups, which makes it less reliable for eyes with ASD lower than 7.90 mm, as other lens formulas provided better estimations in this range. On the other hand, as described by Cooke and Cooke,[21] the two types of Olsen formula (Olsen OLCR and Olsen Phacooptics) might have different

accuracy outcomes. In our study, the presented results belonged to Olsen OLCR formula. Observing the apparent success of older formulas in eyes with ASD less than 7.90 mm, adjusting these formulas according to ASD changes might be considered as an effective option to improve their results for eyes with ASD greater than 7.90 mm. Norrby et al.[22] argued that using ACD as the sole predictor for postoperative IOL position was sufficient. However, our findings suggest that using ASD, which includes LT measurement as an intrinsic adjusting factor for ACD, might also be beneficial.

Study limitations

Limitations of this study are its small sample size, retrospective design, and the inability to analyze AL and mean K variations in the three ASD groups due to the sample size, which are equally important to explain the PEs of lens formulas. We calculated ocular biometric parameters with the OLCR device only, which is not considered the gold standard for anatomical measurements. Despite these limitations, our study offers a new approach to classifying cataract surgery candidates preoperatively to assess postoperative ELP which indicates more accurate lens formulas for different ASD values. Further studies with larger sample sizes (1) to evaluate the effect of ASD on lens formulas in eyes with short and long ALs, (2) to compare different biometric measurement devices that use OLCR, partial coherence interferometry, and ultrasound in the calculation of ASD, and (3) to detect the ability of ASD to predict ELP with the calculation of postoperative IOL position might show promising results.

Conclusion

Our study showed that ASD seems to be important in assessing postoperative refraction predictions of IOL calculation formulas. Although most IOL calculation formulas do well between ASD 7.30 mm and 7.90 mm, selecting formulas which take ACD and LT into account may achieve better results when ASD is out of this range. Variations in ASD affected the PEs of older vergence formulas and Hill-RBF. Therefore, including ASD in ELP calculations would improve IOL predictions. More and possibly larger studies including extreme biometric measurements are needed to further evaluate the effects of ASD on IOL calculation predictions.

Ethics

Ethics Committee Approval: This study was conducted with Koç University Institutional Review Board approval (decision number: 2019.410.IRB2.131), according to the tenets of the Declaration of Helsinki.

Informed Consent: Patient consent was obtained for the use of their medical records.

Peer-review: Externally peer reviewed.

Authorship Contributions

Surgical and Medical Practices: A.Ş., O.M., Concept: A.Ş., O.M., M.H., Design: A.Ş., O.M., Data Collection or Processing: C.K., A.Y.T., M.Z.K., Analysis or Interpretation: C.K., A.Ş., O.M., Literature Search: C.K., A.Y.T., M.Z.K., Writing: C.K.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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