IOL Power Calculation in Long Eye

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In long axial length (AL) eyes, traditional intraocular lens (IOL) power formulas tend to select IOLs of insufficient power, leaving patients with postoperative hyperopia. To reduce the chances for hyperopic surprises, surgeons used to empirically aim for a more myopic postoperative outcome by targeting a postoperative refraction of −1.00 to −2.00 diopter (D). Norrby [1] reported that the largest contributor of error in IOL power calculation was the estimation of effective lens position (ELP) (35%), followed by the postoperative refraction determination (27%) and AL measurement (17%). In long eyes, the required IOL powers are low, and errors in ELP produce low refractive effect. This indicates that accuracy of ELP estimation in long eyes is not as important as in normal and short eyes in which higher IOL powers are required. In this chapter, we will discuss the factors contributing to challenges in IOL power prediction in long eyes, the formulas appropriate for use in these eyes, and the refractive outcomes with these formulas.

Factors Contributing to Challenges in IOL Power Calculation in Long Eyes

Inaccurate measurement of preoperative AL has been reported to be the main reason for postoperative refractive error in axial high myopia [2]. There are three factors that primarily contribute to challenges in IOL power calculations in long eyes.

Posterior Staphyloma

The incidence of posterior staphyloma increases with increasing AL, and it is likely that nearly all eyes with pathologic myopia have some form of posterior staphyloma. Ultrasonic biometric methods can produce errors in the presence of a posterior staphyloma by giving falsely long AL.

An immersion A/B-scan approach for AL measurement has been described in the setting of posterior staphyloma [3]. Using a horizontal axial B-scan, an immersion echogram through the posterior fundus is obtained with the cornea and lens echoes centered while simultaneously displaying the optic nerve void. The A-scan vector is then adjusted to pass through the middle of the cornea as well as the anterior and posterior lens echoes to ensure that the vector will intersect the retina in the region of the fovea. Optical biometry with appropriate patient fixation may solve this problem of identifying the fovea and

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has improved outcomes in long eyes with a posterior staphyloma.

Calculation of Axial Length Matching US Data: The IOL Master Calibration

Theoretically, optical biometry permits more accurate measurements when a posterior staphyloma is present. However, in a study investigating the accuracy of SRK/T formula in eyes with negative and zero-powered IOLs, MacLaren and colleagues [4] reported consistent hyperopic errors across all three methods of biometry (A-scan, B-scan, and optical). This indicates that eliminating or minimizing the adverse impact of posterior staphylomata on IOL calculations does not prevent hyperopic surprises in long eyes.

During the development of the first optical biometer (Carl Zeiss Meditec, Jena, Germany), first, the OPL data were transformed to geometrical path length (GPL) data using a group refractive index calculated theoretically from the Gullstand eye model ($n = 1.3549$). Then regression analysis produced the definitive conversion formula programmed in the commercial version of the first IOL Master model: GPL (OPL/1.3549) = $AL_{GBS} \times 0.9571 + 1.3033$, where AL_{GBS} is the AXL measured by immersion US. There were two main reasons for this transformation: (1) to avoid the bias produced in the extremes of the AXL range that would have occurred if only an average refractive index was used for the calculation from measured OPL and (2) to adjust the retinal plane reference from PCI to the internal limiting membrane for US. In the PCI instrument, the main retinal signal is produced in the retinal pigment epithelium, which produces systematically longer measurements.

With the IOL Master calibration, the same IOL constants could be used when surgeons moved from immersion US to optical biometry, which, of course, made this transition easier. All optical biometers developed thereafter, except the Argos biometer (Movu, Komaki, Japan), are all calibrated to provide an AL equivalent or similar to the first optical biometer. However, in long eyes, the relative lengths of the ocular segments may differ from those in eyes with normal ALs, and the use of a fixed group refractive index for the entire eye may yield incorrect values for AL.

We proposed a segmented AL that is calculated by summing the GPL of individual ocular segments converted from their respective OPLs using specific refractive indices for each ocular medium: cornea, aqueous depth (AD), lens thickness (LT), and vitreous chamber depth [6]. Theoretically, the segmented AL may provide more accurate AL measurements in eyes with unusual ocular segment proportions. We found that the segmented ALs were shorter in long eyes compared with the AL calculated with the IOL Master calibration in an OLCR instrument. The refractive accuracy with segmented ALs was improved in long eyes with the Barrett, Haigis, Hoffer Q, Holladay 1, and SRK/T formulas [6]. Cooke and Cooke [7] compared prediction accuracy with the AL calculation method of the Lenstar biometer (transitional AL) and that of the Argos biometer (sum-of-segments AL). They found that using sum-of-segments AL, instead of traditional AL, improved predictions for formulas designed on ultrasound data (SRK/T, Holladay 1, Holladay 2, Hoffer Q, and Haigis), although it worsened the Barrett and Olsen formulas. Further studies are desirable in this regard.

Extrapolation Issue in Extreme Long Eyes

The dataset used in the study by Haigis et al that developed regression formula by converting the OPL data to GPL in millimeters, eyes with AL up to 27.45 mm were included [5]. When this conversion method is used in eyes longer than 27.45 mm, extrapolation is introduced and errors may presumably occur.

Principal Plane Shift in Negative-Power IOLs

There are differences in geometries of positive-diopter IOLs and negative-diopter IOLs. The optic principle plane shifts in negative-power

IOLs, compared to the principle plane in positive-power IOLs. Petermeier and colleagues [8] proposed seperate constants optimization for eyes with negative IOL powers.

IOL Power Calculation Formulas for Long Eyes

Axial Length Adjustment Methods (Wang-Koch Adjustment)

We assume that the hyperopic error seen in long eyes is in the measurement of AL or in the way that formulas use this value. In a previous study, we proposed a method of optimizing AL in long eyes (Wang-Koch adjustment) [9]. Our results showed that this method significantly improved the accuracy of IOL power calculation in eyes with IOL powers ≤5 D, and significantly reduced the percentage of eyes that would be left hyperopic.

In a more recent study [10], we modified the original AL adjustment formulas by using ULIB (User Group for Laser Interference Biometry) lens constants and manifested refraction converted to 6 meters. The modified AL adjustment formulas are less aggressive (less myopic outcomes) than the original AL adjustment formulas. AL adjustment is required in eyes with an AL > 26.5 mm for the modified Holladay 1 formula and AL > 27.0 mm for the modified SRK/T formula. The modified equations for optimizing the AL are as follows:

- Modified Holladay 1 optimized AL = 0.817 × (measured AL) + 4.7013.
- Modified SRK/T optimized AL = 0.8453 × (measured AL) + 4.0773.

Based on the formula, the optimized AL is calculated from the measured optical or ultrasonic AL. Then, the optimized AL is entered into the IOLMaster or Lenstar, and the calculation is performed again. We recommend selecting the IOL power that predicts a minus prediction error close to zero (−0.1 to −0.2 D), since slight myopic results may occur with this approach of optimizing AL. Figure 63.1 shows that an 8.0 D SN6ATT was suggested using the Holladay 1 with original AL of 28.41 mm. Recalculation with the optimized AL of 27.81 mm produced a 9.5 D IOL with predicted refraction of −0.06 D. A 9.5 D SN6AT3 was implanted and, at 3 weeks postoperatively, the uncorrected visual acuity was 20/15 and the manifest refraction was plano.

We also developed an AL adjustment equation for Holladay 2 formula [11]. The polynomial optimization equation is as follows:

- Holladay 2 optimized AL = 0.0001154786 × (measured AL)^3 + 0.0032939472 × (measured AL)^2 + 1.001040305 × (measured AL) − 0.3270056564.

With the Holladay IOL Consultant Software, users have the option to select the AL adjustment method, and IOL power calculations will be performed automatically using the optimized AL in long eyes.

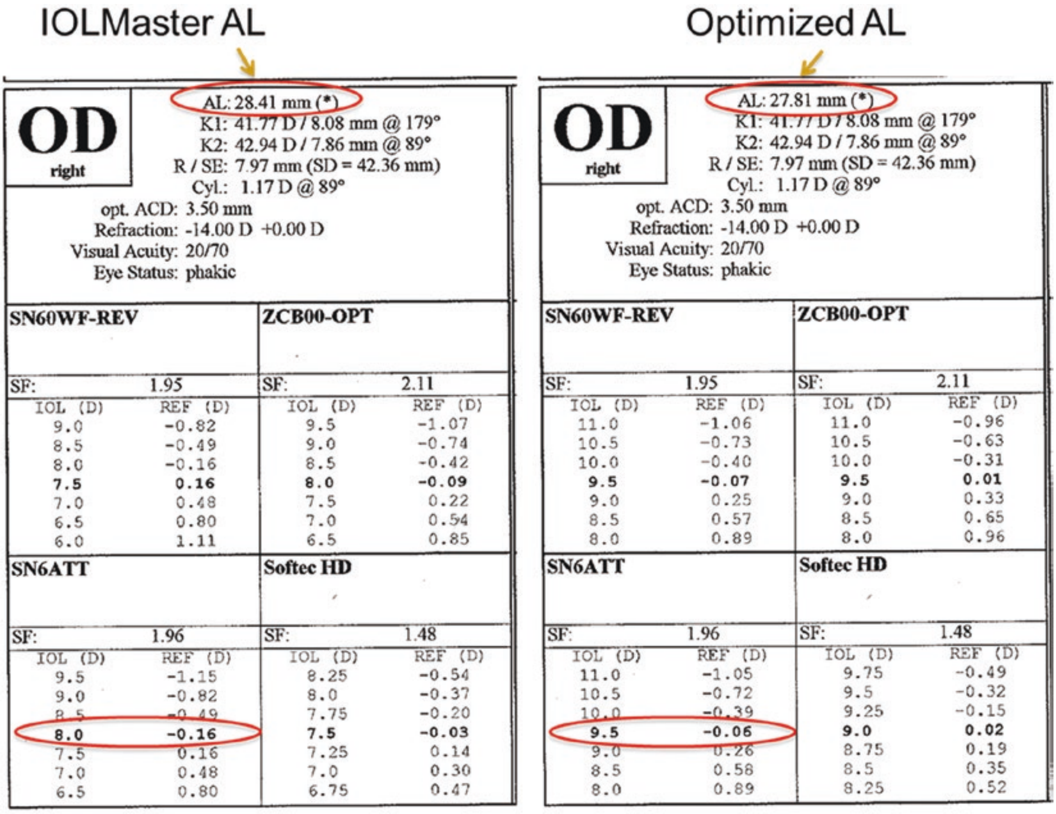
It should be noted that the AL adjustment method should be used with combination of the Holladay 1, Holladay 2, and SRK/T formulas. The newer IOL power calculation formulas already have the AL optimized or adjusted empirically by their authors and the AL adjustment method should not be used.

Super Formula

This formula is a combination of the Hoffer Q, Holladay 1, Holladay 2, and SRK/T formulas and also has a small component of artificial intelligence [12]. In long eyes, the Wang-Koch AL adjustment is used. In 2019, the formula was revised using the postoperative data as component of artificial intelligence. It is available at www.iolcalc.com.

Barrett Universal II Formula

The Barrett Universal II (BUII) formula is the evolution of the Barrett Universal I, which was published in 1987 as a thick-lens paraxial for-



OD
right

AL: 28.41 mm (*)
K1: 41.77 D / 8.08 mm @ 179°
K2: 42.94 D / 7.86 mm @ 89°
R / SE: 7.97 mm (SD = 42.36 mm)
Cyl.: 1.17 D @ 89°
opt. ACD: 3.50 mm
Refraction: -14.00 D +0.00 D
Visual Acuity: 20/70
Eye Status: phakic

SN60WF-REV		**ZCB00-OPT**	
SF:	1.95	SF:	2.11
IOL (D)	REF (D)	IOL (D)	REF (D)
9.0	-0.82	9.5	-1.07
8.5	-0.49	9.0	-0.74
8.0	-0.16	8.5	-0.42
7.5	**0.16**	**8.0**	**-0.09**
7.0	0.48	7.5	0.22
6.5	0.80	7.0	0.54
6.0	1.11	6.5	0.85

SN6ATT		**Softec HD**	
SF:	1.96	SF:	1.48
IOL (D)	REF (D)	IOL (D)	REF (D)
9.5	-1.15	8.25	-0.54
9.0	-0.82	8.0	-0.37
8.5	-0.49	7.75	-0.20
8.0	**-0.16**	**7.5**	**-0.03**
7.5	0.16	7.25	0.14
7.0	0.48	7.0	0.30
6.5	0.80	6.75	0.47

OD
right

AL: 27.81 mm (*)
K1: 41.77 D / 8.08 mm @ 179°
K2: 42.94 D / 7.86 mm @ 89°
R / SE: 7.97 mm (SD = 42.36 mm)
Cyl.: 1.17 D @ 89°
opt. ACD: 3.50 mm
Refraction: -14.00 D +0.00 D
Visual Acuity: 20/70
Eye Status: phakic

SN60WF-REV		**ZCB00-OPT**	
SF:	1.95	SF:	2.11
IOL (D)	REF (D)	IOL (D)	REF (D)
11.0	-1.06	11.0	-0.96
10.5	-0.73	10.5	-0.63
10.0	-0.40	10.0	-0.31
9.5	**-0.07**	**9.5**	**0.01**
9.0	0.25	9.0	0.33
8.5	0.57	8.5	0.65
8.0	0.89	8.0	0.96

SN6ATT		**Softec HD**	
SF:	1.96	SF:	1.48
IOL (D)	REF (D)	IOL (D)	REF (D)
11.0	-1.05	9.75	-0.49
10.5	-0.72	9.5	-0.32
10.0	-0.39	9.25	-0.15
9.5	**-0.06**	**9.0**	**0.02**
9.0	0.26	8.75	0.19
8.5	0.58	8.5	0.35
8.0	0.89	8.25	0.52

Fig. 63.1 A sample of IOL power calculation using the original IOLMaster axial length (AL) (left) and the optimized AL with the Holladay 1 Wang-Koch AL adjustment (right)

mula [13]. It uses AL, keratometry, anterior chamber depth (ACD), LT, and corneal diameter (CD) values. The detailed prediction approach for effective lens position (ELP) is not published. This formula has been refined to improve outcomes in long eyes.

Hill-RBF Formula

The Hill-RBF (Radial Basis Function) calculator is an artificial intelligence-based, self-validating method for IOL power selection employing pattern recognition and a sophisticated form of data interpolation [14]. Based on artificial intelligence, this methodology is entirely data-driven. This approach also employs a validating boundary model, indicating to the user when it is performing within a defined area of accuracy. The Hill-RBF 3.0 was recently released based on significantly expanded datasets for short and long eyes. Additionally, it has increased the number of parameters used for IOL power selection by adding central corneal thickness (CCT), LT, CD, and gender to the existing parameters of AL, keratometry, ACD, and the desired postoperative spherical equivalent refraction.

Olsen Formula

With the Olsen formula, IOL power is calculated based on exact ray tracing (Snell's law of refraction) and paraxial ray tracing (Gaussian Optics). This formula incorporates the latest generation ACD prediction algorithms based on the complex relationship between the preoperative ocular dimensions (in particular ACD and LT) and the postoperative position of the IOL (the postoperative ACD) [15]. Measurements of the anterior and posterior corneal curvatures as well as conic coefficients (Q-values) obtained by modern anterior segment imaging systems can be used directly by the PhacoOptics program developed by Thomas Olsen (www.phacooptics.net).

Kane Formula

The Kane formula was developed by Jack X. Kane. It uses theoretical optics with artificial intelligence and regression-based components to refine the predictions (www.iolformula.com). It utilizes K, AL, ACD, and gender to predict the IOL position, with LT and CCT being optional factors.

EVO Formula

The Emmetropia Verifying Optical (EVO) formula was developed by Tun Kuan Yeo in Singapore (www.evoiolcalculator.com). It is a thick lens formula based on the theory of emmetropization. It uses AL, K, and ACD as the predictors, and LT and CCT are optional.

Panacea IOL Calculator

The Panacea IOL calculator was developed by David Flikier (www.panaceaiolandtoriccalculator.com). It is a vergence formula. In addition to the AL, keratometry, ACD, and LT, it also uses additional variables, such as ratio of posterior to anterior corneal radius of curvature for corneal value adjustment, and corneal asphericity in the IOL power calculation.

Pearl-DGS Calculator

The PEARL stands for Prediction Enhanced by ARtificial Intelligence and output Linearization, and DGS is named after the formula developers: Debellemanière, Gatinel, and Saad. This formula is based on artificial intelligence and optics (www.iolsolver.com). It uses several machine learning models that are selected according to the inputs entered by the surgeon and can adjust its prediction using the postoperative data of the contralateral eye if it is available.

Refractive Accuracy of IOL Formulas in Long Eyes

Table 63.1 shows the refractive accuracy of IOL power prediction in long eyes using different formulas reported in the literature over the past 10 years.

IOL Power Prediction Accuracy

Axial length adjustment methods ((Wang-Koch Adjustment): With the AL adjustment method, 64–82.4% of eyes have accuracy of refractive prediction errors ±0.5 D using Holladay 1 formula, 60–76.22% using SRK/T formula, and 71–84.21% using Holladay 2 formula. In an independent dataset of 1664 eyes with AL $\geq$ 25 mm used for the Hill-RBF formula development from Dr. Warren Hill, 93% of eyes had prediction errors of ±0.5 D using the modified AL adjustment Holladay 1 formula (unpublished data).

Super formula: With the Super formula, 55.3–83.33% of eyes have accuracy of refractive prediction errors ±0.5 D.

Barrett Universal II formula: The BUII formula is refined/optimized constantly. There are many studies that evaluated the accuracy of the BUII formula in long eyes, and 57.14–89.5% of eyes have accuracy of refractive prediction errors ±0.5 D.

Hill-RBF formula: The Hill-RBF 3.0 version was just released recently, and no study has yet reported its outcomes in long eyes. Several studies evaluated its accuracy in long eyes using the Hill-RBF 2.0 version, and 51.79–94.74% % of eyes had accuracy of refractive prediction errors ±0.5 D.

Table 63.1 Percentage of eyes with refractive prediction errors (RPE) within ±0.50 D, percentage of eyes with hyperopic RPE, refractive mean absolute error (MAE), and median absolute error (MedAE) in long eyes using various formulas reported in studies over the past 10 years

Studies with various formulas	No. of eyes	AL (mm)	RPE ± 0.50 D (%)	Hyperopic RPE (%)	MAE (D)	MedAE (D)
Axial length adjustment methods						
Original AL adjustment Holladay 1						
Cheng et al. [21]	370	≥26	NA	27.8, 52.4	0.39, 0.34	0.32, 0.27
Zhang et al. [26]	164	≥26	74.39	NA	0.35	0.27
Zhang et al. [22]	108	>26	74.07	NA	0.40	0.34
Liu et al. [19]	136	≥26	72	15	0.37	0.34
Popovic et al. [23]	262	>25	62–82.4	NA	0.35–0.56	0.24–0.40
Hill et al. [20]	51	>28	82.4, 81.6	49.0, 47.4	NA	NA
Cooke et al. [24]	54	>25	75.9, 72.2	NA	0.348, 0.335	0.291, 0.278
Abulafia et al. [25]	106	≥26	69.7, 80.0	NA	0.36, 0.32	0.33, 0.29
Modified AL adjustment Holladay 1						
Cheng et al. [21]	370	>26	NA	45.7, 50.5	0.35, 0.34	0.27, 0.28
Liu et al. [19]	136	≥26	64	33	0.39	0.38
Zhang et al. [22]	108	≥26	75.51	NA	0.36	0.34
Original AL adjustment SRK/T						
Cheng et al. [21]	370	>26	NA	25.9, 52.7	0.46, 0.39	0.34, 0.32
Zhang et al. [26]	164	≥26	76.22	NA	0.38	0.29
Liu et al. [19]	136	≥26	63	18	0.46	0.40
Zhang et al. [22]	108	≥26	67.59	NA	0.45	0.37
Abulafia et al. [25]	106	>26	65.8, 66.7	NA	0.41, 0.39	0.39, 0.34
Modified AL adjustment SRK/T						
Cheng et al. [21]	370	>26	NA	39.7, 51.9	0.41, 0.39	0.33, 0.32
Zhang et al. [26]	164	≥26	69.51	NA	0.42	0.36
Liu et al. [19]	136	≥26	60	28	0.47	0.43
Zhang et al. [22]	108	≥26	69.41	NA	0.41	0.33
AL adjustment Holladay 2						
Savini et al. [27]	19	>26	84.21	NA	0.296	0.265
Darcy et al. [28]	637	≥26	71.0	NA	0.352	NA
Super formula						
Gonzalez et al. [29]	115	>25	83.33	NA	0.29	0.22
Kane et al. [30]	47	≥26	55.3	NA	0.503	0.435
Cooke et al. [24]	54	≥26	75.9, 72.2	NA	0.348, 0.335	0.291, 0.278

Table 63.1 (continued)

Studies with various formulas	No. of eyes	AL (mm)	RPE ± 0.50 D (%)	Hyperopic RPE (%)	MAE (D)	MedAE (D)
Barrett universal II formula						
Cheng et al. [21]	370	≥26	NA	63.8, 47.6	0.39, 0.37	0.33, 0.31
Ji et al. [31]	56	>26	57.14	NA	0.53	0.46
Savini et al. [27]	19	>26	84.21	NA	0.253	0.22, 0.25
Gonzalez et al. [29]	115	≥25	88.60	NA	0.26	0.24
Omoto et al. [32]	44,87	≥26	84.1, 83.9	NA	0.22, 0.25	NA
Zhang et al. [26]	164	≥26	73.17	NA	0.38	0.28
Tang et al. [33]	125	>25	62.9	NA	0.507	0.355
Fernandes et al. [34]	51	≥26	NA	NA	0.319	NA
Darcy et al. [28]	637	≥26	70.7	NA	0.338	NA
Liu et al. [19]	136	≥26	78	36	0.32	0.27
Zhang et al. [22]	108	>26	71.56	NA	0.42	0.33
Zhou et al. [35]	43, 23	≥27	NA	NA	0.29, 0.55	NA
Wan et al. [36]	127	≥26	86.61	NA	NA	0.21
Rong et al. [37]	108	>26	70	NA	0.36–0.45	0.34–0.40
Wang et al. [10]	310	≥26	75, 82	NA	0.37, 0.32	0.31, 0.26
Roberts et al. [38]	90	>24.5	NA	NA	0.507	NA
Connell et al. [39]	44	≥26	NA	NA	0.331	NA
Kane et al. [30]	47	≥26	76.6	NA	0.375	0.325
Hill et al. [20]	51	>25	73.9, 79.4	76.1, 73.5	NA	NA
Kane et al. [40]	77	≥26	62.7	NA	0.435	0.37
Cooke et al. [24]	54	≥26	75.9, 83.3	NA	0.303, 0.274	0.255, 0.218
Abulafia et al. [25]	106	>26	89.5, 83.3	NA	0.28, 0.30	0.26, 0.21
Hill-RBF calculator 2.0						
Cheng et al. [21]	370	≥26	NA	72.4, 49.5	0.46, 0.38	0.38, 0.30
Ji et al. [31]	56	>26	51.79	NA	0.58	0.47
Gonzalez et al. [29]	115	≥25	81.58	NA	0.29	0.22
Tang et al. [33]	125	>25	62.5	NA	0.474	0.335
Savini et al. [27]	19	>26	94.74	NA	0.244	0.230
Darcy et al. [28]	637	≥26	71.2	NA	0.352	NA
Liu et al. [19]	136	≥26	76	54	0.37	0.33
Wan et al. [36]	127	≥26	86.61	NA	NA	0.20
Roberts et al. [38]	90	>24.5	NA	NA	0.32	NA
Connell et al. [39]	44	≥26	NA	NA	0.358	NA
Kane et al. [30]	47	≥26	66.0	NA	0.373	0.310
Hill et al. [20]	51	>25	76.7, 78.8	74.4, 69.7	NA	NA
Olsen formula						
Savini et al. [27]	19	>26	84.21, 89.47	NA	0.338, 0.256	0.205, 0.209
Gonzalez et al. [29]	115	≥25	85.96	NA	0.27	0.22
Darcy et al. [28]	637	≥26	70.6	NA	0.352	NA
Rong et al. [37]	108	>26	65	NA	0.34–0.53	0.32–0.43
Wang et al. [10]	310	≥26	77, 273	NA	0.36, 0.35	0.28, 0.31
Connell et al. [39]	44	≥26	NA	NA	0.352	NA
Cooke et al. [24]	54	≥26	83.3, 85.2	NA	0.290, 0.249	0.198, 0.218
Abulafia et al. [25]	106	>26	88.6, 57.1	NA	0.26, 0.49	0.21, 0.37
Kane formula						
Cheng et al. [21]	370	≥26	NA	54.1, 50.3	0.34, 0.34	0.27, 0.26
Savini et al. [27]	19	>26	94.74	NA	0.220	0.200
Gonzalez et al. [26]	115	≥25	86.84	NA	0.27	0.22
Fenandes et al. [34]	51	≥26	NA	NA	0.301	NA
Darcy et al. [28]	637	≥26	72.0	NA	0.329	NA
Connell et al. [39]	44	≥26	NA	NA	0.326	NA

(continued)

Table 63.1 (continued)

Studies with various formulas	No. of eyes	AL (mm)	RPE ± 0.50 D (%)	Hyperopic RPE (%)	MAE (D)	MedAE (D)
EVO formula						
Cheng et al. [21]	370	≥26	NA	56.5, 49.7	0.41, 0.40	0.32, 0.31
Savini et al. [27]	19	>26	89.47	NA	0.211	0.168
Gonzalez et al. [29]	115	≥25	85.96	NA	0.28	0.24
Zhang et al. [26]	164	≥26	79.27	NA	0.35	0.27
Fernandes et al. [34]	51	≥26	NA	NA	0.308	NA
Panacea IOL calculator						
Savini et al. [27]	19	>26	63.16	NA	0.415	0.345

D diopter; *AL* axial length; *NA* not available

Olsen formula: Several studies evaluated the accuracy of Olsen formula in long eyes, and 65–89.47% of eyes had refractive prediction errors ±0.5 D.

Kane formula: A few studies evaluated the accuracy of Kane formula in long eyes, and 72–94.74% of eyes had refractive prediction errors ±0.5 D.

EVO formula: A few studies evaluated the accuracy of EVO formula in long eyes, and 79.27–89.47% of eyes had refractive prediction errors ±0.5 D.

Panacea IOL Calculator: One study evaluated the accuracy of Panacea IOL calculator in long eyes, and 63.16% of eyes had refractive prediction errors ±0.5 D.

Pearl-DGS Calculator: The Pearl-DGS calculator was introduced recently and there is no report of its accuracy in long eyes yet.

Comparison of Refractive Accuracy Among Formulas

The majority of studies reported that the performances of the above formulas were comparable in long eyes [16–18]. In general, studies have reported that the BUII, Kane, Hill-RBF, and Olsen formulas produced the best results or the lowest prediction errors, with no significant differences among those formulas.

The incidence of hyperopic outcomes (hyperopic relative to the predicted refraction) with the AL adjustment formulas was significantly lower than the BUII and Hill-RBF 2.0 (15–33% vs. 36–54%) [19]. Hill and colleagues [20] reported that the AL adjusted Holladay 1 produced less eyes with hyperopic outcomes (47.4–49%) than did the BUII and Hill-RBF 1.0 formulas (69.7–76.1%). Using the ULIB lens constants, Cheng et al. [21] found that the original AL adjustment Holladay 1 and SRK/T formulas produced significantly lower percentages of eyes (25.9–27.8%) with hyperopic outcomes than did the Kane, Hill-EBF 2.0, EVO, and BUII formulas (54.1–72.4%).

Conclusion

Due to the low IOL powers required in long eyes, accuracy of ELP estimation is not as important as in normal and short eyes. By adjusting the AL values used in Holladay 1, Holladay 2, and SRK/T formulas, excellent outcomes can be achieved. The refractive accuracy can be improved in long eyes with segmented ALs using specific refractive indices for each ocular medium. For IOL power calculation, based on the findings in the literature, any of the following formulas is a reasonable choice in long eyes: modified AL adjustment Holladay 1, BUII, Hill-RBF, Olsen, Kane, and EVO formulas.

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