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Comparison of the Refraction Precision Results between Pentacam AXL and IOL Master 700 Using Universal II Barrett Formula after Cataract Surgery

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Abstract

Background: The availability of premium intraocular lenses (IOL), including toric, multifocal, and EDOF, has become very sophisticated and now demands accurate biometric measurement accuracy. The Pentacam AXL and IOL Master 700 are often used for optical biometry and they are available in the market today. They can also be used to measure the parameters needed in the IOL calculation using the latest generation formulas, such as the Barett Universal II. Therefore, this study aims to compare the accuracy of refraction results between Pentacam AXL compared to IOL Master 700 after cataract surgery with the Barett Universal-II formula. **Method:** A total of 64 eyes from 64 patients who had a preoperative examination with IOL Master 700 and Pentacam AXL were included in this study. Parameters such as K, ACD, LT, WTW, and AL were then compared between the two tools. Prediction error values were also calculated and compared based on the difference between the Spherical equivalent (SE) of subjective refraction results after 4 weeks of surgery with their refractive prediction targets. **Results:** There was no statistically significant difference in the parameters measured from the two tools except ACD and WTW. Furthermore, LT was difficult to obtain on the Pentacam AXL due to penetration problems, as well as in patients with significant lens opacities. The percentage of error prediction values that reach ± 0.50 D on Pentacam AXL and IOL Master 700 was 70.3% and 73.5%, respectively. However, the average prediction error that was close to emmetropia with IOL Master 700 was greater compared to the other tool. **Conclusion:** Pentacam AXL has a fairly good accuracy for refraction prediction compared to IOL

Master 700. However, it is still necessary to optimize its constants to obtain optimal results.

Keywords

Error Prediction, Biometry, IOL Master 700, Pentacam AXL

1. Introduction

Cataract and refractive surgeries have become very popular in the community. Furthermore, the availability of premium intraocular lenses (IOL), including toric lenses, multifocal and EDOF, has become increasingly sophisticated and requires accurate biometric measurement accuracy [1] [2]. There has also been an increase in the development of accurate IOL calculation formulas [3] [4]. The fourth generation LIO formula, such as the Barrett Universal II, requires several parameters in its calculation, including the keratometer value (K), the corneal diameter distance from the limbus to the limbus (WTW), anterior chamber depth (ACD), lens thickness (LT), and axial length of the eyeball (AL) [5] [6]. The total value of the keratometer is influenced by the anterior and posterior curvature of the cornea [2]. Parameters of the cornea posterior curvature have now become important factors, which are often considered in the measurement of monofocal and multifocal toric lenses [7].

Pentacam AXL is the result of the development of the previous Pentacam tool. The existing Scheimpflug camera, which is often used to measure the anterior segment of the eye in 3D has added partial coherence interferometry technology to obtain AL [2] [8]. The combination of these two technologies enables the Pentacam AXL to calculate the IOL power required for cataract and refractive surgeries [4]. It can also measure the parameters needed for IOL calculations using the latest generation formulas. Several studies comparing the results of the Pentacam AXL measurement parameters with other gold standard tools, such as IOL Master 700 and Lenstar LS 900 showed varying results [8] [9] [10]. Sel *et al.*, revealed that there were significant differences in the results of keratometry, ACD, and AL obtained from Pentacam AXL compared to IOL Master 700. However, in clinical practice, the difference between ACD and AL was too minute to affect the biometric calculations [9]. Haddad *et al.* revealed that only the keratometry and ACD parameters were significantly different between the Pentacam AXL and the IOL Master 500 [2]. The existence of a keratometry difference of more than 1D causes an error in the prediction of IOL to 1D power.

Based on findings, no studies have directly compared the prediction results of refractive targets after cataract surgery between Pentacam AXL and IOL Master 700. Arruda *et al.* recently carried out a comparison of the prediction error results on the Pentacam AXL with LS 900, where LS 900 had better accuracy on 3 different biometric formulas namely SRK/T, Haigis, and Hoffer Q [8]. Therefore, this study aims to compare the prediction of post-cataract surgery error between Pentacam AXL and IOL Master 700 using the Barett Universal II formula.

2. Method and Patient

This is an analytical experimental study with a cross-sectional design, which involved 64 eyes. The inclusion criteria were patients who underwent uneventful cataract surgery at the Cicendo Eye Hospital National Eye Center (PMN RSMC) from February to September 2022, reliable Pentacam-AXL and IOL Master 700 measurement, IOL implantation using Sensar AR40. Exclusion criteria were significant refractive media opacities, such as mature cataracts, corneal cicatrix, history of glaucoma, retinal abnormalities, ocular trauma, pregnancy, breastfeeding, and previous eye surgery. Biometry was performed using IOL master 700 and Pentacam AXL. The selection of IOL to be implanted was carried out based on the results of biometric measurements using the Barett Universal II formula with emmetropic targets. Phacoemulsification was performed on the patient with a 2.75 mm keratome on the steep axis and LIO implantation in the bag. Four weeks after the surgery, spherical equivalent (SE) results were taken based on the patient's subjective refraction measurement results. Furthermore, the predicted error value was calculated from the difference in SE between the results of refractive surgery and the refractive prediction target obtained from the IOL Master 700 and Pentacam AXL. Other data compared include K1, K2, mean K, ACD, WTW, and AL.

This study is in accordance with the Declaratio of Helsinki and has been approved by PMN RSMC Etic Committee No. PB.02.01/2.3/4263/2022.

Statistical Analysis

The normality test of the data was carried out using the *Shapiro-Wilk* test. The significance test used paired t-test to assess K1, K2, and ACD, while the remaining parameters were evaluated using the Wilcoxon test. The results are statistically significant when the p-value < 0.05. Furthermore, Bland Altman plots were used to determine the suitability between the two tools, where a correlation coefficient (rc) that is close to 1 indicates a strong correlation. Statistical analysis was carried out using the SPSS version *24.0 program/m for Windows.*

3. Results

Among the 64 patients who underwent surgery, 59.3% were women with a mean age of 56.4 ± 6.2. Furthermore, a total of 22 patients were excluded because the Pentacam AXL measurement results were not obtained due to significant lens opacities. Table 1 shows the comparison of the mean values of K1, K2, mean K, ACD, AL, and WTW obtained from both measurement tools. From the paired T-test, there was no significant difference (p > 0.05) in the values of all parameters, except for ACD and WTW. The Bland Altman curve for each parameter in Figures 1-6 shows a strong correlation.

Meanwhile, the ACD of the Pentacam AXL, namely 0.06 mm was greater,

Table 1. Comparison of the relationship between K1, K2, Mean K, ACD, AXL, WTW, CCT, Prediction error 1, and Prediction error 2 between pentacam AXL and IOL Master 700.

Variable	Groups		Mean difference (95%CI)	P Score
	Pentacam AXL N = 64	IOL Master 700 N = 64		
K1				**0.611**
Mean ± SD	43.64 ± 1.232	43.62 ± 1.232	0.0200 (−0.59403; 0.634029)	
Median	43.70	43.68		
Range (min-max)	39.90 - 47.20	40.17 - 47.28		
K2				**0.569**
Mean ± SD	44.78 ± 1.442	44.81 ± 1.390	−0.0309 (−0.87711; 0.81531)	
Median	44.90	44.90		
Range (min-max)	41.00 - 48.50	41.07 - 47.29		
Mean K				**0.431**
Mean ± SD	44.21 ± 1.281	44.23 ± 1.254	−0.0116 (−0.57496; 0.551763)	
Median	44.40	44.40		
Range (min-max)	40.40 - 47.20	40.62 - 47.28		
ACD				**0.0001****
Mean ± SD	3.36 ± 0.459	3.30 ± 0.466	0.0606 (−0.14475; 0.265949)	
Median	3.37	3.29		
Range (min-max)	2.37 - 4.61	2.39 - 4.78		
AXL				**0.150**
Mean ± SD	25.51 ± 3.112	25.52 ± 3.107	−0.013 (−0.15032; 0.124318)	
Median	24.01	24.01		
Range (min-max)	21.69 - 34.56	21.67 - 34.68		
WTW				**0.0001***
Mean ± SD	11.54 ± 0.384	11.88 ± 0.418	−0.3406 (−0.68048; −0.00072)	
Median	11.55	11.90		
Range (min-max)	10.50 - 12.70	10.70 - 13.00		
Prediction error				**0.587**
(PE)				
Mean ± SD	−0.32 ± 0.484	−0.31 ± 0.428	−0.0136 (−0.60387; 0.576674)	
Median	−0.35	−0.15		
Range (min-max)	−1.80 - 0.75	−1.32 - 0.60		

Description: the * sign indicates the value of $p < 0.05$, which means that it is statistically significant or significant. SD: Standard deviation.

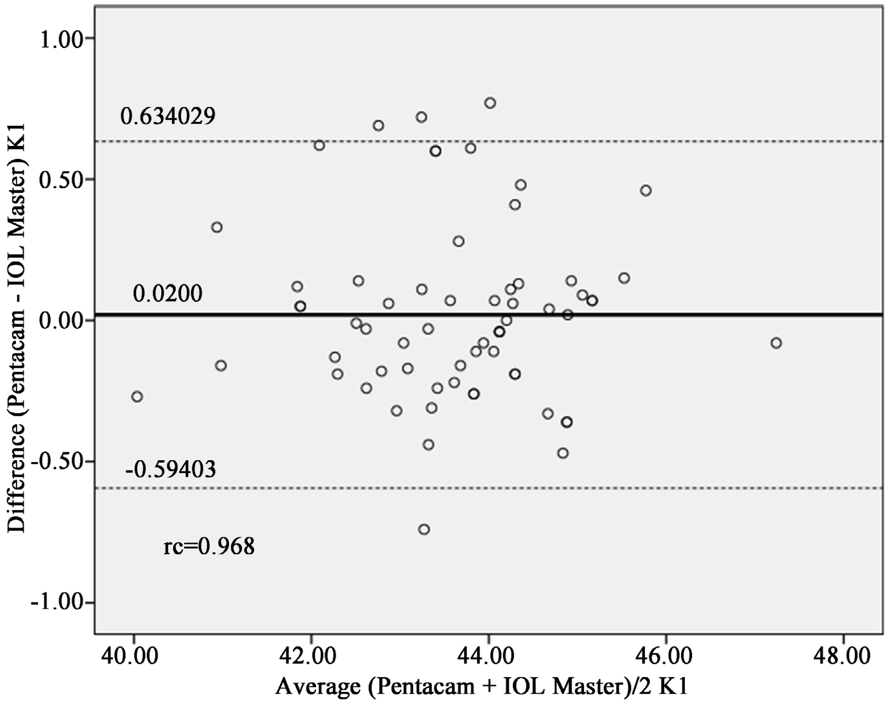

Figure 1. The bland-Altman curve for K1 between Pentacam AXL and IOL Master 700.

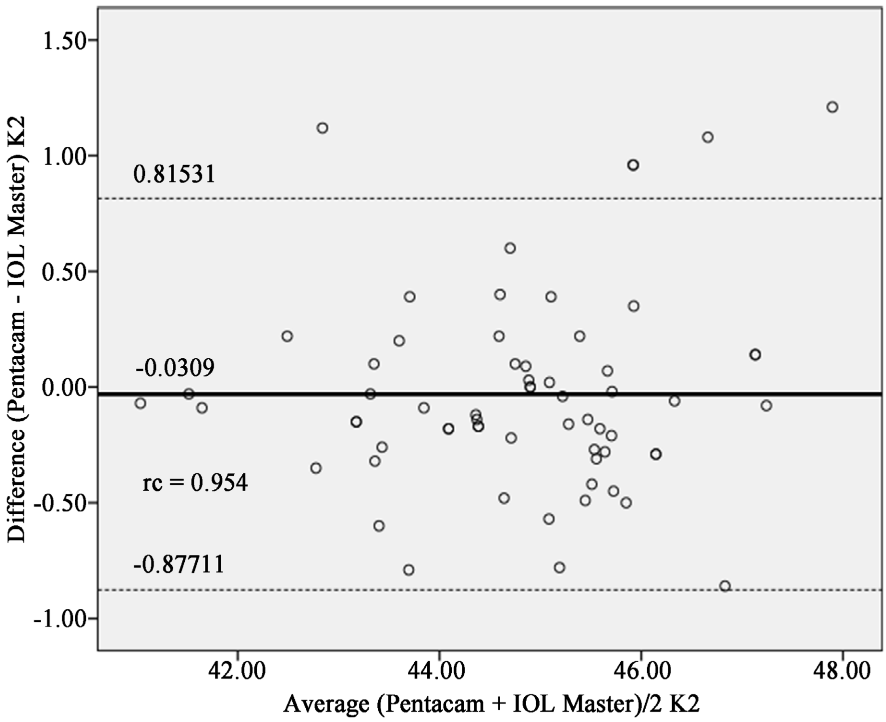

Figure 2. The bland-Altman curve for K2 between Pentacam AXL and IOL Master 700.

while its WTW of 0.34 mm was smaller compared to IOL Master 700, which indicates that there was a significant difference in these parameters. The predicted error value at 0.31 D and 0.32 D were more myopic than the predicted refractive target values for both IOL Master 700 and Pentacam AXL. The MAE and MedAE obtained in this study are presented in Table 2. Figure 7 shows that the percentage proportion of the average predictive error (PE) of the Pentacam AXL was 35.9%, 34.4%, 17.2%, and 12.5% at ±0.25 D, ±0.50 D, ±1.00 D, and ±2.00 D. Meanwhile, values of 56.3%, 17.2%, 14.1%, and 12.5% were obtained for IOL

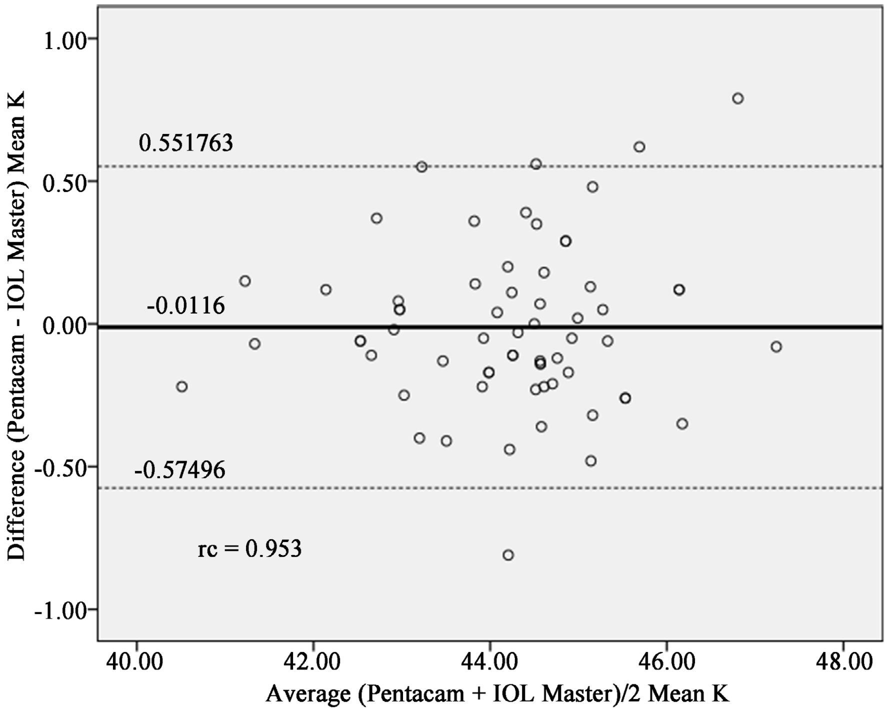

Figure 3. Bland-Altman Curve for Mean K between Pentacam AXL and IOL Master 700.

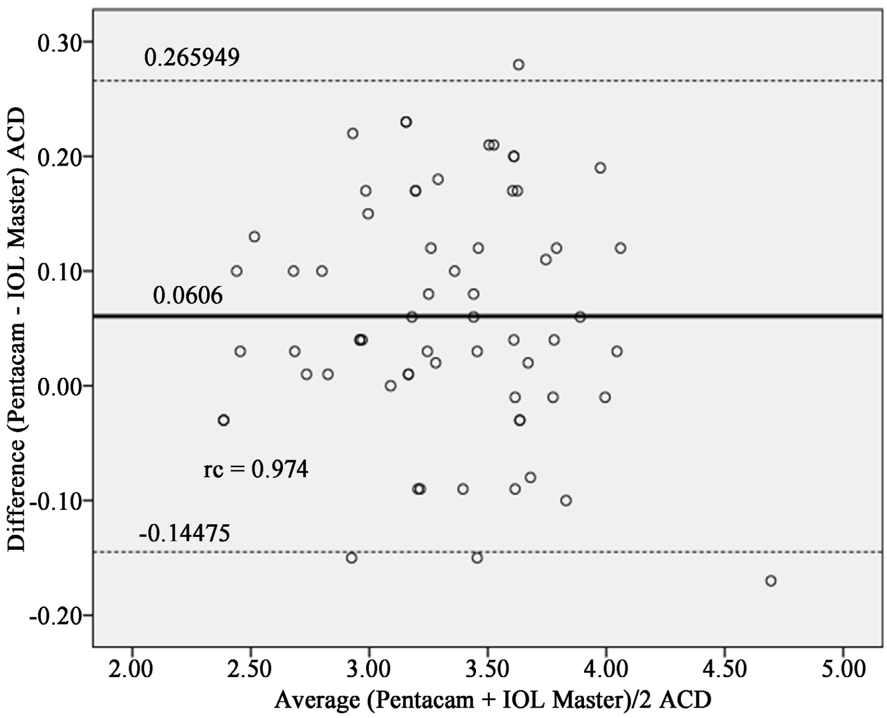

Figure 4. The bland-Altman curve for ACD between Pentacam AXL and IOL Master 700.

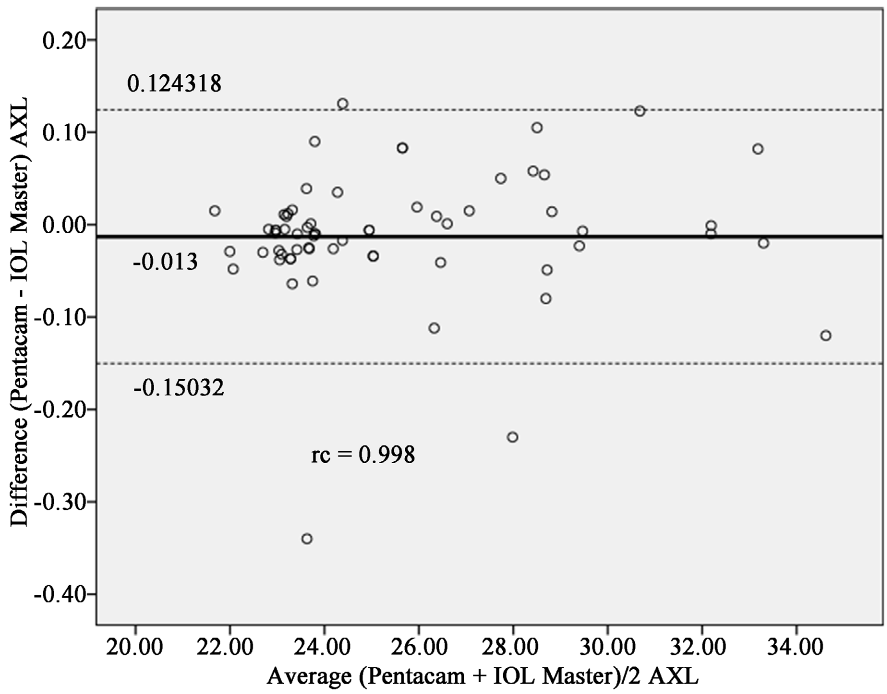

Figure 5. Bland-Altman curve for AL between Pentacam AXL and IOL Master 700.

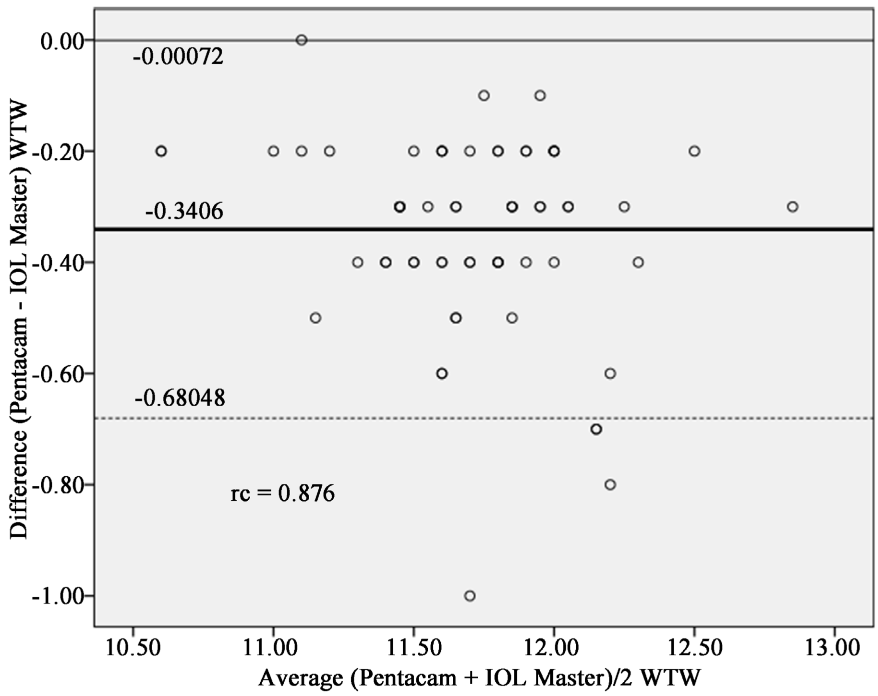

Figure 6. The bland-Altman curve for WTW between Pentacam AXL and IOL Master 700.

Master 700 AXL at ±0.25 D, ±0.50 D, ±1.00 D, and ±2.00 D.

4. Discussion

The availability of premium IOLs demands increased accuracy of biometric

Table 2. Comparison of PE, MAE, and MedAE between Pentacam AXL and IOL Master 700.

	Barett Universal II	
	IOL Master 700	**Pentacam AXL**
PE (Mean ± SD) (D)	−0.31 ± 0.428	−0.32 ± 0.484
Range	−1.32 - 0.60	−1.80 - 0.75
MAE (Mean ± SD) (D)	0.39 ± 0.35	0.46 ± 0.36
MedAE (D)	0.29	0.39

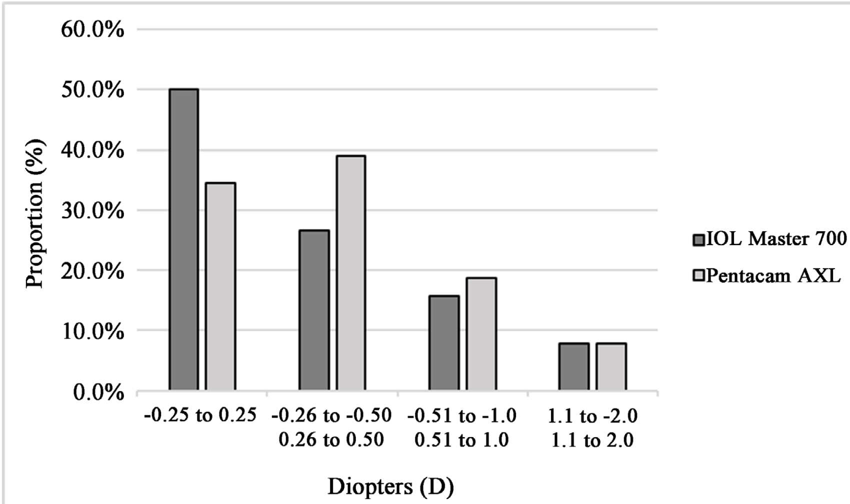

Figure 7. The proportion of eyes by a range of PE results for Pentacam AXL and IOL Master 700.

measurements. Optical biometry is still the standard for preoperative cataract surgery to minimize refractive errors after the process [4] [9]. Several studies showed IOLMaster 700 and Oculus Pentacam AXL have good reliability in optical biometric measurements [10] [11] [12]. Furthermore, only a few studies have compared the refraction prediction results from both tools.

In this study, 2 measurement parameters showed statistically significant differences, namely ACD and WTW. The ACD results on the Pentacam AXL were 0.06 mm deeper than the IOL Master 700. The average difference in a previous study was 0.049 mm [2] and 0.02 mm [13]. Although this difference was statistically significant, it was not more than 0.2 mm and does not affect the IOL power measurement. The variation in the anterior chamber depth measurement of 0.2 mm affected the IOL strength of 0.1 D [14].

In addition to LT, WTW is one of the optional parameters in the calculation of the Barett Universal II formula. The difference in the mean horizontal diameter of the cornea or WTW was 0.34 mm for the two tools, where the result for IOL Master 700 was larger and statistically significant. Chan *et al.* stated that the parameter's measurement on SS-OCT was longer than partial coherence interference biometry with a mean difference of 0.283 mm, and the 95% *limits of* *agreement* ranged from −0.313 to 0.879. The statistically significant difference in the results of the two tools can be explained by the variation in methods used for detecting the limbus [11]. Jung *et al.* stated that WTW between SS-OCT biometry and Dual *Scheimpflug Topography* had a good match, but the 95% limits of agreement was −0.64 to 0.76 mm and the average difference was 0.07 mm [15].

Other parameters, such as the K1, K2, and mean K values showed insignificant results. Shahjari *et al.* and Li *et al.* showed that the keratometry and total keratometry values of Pentacam and IOL Master 700 were not significantly different [10] [16]. Furthermore, another study showed a flatter K on the Pentacam AXL, but this difference was not more than 0.25 D [1] [2]. Ruan *et al.* revealed that a 0.5 D variation in corneal curvature was still clinically acceptable [17]. The Pentacam AXL measured diameter values of 3.0 mm and 4.0 mm for the anterior and total cornea, respectively, while IOL Master 700 obtained 2.5 mm for both of them [16]. However, this was not the cause of the difference in keratometry results. One of the factors that influenced the variation was the condition of the tear film on the surface of the eye [18] [19].

The axial length of the Pentacam AXL was 0.01 mm shorter than the IOL Master 700. However, this difference was not significant and did not affect the calculation of IOL power. Haddad *et al.* also showed that the axial length was not significantly different from the previous generation, namely IOL Master 500, and both of them use the same PCI principles with the Pentacam AXL [2]. Sel *et al.* reported that the AL measurement on the Master IOL 700 was 0.05 mm longer than the Pentacam AXL, but this had no effect on the power of the IOL used [12]. This was probably because the IOL master 700 already had SS-OCT. It is also important to note the penetrating power of Pentacam AXL in this study.

A total of 22 eyes were excluded because Pentacam AXL did not penetrate them. Meanwhile, reliable results were still obtained with IOL Master 700, which uses swept-source OCT technology with better penetrating power than the partial coherence interferometry technology on the other tool. Cataracts with LOCS nuclear opacity (NO) 3 and above grading system as well as posterior capsule opacity (P) 2 or above grading, especially in the center, are very difficult for pentacam AXL to penetrate. Wozniak *et al.* also revealed that the tool could not measure accurately in cases with thick cataract opacities and high myopia [1]. The lens thickness (LT) parameter cannot be compared in this study because the value of the pentacam AXL was often unreadable. However, the calculation of the LIO strength using the *Barret Universal II* formula can still be carried out without the measurement of LT. This parameter does not significantly affect the IOL force measurement unless it is combined with ACD [20].

The calculation using the Barett Universal II formula was chosen because it is the most accurate for all axial lengths of the eyeball compared to the previous generation formulas [3] [6] [21]. Furthermore, the results of these calculations show that the difference between the objective refraction and the refractive prediction target between the two tools was not significantly different. Pentacam AXL and IOL Master 700 have MAE percentage proportions of 70.3% and 73.5%

at ±0.50 D, respectively. The percentage proportion of eyes that were in MAE at ±0.25 D using the Barett Universal II formula was still greater than IOL master 700. This indicates that it is necessary to recalculate the optimization of the IOL constant on the Pentacam AXL to provide error prediction results approaching emmetropia. Arruda *et al.* revealed that the mean refractive prediction value of pentacam AXL was more myopic around 0.2 - 0.3 D using the SRK/T, Haigis, and Hoffer Q formulas [8]. Cheng *et al.* also showed that the measurement using IOLMaster 700 and the Barret Universal II formula had the best accuracy with the lowest *absolute error* median value of 0.295 D [22].

This study has no conflict of interest and not funded by any third party.

5. Conclusion

Pentacam AXL has fairly good accuracy in refraction prediction compared to IOL Master 700, except for ACD and WTW. Furthermore, LT was difficult to obtain on the Pentacam AXL due to significant lens opacities. Constant optimization is still needed to obtain optimal refraction results. The average prediction error that was close to emmetropia with IOL Master 700 was greater compared to the other tool.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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