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Research Article

The Accuracy of Intraocular Lens Power Calculation Formulas for Eyes of Axial Length Exceeding 25.0mm

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Abstract

Purpose: Comparison of intraocular lens power calculation formulas accuracy for eyeballs longer than 25.00mm.

Material and Methods: 70 patients (81 eyeballs) were examined, whose ocular axial length ranged between 25.01mm and 28.57mm. Preoperatively, the intraocular lens power for each patient was calculated using six different formulas (Holladay1, SRK/T, Hoffer Q, Holladay 2, Haigis and Barrett Universal II). The power of the implanted IOL was based on the Holladay 2 formula. Three months after cataract surgery, postoperative refraction was measured. Mean absolute error as a difference between postoperative and predicted spherical equivalences of refractive error was calculated.

Results: The Barrett Universal II formula achieved the lowest level of mean absolute error of 0.08 ± 0.08 D ($p < 0.001$ for Barrett Universal II versus each of the other formulas). Further places were taken by the following formulas: Holladay 2 (0.13 ± 0.09 D), Haigis (0.17 ± 0.12 D), SRK/T (0.18 ± 0.13 D), Holladay 1 (0.20 ± 0.14 D), Hoffer Q (0.26 ± 0.15 D). $P < 0.001$ for Holladay 2 versus Hoffer Q formula, for Haigis versus Hoffer Q and for SRK/T versus Hoffer Q. Additionally, correlation between absolute error and axial length was evaluated. It was observed, that absolute error had been associated with axial length when Holladay 1 or Barrett Universal II or Hoffer Q formula had been used.

Conclusions:

1. The Barrett Universal II formula is recommended for intraocular lens power calculation for eyeballs with axial length longer than 25.0mm.

2. Holladay 2 formula seems to be satisfactory for these cases.

Keywords: Intraocular lens power calculation formula; Eyeball longer than 25.0mm; Barrett Universal II formula; Mean absolute error

Introduction

It is generally accepted that most Intraocular Lens (IOL) power calculation formulas perform well for eyes of average Axial Length (AL) i.e. 22.0 – 25.0mm [1]. The choice of intraocular lens power calculation formulas must be very careful in the cases when an eyeball is longer than 25.0mm or shorter than 22.0mm [2-4]. There are many IOL power formulas. They form five generations – details in Table 1 [5].

Material

This study reviewed 81 cataract eyeballs from 70 patients (36 men and 34 women at the age of 47 to 86 years). Axial lengths of the eyeballs were in the range between 25.01mm and 28.57mm. Patients after retinal detachment and refractive surgery were excluded from this study.

Methods

Before cataract surgery, auto refractor keratometer was used for corneal power measurement. AL was measured by IOL Master 700, as well as IOL power was calculated according to six different formulas (Holladay 1, SRK/T, Hoffer Q, Haigis, Holladay 2, Barrett Universal II). Each cataract surgery was performed by the same doctor. Only acrylic foldable intraocular lenses with power calculated according to the Holladay 2 formula were implanted. Postoperative refraction was measured three months after cataract surgery. Mean Absolute Error (MAE) as a difference between postoperative and predicted spherical equivalences of refractive error was calculated.

Statistical analysis was performed using the Statistical 13.1 package.

Results

The Barrett Universal II formula achieved the lowest level of MAE 0.08 ± 0.08 D. Detailed results of the calculated Absolute Error (AE) for each formula were summarized using descriptive statistics (mean, standard deviation, median and range) and were collected in Table 2 and Figure 1.

The nonparametric Kruskal-Wallis test was performed to compare AE scores according to six formulas. The results were considered statistically significant if the p-value was less than 0.05 ($p<0.05$). The obtained probability value was $p<0.001$ (lower than the

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Table 1: Five generations of intraocular lens power calculation formulas.

	Generation				
	The first	The second	The third	The fourth	The fifth
	Fyodorov		Holladay 1	Holladay 2	Hoffer H-5
	Binkhorst		SRK/T	Haigis	Hill RBF
Formulas	SRK	SRK II	Hoffer Q	Olsen	The Ladas
				Hoffer H	Fullmonte
				Barrett	
				Universal II	

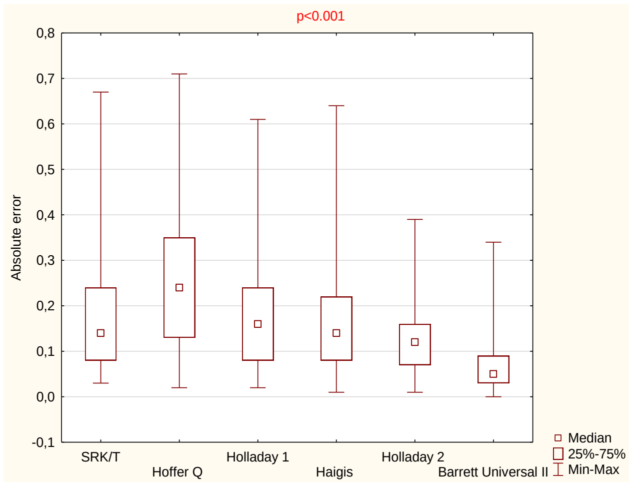

Figure 1: Descriptive statistics of absolute error.

assumed significance level α = 0.05) therefore, it was checked between which pairs of formulas there were statistically significant differences. For this purpose, the nonparametric U-Mann-Whitney test was performed. Due to multiple comparisons, Bonferroni corrections were applied and that was why the significant level was assumed to be $\alpha = 0.05/15 = 0.003$. For variables Barrett Universal II versus each other formulas as well as Haigis versus Hoffer Q, Holladay 2 versus Hoffer Q and SRK/T versus Hoffer Q statistically significant differences were found. The results were shown in Table 3.

Additionally, the correlation between AL and AE was evaluated. The results of Spermann rank correlation between AE and AL for each of the six formulas are presented in Table 4.

Statistically significant correlation factors occur between AE and AL for the Holladay 1 formula as well as for Barrett Universal II and Hoffer Q formulas. For the Holladay 1 formula, correlation is moderate and for Barrett Universal II and Hoffer Q formulas, correlation is low. Detailed correlation charts are presented in Figures 2-4.

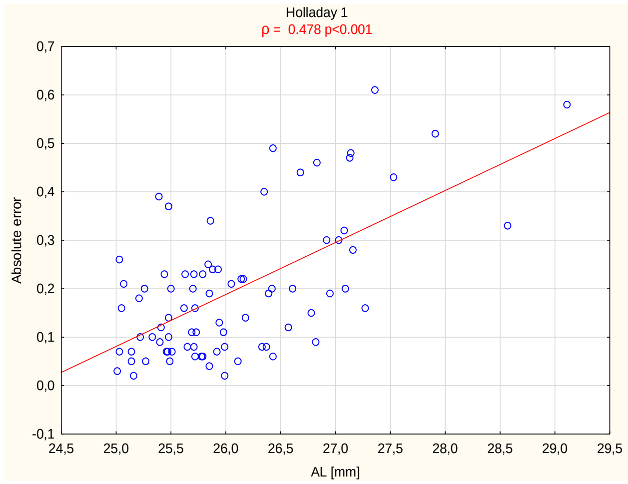

Figure 2: Correlation between absolute error and axial length for the Holladay 1 formula.

Discussion

Accuracy of IOL power calculation formulas is the most important factor affecting the postoperative refractive status [1]. On the other hand, the IOL power calculation's inaccuracy in eyes with long AL is well documented [6]. Choosing the right and the most accurate IOL power calculation formula is still a matter of debate [7]. The meta-analysis of 4047 eyeballs longer than 24.5mm published in 2018 showed the superiority of the Barrett Universal II formula over Holladay 1, Hoffer Q, SRK/T and Holladay 2 formulas [6]. This same study demonstrated no statistically significant difference between Barrett Universal II and Haigis as well as Olsen formula [6]. The highest accuracy of the Barrett Universal II formula was also shown by a study carried out by Liu et al., as well as by Zhou, Sun, Deng [2,3]. In turn, Hoffer and Savini did not notice the difference in the accuracy of Barrett Universal II, Haigis, Olsen and SRK/T formulas for long eyeballs [8]. Similarly, Rong et al. equally well evaluated Barrett Universal II, Haigis and Olsen formulas [9]. Chong and Mehta demonstrated also that Barrett Universal II, Haigis and Holladay 1 formulas gave equally good calculation results for long eyeballs [10]. On the other hand, Zheng et al. found no differences in the accuracy of Haigis and SRK/T formulas [11]. In turn, Haigis formula gave the best accuracy of intraocular lens power calculation in the study of Ghenam and El-Sayed [12]. In my 2013 study, I showed the greatest accuracy of the Holladay 1 formula, but I did not consider Barrett Universal II or Holladay 2 formulas at the time [5]. Nevertheless, Aristodemou et al. in their research with 8,108 eyes proved that the Holladay 1 formula used for calculating the IOL power for eyes with AL between 24.5mm and 26.0mm gave the best results, whereas the SRK/T formula was the most precise one for eyes longer than 27.0mm

Table 2: Descriptive statistics of absolute error.

	Absolute error					
	SRK/T	Hoffer Q	Holladay 1	Haigis	Holladay 2	Barrett Universal
Average±SD	0.18±0.12	0.26±0.15	0.20±0.14	0.17±0.12	0.13±0.09	0.08±0.08
Median	0.14	0.24	0.16	0.14	0.12	0.05
Min-max	0.03-0.67	0.02-0.71	0.02-0.61	0.01-0.64	0.01-0.39	0.05-0.34

Table 3: U-Mann-Whitney test results for each pair of formulas.

U-Mann-Whitney test results	p
SRK/T *vs* Hoffer Q	<0.001
SRK/T *vs* Holladay 1	0,613
SRK/T *vs* Haigis	0,685
SRK/T *vs* Holladay 2	0,022
SRK/T *vs* Barrett Universal II	<0.001
Hoffer Q *vs* Holladay 1	0,006
Hoffer Q *vs* Haigis	<0.001
Hoffer Q *vs* Holladay 2	<0.001
Hoffer Q *vs* Barrett Universal II	<0.001
Holladay 1 *vs* Haigis	0.313
Holladay 1 *vs* Holladay 2	0,007
Holladay 1 *vs* Barrett Universal II	<0.001
Haigis *vs* Holladay 2	0.052
Haigis *vs* Barrett Universal	<0.001
Holladay 2 *vs* Barrett Universal II	<0.001

Table 4: Spermann rank test results.

Variables	Formula	N	R	t(N-2)	p
AL & AE	SRK/T	81	0,163	1,468	0,146
AL & AE	Hoffer Q	81	0,293	2,728	0,008
AL & AE	Holladay 1	81	0,478	4,834	<0.001
AL & AE	Haigis	81	0,039	0,349	0,728
AL & AE	Holladay 2	81	0,195	1,764	0,082
AL & AE	Barrett Univ.	81	0,312	2,922	0,005

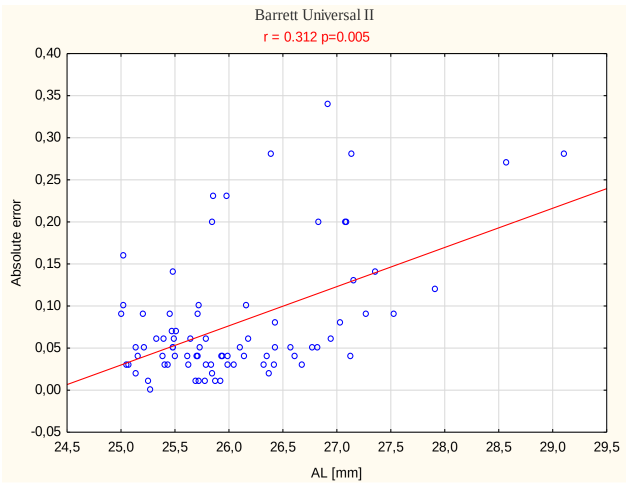

Figure 3: Correlation between absolute error and axial length for the Barrett Universal II formula.

[13]. However, according to Ioannidis, the Holladay 2 formula is the most accurate for IOL power calculation for long eyes [14]. In turn, Bang et al. as well as Haigis in their studies proved the superiority of the Haigis formula over the other ones [15,16]. Obviously, Olsen pointed to his formula as the most precise for eyes with AL exceeding

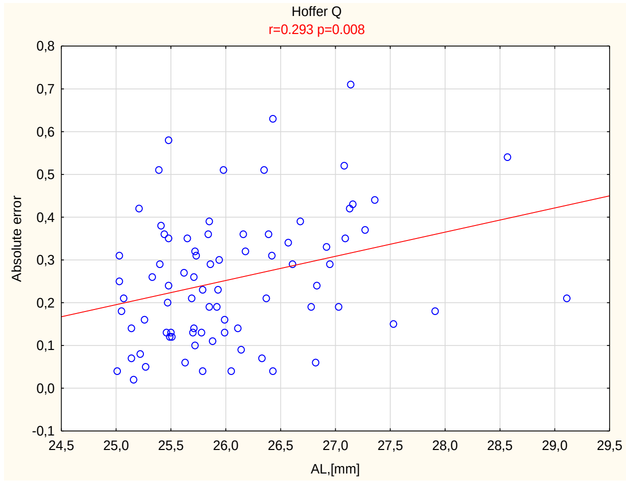

Figure 4: Correlation between absolute error and axial length for the Hoffer Q formula.

24.5mm [17].

As can be seen, there is no single IOL power calculation formula in the case of long eyeballs. The Barrett Universal II formula is considered most often as the best one [2,3,6]. My study showed similar conclusions. The Barrett Universal II formula gave the smallest result of AE as both an average as a median.

Conclusions

1. The Barrett Universal II formula is recommended for IOL power calculation for eyeballs with AL longer than 25.0mm.

2. The Holladay 2 formula seems to be satisfactory for these cases.

References

1. Chen C, Xu X, Miao Y, Zheng G, Sun Y, Xu X. Accuracy of Intraocular Lens Power Formulas Involving 148 Eyes with Long Axial Lengths: A Retrospective Chart-Review Study. J Ophthalmol. 2015; 2015: 976847.
2. Liu J, Wang L, Chai F, Han Y, Qian S, Koch DD, et al. Comparison of intraocular lens power calculation formulas in Chinese eyes with axial myopia. J Cataract Refract Surg. 2019; 45: 725-731.
3. Zhou D, Sun Z, Deng G. Accuracy of refractive prediction determined by intraocular lens power calculation formulas in high myopia. Indian J Ophthalmol. 2019; 67: 484-489.
4. Wang Q, Jiang W, Lin T, Wu X, Lin H, Chen W. Meta-analysis of accuracy of intraocular lens power calculation formulas in short eyes. Clin Exp Ophthalmol. 2018; 46: 356-363.
5. Stopyra W. The accuracy of IOL power calculation formulas for eyes of axial length exceeding 24.5 mm. Klin Oczna. 2013; 115: 93-95.
6. Wang Q, Jiang W, Lin T, Zhu Y, Chen C, Lin H, et al. Accuracy of intraocular lens power calculation formulas in long eyes: a systemic review and meta-analysis. Clin Exp Ophthalmology. 2018; 46: 738-749.
7. Abulafia A, Barrett GD, Rotenberg M, Kleinmann G, Levy A, Reitblat O, et al. Intraocular lens power calculation for eyes with an axial length greater than 26.0 mm: comparison of formulas and methods. J cataract Refract Surg. 2015; 41: 548-556.
8. Hoffer KJ, Savini G. IOL power calculation in short and long eyes. Asia Pac. J Ophthalmol (Phila). 2017; 6: 330-331.
9. Rong X, He W, Zhu Q, Qian D, Lu Y, Zhu X. Intraocular lens power calculation fin eyes with extreme myopia: Comparison of Barrett Universal II, Haigis and Olsen formulas. J Cataract Refract Surg. 2019; 45: 732-737.

10. Chong EW, Mehta JS. High myopia and cataract surgery. Curr Opin Ophthalmol. 2016; 27: 45-50.

11. Zheng Q, Zhao Z, Lian H, Zhao Y. The analysis of refractive error of long axial high myopic eyes after IOL implantation. Zhonghua Yan KeZaZhi. 2015; 51: 276-281.

12. Ghanem A, El-Sayed H. Accuracy of intraocular lens power calculation in high myopia. Oman J Ophthalmol. 2010; 3: 126-130.

13. Aristodemou P, Knox Cartwright N, Sparrow J, Johnston R. Formula choice: Hoffer Q, Holladay 1 or SRK/T and refractive outcomes in 8108 eyes after cataract surgery with biometry by partial coherence interferometry. J Cataract Refract Surg. 2011; 37: 63-71.

14. Ioannides A. Holladay 2 formula. Ophthalmology. 2011; 118: 2525.

15. Bang S, Edell E, Yu Q, Pratzer K, Stark W. Accuracy of intraocular lens calculations using the IOL Master in eyes with long axial length and a comparison of various formulas. Ophthalmology. 2011; 118: 503–506.

16. Haigis W. Intraocular lens calculation in extreme myopia. J Cataract Refract Surg. 2009; 35: 905-911.

17. Olsen T. Calculation of intraocular lens power: a review. Acta Ophthalmol Scand. 2007; 85: 472–485.