

Agreement of Corneal Diameter and Anterior Chamber Depth Measurements with the IOLMaster 500 and the IOLMaster 700 Optical Biometers in Myopic Eyes

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Purpose: To assess the agreement in automated corneal diameter (CD) and anterior chamber depth (ACD, measured from corneal epithelium to lens) distances measurements between the IOLMaster 500 and 700 optical biometers in myopic eyes.

Methods: One hundred and sixteen eyes of 116 myopic patients aged between 21 to 60 years were included in this study. Measurements of CD and ACD distances were taken with each biometer for all patients in the same session. A *t*-test and a *p*-value less than 0.05 was considered statistically significant when the measurements were compared. The agreement between biometers was studied by applying a Bland–Altman analysis.

Results: The mean CD values obtained using the IOLMaster 500 and 700 biometers were 12.26 ± 0.35 mm and 12.13 ± 0.34 mm, respectively. The mean ACD distance values were 3.61 ± 0.29 mm and 3.62 ± 0.31 , for the IOLMaster 500 and 700 biometers, respectively. There were statistically significant differences between the two devices only for CD measurements ($p < 0.001$), but not for ACD measurements ($p = 0.26$). The limits of agreement obtained were wide in both types of measurements, being 0.422 mm for the CD distance and 0.389 mm for the ACD distance.

Conclusion: There were statistically significant differences between the IOLMaster 500 and 700 biometers regarding CD but not in ACD measurements in healthy myopic eyes. These differences could be clinically significant in some cases. According to these results, medical judgement should be used to assess whether the two devices could be used interchangeably for CD and ACD measurements during the clinical practice.

Keywords: anterior chamber depth, white-to-white, IOLMaster 500, IOLMaster 700, optical biometry

Introduction

The use of ocular biometry is necessary for cataract and refractive surgery planning, considering that it provides a measurement of several ocular parameters used in intraocular lens (IOL) calculations. Specifically, the measurement of corneal diameter (CD) and anterior chamber depth (ACD, measured from corneal epithelium to lens) distances has become increasingly important in cataract and refractive surgery, calculating phakic or pseudophakic IOL power and size. Different clinical studies have been published focusing on device interchangeability to measure CD or ACD distances. There are several techniques available for the measurement of CD and ACD distances based on manual techniques, for CD measurement (ie surgical calipers), and automated, for CD and ACD measurement (ie optical biometry).

Optical biometers are frequently used to measure CD and ACD distances in clinical practice. Two of the most popular optical biometers are the IOLMaster 500, that uses partial coherence interferometry (PCI), and the IOLMaster 700, that uses swept-source optical coherence tomography (SS-OCT), both from Carl Zeiss Meditec AG, Jena, Germany. There are some publications comparing these devices in different ocular populations/conditions, such as children, cataract, and

healthy patients, but some of these studies show discrepancies in their findings and whether they can be used interchangeably during clinical practice.^{1–11} Mean differences between devices reported varied from -0.15^7 to 0.12^8 mm for CD and from -0.08^2 to 0.10^9 mm for ACD measurements. In addition to the mean differences, the limits of agreement (LoA) should be also considered to ascertain if the devices can be used interchangeably. Previous literature has reported CD LoA width varying from 0.47 mm^8 up to 1.9 mm^6 and ACD LoA width varying from 0.30 mm^6 up to 1.00 mm^7 . Then, considering the differences found in these previous clinical studies, we consider that a comparative study of the two devices in a large sample should be carried out. Specifically, we were interested to analyse possible differences in myopic eyes. The findings reported will provide clinicians with useful information in order to improve cataract and refractive surgery outcomes when they use these specific values to calculate IOL parameters.

Then, the objective of the present study was to assess the possible differences in automated CD and ACD measurements in myopic eyes between two common optical biometers used: the IOLMaster 500 and the IOLMaster 700. The LoA between the two devices were also obtained in order to ascertain if they can be used interchangeably clinically.

Methods

This single-centre observational study was conducted in accordance with the tenets of the Helsinki Declaration, approval from the Oftalvist Institutional Review Committee (01-2023) was received, and all patients provided written informed consent before they participated.

Patients and Procedure

The established inclusion criteria were healthy patients with age ranging from 21 to 60 years old and refractive error (spherical equivalent) ranging from -0.50 to -18.00 diopters (D). Refraction was measured using an automatic autorefractometer, and the assessment of corneal abnormality was done with the slit-lamp. CD and ACD distance measurements were obtained using both devices, but only right eyes were considered for the study due to the similarity of parameters between eyes.¹¹ Both biometers were calibrated prior to each measurement session. The measurements were done in a single session.

Optical Biometers: IOLMaster 700 and 500

The IOLMaster 700 is based on SS-OCT technology with a scanning rate of 2000 scans/s. The scan provides the horizontal CD and ACD distances being measured with a light-emitting diode (LED) source of 800 nm. The IOLMaster 500 provides the CD distance using a LED light source and uses an image-based slit lamp system for ACD measurements.

Statistical Analysis and Sample Size

Excel software was used for data analysis (v. 2016, Microsoft Corporation, Redmond, WA, USA) and SPSS statistical software for statistical analysis (v. 24.0, IBM Corp., Armonk, NY, USA). Shapiro–Wilk test was employed to check the normality of the distribution, and the *t*-test was used to find possible statistically significant differences between the paired measurements taken using the 2 optical biometers (*p* value <0.05 was considered statistically significant). To evaluate the agreement between the biometers a Bland–Altman analysis was applied. We also determined the following values: average difference, confidence interval of the average difference at 95%, and the 95% LoA (being calculated as the mean difference ± 1.96 standard deviation).

The sample size was calculated based on McAlinden et al^{11,12} for agreement studies. We considered a desired confidence interval for the LoA of 0.03 mm for the CD value as the primary outcome. This value is less than 0.1 mm, considered to be the limit of precision of commercially available calipers.¹³ Considering this value and the standard deviation of the differences obtained in a first examination of 30 patients, the sample size required for the agreement was 94.

Table 1 Mean $\pm$ Standard Deviation (Range) and Agreement Between the IOLMaster 700 and 500 for the Corneal Diameter Distance and Anterior Chamber Depth (Measured from Corneal Epithelium to Lens)

Parameter	IOLMaster 700	IOLMaster 500	Agreement				
			Mean Difference $\pm$ SD	95% CI	95% LoA	LoA Width	p value
CD (mm)	12.13 $\pm$ 0.34 (11.01 to 13.10)	12.26 $\pm$ 0.35 (11.20 to 13.30)	-0.133 $\pm$ 0.108	-0.150, -0.116	-0.345, 0.078	0.424	<0.001*
ACD (mm)	3.62 $\pm$ 0.31 (2.93 to 4.43)	3.61 $\pm$ 0.29 (2.79 to 4.41)	0.005 $\pm$ 0.099	-0.010, 0.020	-0.190, 0.200	0.390	0.26

Note: *Significant differences <0.05.

Abbreviations: CD, corneal diameter distance; ACD, anterior chamber depth; SD, standard deviation; CI, confidence interval; LoA, limits of agreement.

Results

A total of 116 right eyes of 116 patients between 21 to 60 years were examined in this study. The mean spherical equivalent in our sample was -4.06 ± 2.85 D (mean $\pm$ standard deviation) (ranging from -0.50 D to -15.88 D), and the mean age was 37.54 ± 11.79 years. All measurements were fully obtained in all patients using both optical biometers, and no complications were reported during the study.

The mean values obtained for the CD distance using the IOLMaster 700 and 500 optical biometers were 12.13 ± 0.34 mm and 12.26 ± 0.35 mm, respectively. The mean ACD values found for the two optical biometers were 3.62 ± 0.31 mm and 3.61 ± 0.29 mm, respectively. Table 1 shows the mean values with ranges for each parameter and optical biometer used. This table also shows the level of agreement between the two optical biometers, with the mean difference $\pm$ standard deviation, the 95% confidence interval, the 95% LoA, and the LoA range for the comparison between CD and ACD values obtained using the two optical biometers. Statistically significant differences were obtained only for CD measurements when compared between the two devices ($p < 0.001$) but not for ACD values ($p = 0.26$). Figure 1 shows the Bland–Altman plot obtained for the comparison between the two optical biometers for the CD measurements. For the ACD measurement comparison, Figure 2 plots the Bland–Altman graph.

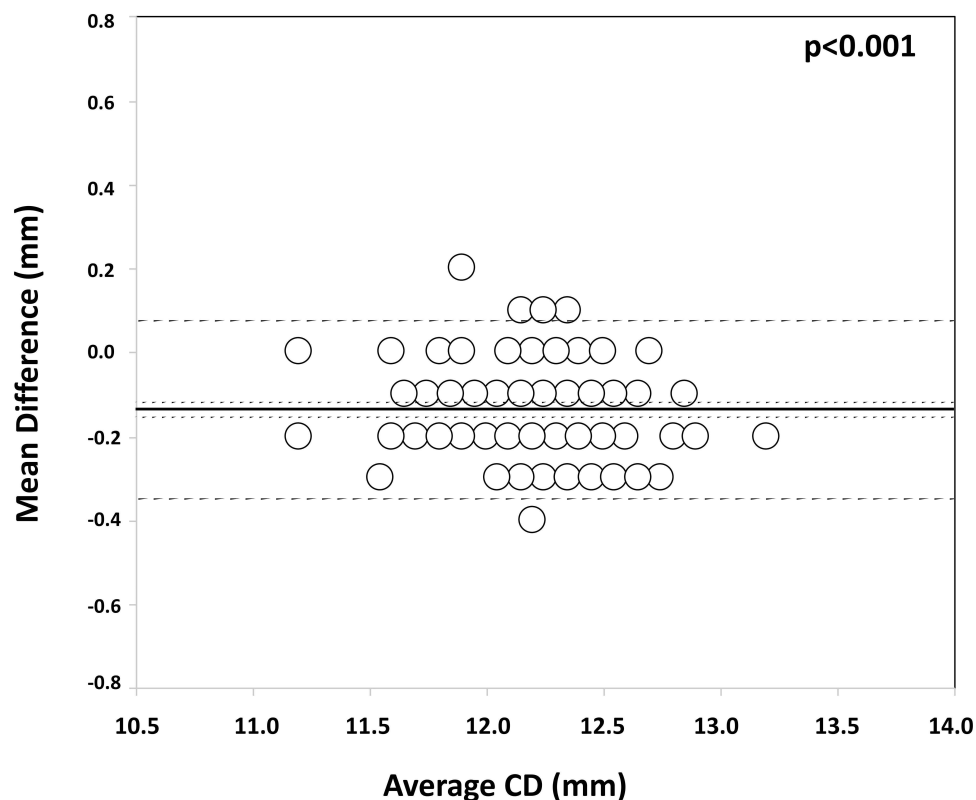


Figure 1 Bland–Altman plots of the mean difference versus the average of CD (corneal diameter) distance used to compare the two biometers. The plots show the mean (continuous line), lower and upper limits of agreement (± 1.96 SD [standard deviation], peripheral dotted lines), and the lower and upper confidence intervals (95%).

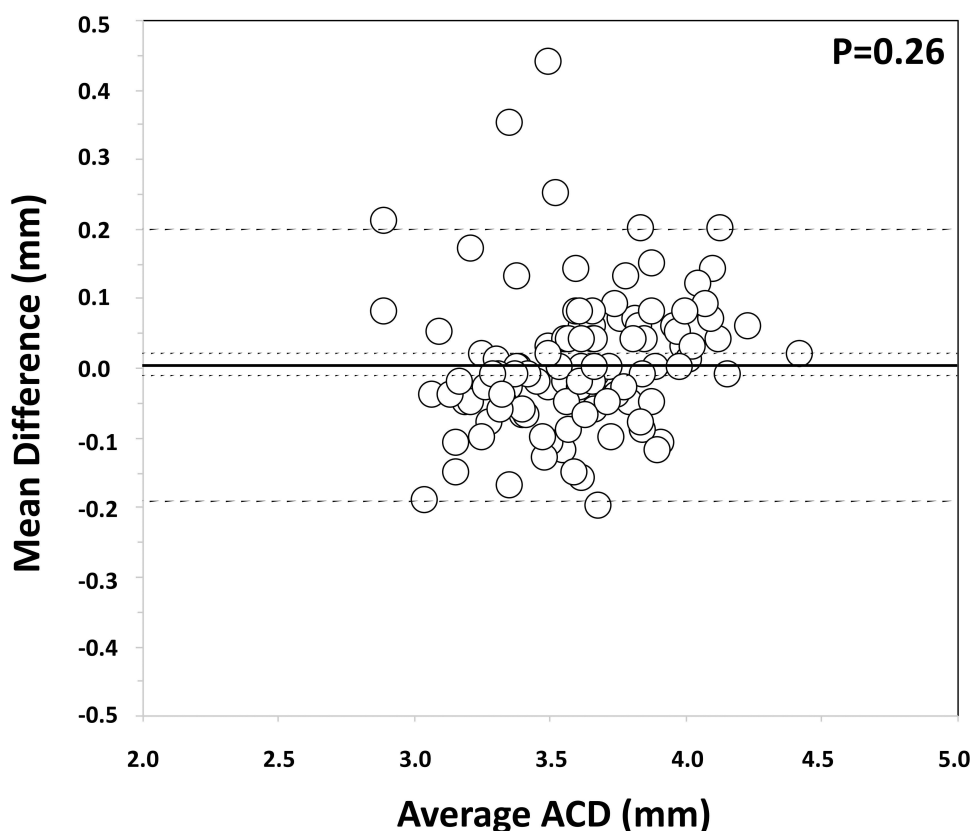


Figure 2 Bland–Altman plots of the mean difference versus the average of ACD (anterior chamber depth, measured from corneal epithelium to lens) used to compare the two biometers. The plots show the mean (continuous line), lower and upper limits of agreement (± 1.96 SD [standard deviation], peripheral dotted lines), and the lower and upper confidence intervals (95%).

Discussion

The purpose of our study was to ascertain the interchangeability of two optical biometers to provide CD and ACD measurements under clinical practice. CD and ACD distances are important parameters that are used, for instance, for phakic and pseudophakic IOL calculations during standard clinical procedures, so it is important to be sure that these parameters are obtained reliably and with proper accuracy in order to provide the best refractive outcome after any ocular surgery.

As stated earlier, different peer-reviewed clinical studies have been published showing the agreement between the IOLMaster 500 and 700 in children, cataract, and healthy patients. Table 2 shows those studies analysing both biometers,

Table 2 Published Studies Reporting Data on Corneal Diameter and Anterior Chamber Depth Agreement Between the IOLMaster 700 and the IOLMaster 500 Optical Biometers

Author	Year	Eyes (Patients)	Age (years) (Range)	Condition
Srivannaboon et al ¹	2015	100 (100)	64.53 $\pm$ 11.20 (NR)	Cataract
Akman et al ²	2016	188 (101)	68.32 $\pm$ 12.71 (24 to 81)	Cataract
Kunert et al ³	2016	120 (120)	68.2 $\pm$ 9.89 (37 to 89)	Cataract
Shajari et al ⁴	2017	79 (79)	NR	Cataract
Lee et al ⁵	2018	175 (175)	69.49 $\pm$ 9.55 (NR)	Cataract
Bullimore et al ⁶	2019	49 (49) 51 (51)	33.7 $\pm$ 9.2 (22 to 58) 62.3 $\pm$ 8.1 (47 to 85)	Healthy Cataract

(Continued)

Table 2 (Continued).

Author	Year	Eyes (Patients)	Age (years) (Range)	Condition
Yang et al ⁷	2019	146 (83)	64.23±10.51 (NR)	Cataract
Huang et al ⁸	2020	100 (100) 92 (92) 109 (109)	10.37±1.81 (7 to 14) 28.90±6.40 (20 to 84) 71.07±10.44 (35 to 92)	Healthy children Healthy adults Cataract
Shi et al ⁹	2021	110 (110)	10.69±2.81 (8 to 18)	Children-Adolescents
Jiang et al ¹⁰	2022	518 (392)	64.48±10.98 (34–90)	Cataracts
Current study	2023	117 (117)	37.39±11.85 (20–60)	Myopic healthy

Abbreviation: NR, not reported.

indicating the conditions of the sample. However, no studies have been done specifically in healthy myopic eyes in order to ascertain if the two devices are interchangeable in these eyes during clinical practice.

Corneal Diameter

Our results revealed that there were statistically significant differences between the two optical biometers when measuring CD distance ($p<0.001$). The mean difference between biometers was -0.133 ± 0.108 mm, and the LoA ranged from -0.345 to 0.078 mm, giving a LoA width of 0.424 mm. We found a significant difference between devices: the IOLMaster 500 measured a longer CD distance than IOLMaster 700. Table 3 summarizes the outcomes reported by previous clinical studies on CD agreement. Our results broadly agree with them. Specifically, Srivannaboon et al¹ in 100 cataract eyes found that the CD agreement for the two biometers was high with a mean difference of -0.101 mm ($p=0.24$, LoA width= 0.75 mm). Similarly, Bullimore et al⁶ found in 51 cataract eyes a mean

Table 3 Published Studies Reporting Data on Corneal Diameter Agreement Between the IOLMaster 700 and IOLMaster 500 Optical Biometers

Author	Device/Condition	Mean±SD (Range)	Difference±SD	95% CI	95% LoA	p
Srivannaboon et al ¹	700 500	11.85±0.41 (10.90–13.00) 11.95±0.39 (11.10–13.30)	-0.101 ± 0.185		$-0.48, 0.27$	0.24
Bullimore et al ⁶	Healthy					
	700	12.2±0.5	-0.1 ± 0.5	$-0.2, 0.1$	$-1.0, 0.9$	0.46
	500	12.3±0.6				
	Cataract					
	700	12.1±0.4	-0.0 ± 0.1	$0.1, 0.0$	$-0.3, 0.3$	0.60
	500	12.1±0.4				
Yang et al ⁷	700 500	11.73±0.48 11.58±0.44	-0.150 ± 0.312		$-0.761, 0.432$	<0.001
Huang et al ^{8,*}	Whole sample	NR	0.09±NR		$-0.22, 0.41$	
	Healthy children		0.12±NR		$-0.12, 0.35$	
	700	12.28±0.43				
	500	NR				
	Healthy adults		0.12±NR		$-0.16, 0.40$	
	700	12.04±0.35				
	500	NR				
	Cataract		0.04±NR		$-0.34, 0.43$	
	700	11.76±0.41				
	500	NR				

(Continued)

Table 3 (Continued).

Author	Device/Condition	Mean±SD (Range)	Difference±SD	95% CI	95% LoA	p
Shi et al ⁹	700	12.13±0.41	0.064±0.171		-0.27, 0.40	0.000
	500	12.07±0.38				
Jiang et al ¹⁰	Whole sample		-0.13±NR		-0.55, 0.26	0.000
	700	11.60±0.44				
	500	11.50±0.43				
	AL < 22.00 mm					
	700	11.27±0.40				
	500	11.14±0.38				
	22.00 mm ≤ AL < 23.00 mm					
	700	11.44±0.33				
	500	11.38±0.35				
	23.00 mm ≤ AL < 24.00 mm					
	700	11.66±0.42				
	500	11.56±0.40				
	24.00 mm ≤ AL < 25.00 mm					
	700	11.73±0.29				
	500	11.61±0.32				
	25.00 mm ≤ AL < 26.00 mm					
	700	11.95±0.42				
	500	11.83±0.36				
	AL ≥ 26.00 mm					
	700	11.68±0.46				
	500	11.56±0.47				

Note: *Mean values from 1st observer.

Abbreviations: AL, axial length; SD, standard deviation; CI, confidence interval; LoA, limits of agreement; NR, not reported.

value of -0.0 mm ($p=0.60$, LoA width=0.60 mm) but also for 49 healthy eyes with a mean value of -0.1 mm ($p=0.46$, LoA width=1.90 mm). They concluded that the CD values were not different between biometers. In contrast, Yang et al⁷ in a sample of 146 cataract eyes of 83 patients reported statistically significant differences between biometers with a mean value of -0.150 mm ($p<0.001$, LoA width=1.19 mm). Huang et al⁸ in 109 cataract eyes of 109 patients found a mean value of 0.04 mm with a LoA width of 0.77 mm, and the Bland–Altman plots showed relatively low agreement. The mean differences for the whole sample of healthy children or adults were higher (0.09 and 0.12 mm, with LoA width ranging from 0.47 to 0.63 mm). Shi et al⁹ found that the difference between the two devices was statistically significant in a sample of 110 eyes of 110 children-adolescents; nevertheless, the Bland–Altman plot analysis indicated that the consistency of the two biometers for the CD distance measurement was good (LoA width=0.67 mm). Specifically, Jiang et al¹⁰ analysed a large sample of 518 cataract eyes of 391 patients as a function of the axial length and found that the two devices had a good agreement in measuring CD distance (except for values of axial length less than 22.00 mm and those values between 24.00 and 26.00 mm, which had a moderate agreement). Note that both biometers use the same technology using a light LED source to obtain CD measurement, but the limbus edge detection may vary among measurements; hence, this could be the source of the mean difference we have obtained. However, despite the statistically significant differences found, they were small. In addition, the LoA range (width) was less than half a millimetre (0.424 mm, Table 1), which could be considered clinically not meaningful. For IOL power, for example, when the Barrett and Holladay 2 formulas use CD, small differences may be expected and also to choose the size of a phakic IOL since surgeons consider it to the nearest 0.50 mm. Then, taking into account the small mean difference and LoA range obtained for CD distance values between the two biometers, we can consider the two devices interchangeable for CD measurement in clinical practice. However, it should be noted that the LoA range is close to the 0.50 step of phakic IOL sizes.

Anterior Chamber Depth

Our results revealed that there were no statistically significant differences between the two biometers when measuring ACD distance ($p=0.26$). The mean difference between the biometers was 0.005 ± 0.099 mm, and the LoA varied from -0.190 to 0.200 mm, the LoA width being 0.390 mm. Table 4 summarizes the findings found in previous clinical studies on ACD agreement. Our results such as CD measurement previously discussed agree with them. Srivannaboon et al¹ showed no statistically significant differences between the values obtained using the two biometers (mean difference of 0.04 mm, $p=0.64$, with a LoA width= 0.44 mm). Akman et al² in a sample of 188 cataractous eyes reported a statistically significant difference, but this difference is quite small for clinical relevance (-0.08 mm, $p<0.001$). They indicated that the IOLMaster 700 optical biometer correlated very highly with the 500 but noted that the 500 biometer did not measure in some eyes ($n=13$). This device analyses the image obtained by means of a slit-illumination system (optical section of the anterior chamber), and the 700 uses an image provided by the SS-OCT. Kunert et al³ in 120 cataractous eyes found a mean non-significant difference of 0.017 mm ($p=0.151$, LoA width= 0.44 mm); Shajari et al⁴ in 79 cataract eyes and Lee et al⁵ in a large sample of 175 cataract eyes also showed a similar value without significant difference (0.017 mm and $p=0.11$, and 0.02 mm and $p=0.06$, respectively). Bullimore et al⁶ both in healthy and cataract eyes reported non-statistically significant differences between biometers with mean differences close to 0 mm ($p>0.6$). In contrast, Yang

Table 4 Published Studies Reporting Data on Anterior Chamber Depth Agreement Between the IOLMaster 700 and IOLMaster 500 Optical Biometers

Author	Devices/Condition	Mean $\pm$ SD (Range)	Difference $\pm$ SD	95% CI	95% LoA	p
Srivannaboon et al ¹	700 500	2.98 $\pm$ 0.38 (2.26–3.82) 2.94 $\pm$ 0.42 (2.15–3.84)	0.040 $\pm$ 0.100		–0.17, 0.27	0.64
Akman et al ²	700 500	3.23 $\pm$ 0.37 (2.33–4.14) 3.31 $\pm$ 0.38 (2.23–4.19)	–0.08 $\pm$ 0.13	–0.102, –0.063		<0.001
Kunert et al ³	700 500	3.06 $\pm$ 0.1 (2.03–4.12) 3.04 $\pm$ 0.40 (2.09–4.08)	0.017 $\pm$ 0.122	–0.006, 0.040	–0.222, 0.222	0.151
Shajari et al ⁴	700 500	NR	0.017		–0.236, 0.270	0.11
Lee et al ⁵	700 500	3.08 $\pm$ 0.41 (2.03–4.15) 3.11 $\pm$ 0.41 (2.14–4.35)	0.02 $\pm$ 0.15			0.06
Bullimore et al ⁶	Healthy 700 500	3.66 $\pm$ 0.32 3.66 $\pm$ 0.30	–0.00 $\pm$ 0.07	–0.02, 0.02	–0.15, 0.15	0.99
	Cataract 700 500	3.26 $\pm$ 0.34 3.27 $\pm$ 0.33	–0.01 $\pm$ 0.09	–0.03, 0.02	–0.18, 0.17	0.6
Yang et al ⁷	700 500	3.13 $\pm$ 0.45 3.20 $\pm$ 0.48	0.065 $\pm$ 0.256		–0.437, 0.567	0.003
Huang et al ^{8,*}	Whole sample		0.02 $\pm$ NR		–0.18, 0.21	
	Healthy children					
	700	3.76 $\pm$ 0.24				
	500	NR				
	Healthy adults					
	700	3.56 $\pm$ 0.27				
	500	NR				
	Cataract					
	700	2.87 $\pm$ 0.36				
	500	NR				

(Continued)

Table 4 (Continued).

Author	Devices/Condition	Mean±SD (Range)	Difference±SD	95% CI	95% LoA	p
Shi et al ⁹	700 500	3.77±0.22 3.67±0.21	0.101±0.085	-0.07, 0.27		0.000
Jiang et al ¹⁰	Whole sample 700 500 AL < 22.00 mm 700 500 22.00 mm ≤ AL < 23.00 mm 700 500 23.00 mm ≤ AL < 24.00 mm 700 500 24.00 mm ≤ AL < 25.00 mm 700 500 25.00 mm ≤ AL < 26.00 mm 700 500 AL ≥ 26.00 mm 700 500	3.00±0.47 3.03±0.47 2.42±0.36 2.42±0.36 2.79±0.38 2.83±0.35 3.06±0.42 3.08±0.38 3.09±0.34 3.14±0.29 3.40±0.39 3.47±0.45 3.30±0.32 3.36±0.30	-0.01±NR 0.04±NR 0.01±NR 0.04±NR 0.06±NR 0.06±NR		-0.22, 0.21 -0.23, 0.32 -0.33, 0.36 -0.24, 0.31 -0.15, 0.30 -0.16, 0.26	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000

Note: *Mean values from 1st observer.

Abbreviations: AL; axial length; SD, standard deviation; CI, confidence interval; LoA, limits of agreement; NR, not reported.

et al⁷ found that ACD did not correlate between biometers, being longer for the 500 device (mean difference of 0.065 mm with LoA width=1.004 mm, $p=0.003$). As previously indicated, the IOLMaster 700 measures ACD distance in the optical axis, but the IOLMaster 500 may not measure this axis since this biometer uses a lateral slit-beam technique. Huang et al⁸ for the whole sample analysed found a mean difference of 0.02 mm with a LoA of 0.39 mm. Shi et al⁹ found significant differences in 101 eyes of 101 children–adolescents, but it was within the acceptance range in clinical practice, and concluded that the differences can be ignored for a practical clinical application. Jiang et al,¹⁰ with the largest cataract sample assessed, showed a high agreement between biometers. They reported a statistically significant difference between devices, the 500 biometer measuring a longer ACD distance than the 700 biometer. However, they considered that based on the 95% confidence interval, the ACD distance measured by both biometers was of excellent reliability. In our sample the mean values obtained were similar between devices (3.62 mm versus 3.61 mm, mean difference 0.005 mm, see Table 1).

Similarly to our previous discussion with the CD values found, it should be noted that the mean difference we have obtained between the two biometers was small (0.005±0.099 mm) but the LoA range was about 0.4 mm. This value should be considered since it has been reported that a difference of 0.1 mm in the ACD distance would lead to a refraction change of 0.15 D for IOL power calculation in the eyes with an average corneal curvature and axial length,¹⁴ and 1 mm of ACD deviation could lead to a 1.5 D of refractive error in IOL power.¹⁵ In the worst-case scenario, considering our LoA range of 0.390 mm, this would lead to a 0.58 D refraction change, which should be considered. In addition, this LoA range cannot be assumed to be negligible when considering the safety distance in a patient to be implanted with a phakic IOL. It is necessary to point out that ACD values vary with accommodation and need to be carefully controlled when ACD is being measured. Surgeons should always keep in mind not only the mean difference obtained, but also the LoA between biometers. A clinical criterion should assess whether the two instruments could be used interchangeably for ACD measurement.

Nevertheless, our study has some limitations that should be considered. Our study only assessed myopic healthy patients, and healthy eyes with other refractive errors should be analysed. In addition, a large sample would be desirable in order to evaluate the effect of age among the values obtained. We hope to address these limitations in a future study.

In conclusion, from the results obtained in our study, medical judgement should be used to assess whether the IOLMaster 500 and 700 biometers could be used interchangeably for ACD and CD distances measurement during standard clinical practice in healthy myopic eyes.

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Disclosure

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