Agreement between Eyestar and IOLMaster700 in ocular biometric measurements in a Brazilian population

Concordância entre Eyestar e IOLMaster700 em medidas biométricas oculares em uma população brasileira

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How to cite:
Gondim LA, Barreto RK, Lucena JM, Moscovici BK, Teixeira IC. Agreement between Eyestar and IOLMaster700 in ocular biometric measurements in a Brazilian population. Rev Bras Oftalmol. 2026;85:e0034.

doi:
https://doi.org/10.37039/1982.8551.20260034

Keywords:
Biometry; Cataract surgery; Intraocular lens calculation; Optical coherence tomography; Swept-source biometry

Descritores:
Biometria; Cirurgia de catarata; Cálculo da lente intraocular; Tomografia de coerência óptica; Biometria de fonte varrida

Received on:
March 14, 2025

Accepted on:
February 6, 2026

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Conflict of interest:
no conflict of interest.

Financial support:
no financial support for this work.

Data availability statement:
The data that support the findings of this study are not openly available and are available from the corresponding author upon reasonable request.

Associate editor:
Ruiz Simonato Alonso
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ABSTRACT

Objective: To evaluate the agreement between the Eyestar900 and IOLMaster700 for biometric measurements and assess their interchangeability.

Methods: This retrospective study analyzed the following parameters: anterior keratometry, axial length, anterior chamber depth, white-to-white diameter, and lens thickness. Agreement was assessed using intraclass correlation coefficients, Bland-Altman plots, and scatter plots. A paired t-test was used to evaluate statistical differences.

Results: A total of 43 eyes from 33 patients were analyzed. The mean differences were 0.03 D for keratometry, 0.08 mm for axial length, 0.48 mm for anterior chamber depth, 0.07 mm for white-to-white diameter, and 0.006 mm for lens thickness. Intraclass correlation coefficient values indicated excellent agreement for keratometry (0.990), axial length (1.000), white-to-white diameter (0.944), and lens thickness (0.994; $p < 0.001$), while anterior chamber depth showed lower agreement (intraclass correlation coefficients = -0.081, $p = 0.599$). Despite statistical significance, keratometry, axial length, white-to-white diameter, and lens thickness differences remained within clinically acceptable limits.

Conclusion: The Eyestar900 and IOLMaster700 demonstrated excellent agreement in keratometry, axial length, white-to-white diameter, and lens thickness, supporting their interchangeability in routine clinical use. While anterior chamber depth measurements showed greater variability, their impact on clinical decisions may be minimized with careful interpretation. These findings reinforce the reliability of both devices for preoperative planning, with the potential to optimize surgical precision and intraocular lens selection.

RESUMO

Objetivo: Avaliar a concordância entre os biometrômetros Eyestar900 e IOLMaster700 em pacientes com catarata e determinar sua intercambiabilidade na prática clínica.

Métodos: Estudo retrospectivo que incluiu pacientes submetidos à biometria óptica com Eyestar900 e IOLMaster700 entre maio e julho de 2023. Os parâmetros analisados foram ceratometria anterior, comprimento axial, profundidade da câmara anterior, diâmetro branco a branco e espessura do cristalino. A concordância foi avaliada por coeficientes de correlação intraclasse, gráficos de Bland-Altman e gráficos de dispersão. O teste t pareado comparou as medições entre os dispositivos.

Resultados: Foram analisados 43 olhos de 33 pacientes. As diferenças médias foram 0,03 D para ceratometria anterior, 0,08 mm para comprimento axial, 0,48 mm para profundidade da câmara anterior, 0,07 mm para diâmetro branco a branco e 0,006 mm para espessura do cristalino. O coeficiente de correlação intraclasse indicou excelente concordância para ceratometria anterior (0,990), comprimento axial (1,000), diâmetro branco a branco (0,944) e espessura do cristalino (0,994; $p < 0,001$), enquanto a profundidade da câmara anterior apresentou menor concordância (coeficientes de correlação intraclasse = -0,081, $p = 0,599$). Embora estatisticamente significativas, as diferenças em ceratometria anterior, espessura do cristalino, diâmetro branco a branco e espessura do cristalino permaneceram dentro de limites clinicamente aceitáveis.

Conclusão: O Eyestar900 e o IOLMaster700 demonstraram excelente concordância para ceratometria anterior, comprimento axial, diâmetro branco a branco e espessura do cristalino, permitindo sua intercambiabilidade em grande parte das aplicações clínicas. Embora a profundidade da câmara anterior tenha apresentado maior variabilidade, seu impacto clínico pode ser minimizado com uma interpretação cuidadosa. Esses achados reforçam a confiabilidade de ambos os dispositivos para planejamento pré-operatório, com potencial para otimizar a precisão cirúrgica e a seleção de lentes intraoculares.

INTRODUCTION

Cataract surgery is one of the most frequently performed and highly successful medical procedures worldwide. In this procedure, an intraocular lens (IOL) replaces the opaque crystalline lens. Ocular biometry is essential for optimizing surgical outcomes and achieving high patient satisfaction. Over the past two decades, the evolution of premium IOLs, including toric, multifocal, and extended depth of focus (EDOF) lenses, has further emphasized the importance of obtaining highly accurate biometric measurements for refractive predictability and optimal visual rehabilitation.[1,2]

Swept-source optical coherence tomography (SS-OCT) has emerged as a cutting-edge technology for ocular biometry, offering high-resolution imaging, superior penetration in dense cataracts, and increased speed compared to older optical coherence biometry (OCB) technologies.[3,4] The Eyestar900 (Haag-Streit, Switzerland) is a fully automated SS-OCT-based biometer capable of anterior segment tomography, corneal topography, and axial length measurements using a 1,060 nm-wavelength and a scan speed of 30 kHz. It employs dual-zone keratometry (K) based on 32 infrared light-emitting diode sources (850 nm) and allows three-dimensional analysis of anterior segment structures, enhancing the accuracy of biometric measurements.[5,6]

The IOLMaster700 (Carl Zeiss Meditec, Germany) is another SS-OCT-based biometer widely used in clinical practice, featuring a scanning rate of 2000 scans per second and a wavelength range of 1,035 to1,095 nm. It employs telecentric K that measures in three optical zones (1.5 mm, 2.5 mm, and 3.2 mm) and utilizes a refractive index of 1.3375 for keratometric calculations.[7,8] The IOLMaster700 has been extensively validated in the literature and is often considered a reference device for biometric comparisons.[9,10]

Several studies have evaluated the agreement of SS-OCT biometers, revealing minor yet statistically significant differences in K, axial length, and anterior segment parameters across different devices.[11,12] However, discrepancies in anterior chamber depth (ACD) measurements have been reported as a potential limitation when considering the interchangeable use of these devices for IOL power calculation and phakic IOL sizing.[13,14] Given that ACD variations can influence the prediction of postoperative effective lens position (ELP), even small differences in measurement techniques may have clinical implications, particularly for eyes with extreme axial lengths or previous refractive surgery.[15,16]

Although previous research has assessed the agreement between various SS-OCT-based biometers, studies comparing the Eyestar900 and IOLMaster700 remain limited, particularly in specific populations. Given the anatomical and demographic variations that may influence biometric measurements, regional studies are necessary to validate the clinical applicability of these devices across different patient groups.[17,18] The present study aims to evaluate the agreement of ocular biometric parameters between the Eyestar900 and the IOLMaster700 in a Brazilian cataract population. This study seeks to determine whether these devices can be used interchangeably in routine clinical practice by assessing the statistical and clinical relevance of measurement discrepancies.

METHODS

Study design and ethical approval

This retrospective comparative study included cataract patients who underwent optical biometry examinations using the Eyestar900 and IOLMaster700 between May and July 2023 at *Hospital de Olhos Paulista* (HOlhos) in São Paulo, Brazil. The study adhered to the tenets of the Declaration of Helsinki and was approved by the Research Ethics Committee of the HOlhos. Due to its retrospective nature and the use of de-identified patient data, the requirement for informed consent was waived.

Inclusion and exclusion criteria

Patients diagnosed with cataracts were eligible for inclusion if they were at least 18 years old, had a best-corrected visual acuity of 20/40 or worse, could maintain stable fixation during scan acquisition, and could cooperate with the examination protocol.

Exclusion criteria included a history of ocular diseases such as keratoconus, glaucoma, diabetic retinopathy, or other retinal pathologies, prior ocular surgery within the last six months, recent use of contact lenses (less than four weeks for soft lenses and six weeks for rigid lenses), and the presence of corneal scarring, pterygium, or dense cataracts (LOCS III: nuclear opalescence ≥ grade 4 or posterior subcapsular ≥ grade 2).

Biometric measurements

Biometric measurements were obtained using both the Eyestar900 and IOLMaster700 devices. The evaluated parameters included K, axial length (AL), ACD, white-to-white corneal diameter (WTW), and lens thickness (LT).

Since the IOLMaster700 measures ACD from the corneal epithelium to the anterior lens surface, central corneal thickness was subtracted to ensure comparability with the Eyestar900, which measures from the endothelium. All measurements were performed under dim lighting conditions. Eyestar900 measurements were taken first, followed by the IOLMaster700. A single experienced examiner performed all measurements to eliminate interobserver variability. Each parameter was measured three times per device, and the mean value was used for analysis.

Statistical analysis

Statistical analyses were performed using SPSS v26 (2019), Minitab 21.2 (2022), and Microsoft Excel Office 2010. The Shapiro-Wilk test was used to assess normality. Parametric or non-parametric tests were applied accordingly.

Paired t-tests were used to compare measurements between devices. Intraclass correlation coefficients (ICC) assessed agreement, interpreted as: poor (< 0.25), fair (0.25 -0.50), good (0.50 -0.75), and excellent (> 0.75).

Bland-Altman plots evaluated limits of agreement and potential systematic biases. Additionally, scatter plots with regression analysis were used to assess linear correlations.

Post-hoc power analysis

A post-hoc power analysis confirmed that a sample size of 43 eyes provided sufficient statistical power to detect clinically meaningful differences, with a significance level set at $p < 0.05$.

RESULTS

This study included 43 eyes from 33 patients who underwent optical biometry with both devices. The biometric parameters obtained from each device are summarized in table 1. All parameters demonstrated high precision and excellent agreement between measurements, except for ACD, which showed greater variability.

Keratometry

Keratometry measurements showed a mean difference of 0.03 D ($p = 0.734$; Table 1) and an ICC of 0.990 (Table 2). The Bland-Altman plot demonstrated narrow limits of agreement (Figure 1A). The scatter plot showed a strong correlation between the devices (Figure 2A), while the boxplot confirmed a similar distribution of measurements (Figure 3A).

Table 1. Ocular biometric measurements of the two devices

Variable	Device	Mean	SD	n	p-value
K (D)	Eyestar 900	43.36	2.53	43	0.734
	IOL Master 700	43.33	2.41	43	
AL (MM)	Eyestar 900	23.90	1.99	43	0.026
	IOL Master 700	23.93	1.97	43	
ACD (MM)	Eyestar 900	3.60	2.93	43	0.294
	IOL Master 700	3.12	0.31	43	
WTW (MM)	Eyestar 900	11.99	0.47	43	0.006
	IOL Master 700	11.90	0.49	43	
LT (MM)	Eyestar 900	4.41	0.45	43	< 0.001
	IOL Master 700	4.47	0.46	43	

SD: standard deviation; K: keratometry; IOL: intraocular lens; AL: axial length; ACD: anterior chamber depth; WTW: white-to-white corneal diameter; LT: lens thickness.

Table 2. Intraclass correction coefficients

Variable	Right eye		Left eye		Both eyes	
	ICC	p-value	ICC	p-value	ICC	p-value
K	0.988	<0.001	0.992	<0.001	0.990	<0.001
AL	1.000	<0.001	1.000	<0.001	1.000	<0.001
ACD	0.976	<0.001	-0.110	0.594	-0.081	0.599
WTW	0.932	<0.001	0.954	<0.001	0.944	<0.001
LT	0.996	<0.001	0.993	<0.001	0.994	<0.001

ICC: intraclass correction coefficients; K: keratometry; AL: axial length; ACD: anterior chamber depth; WTW: white-to-white corneal diameter; LT: lens thickness.

The boxplots illustrate the median, interquartile range (IQR), and possible outliers for each parameter measured by both devices.

Axial length

Axial length exhibited a mean difference of 0.08 mm ($p = 0.026$) and an ICC of 1.000. The Bland-Altman plot indicated minimal variation, with a strong correlation observed in the scatter plot. The boxplot demonstrated consistent measurement distribution across devices.

Anterior chamber depth

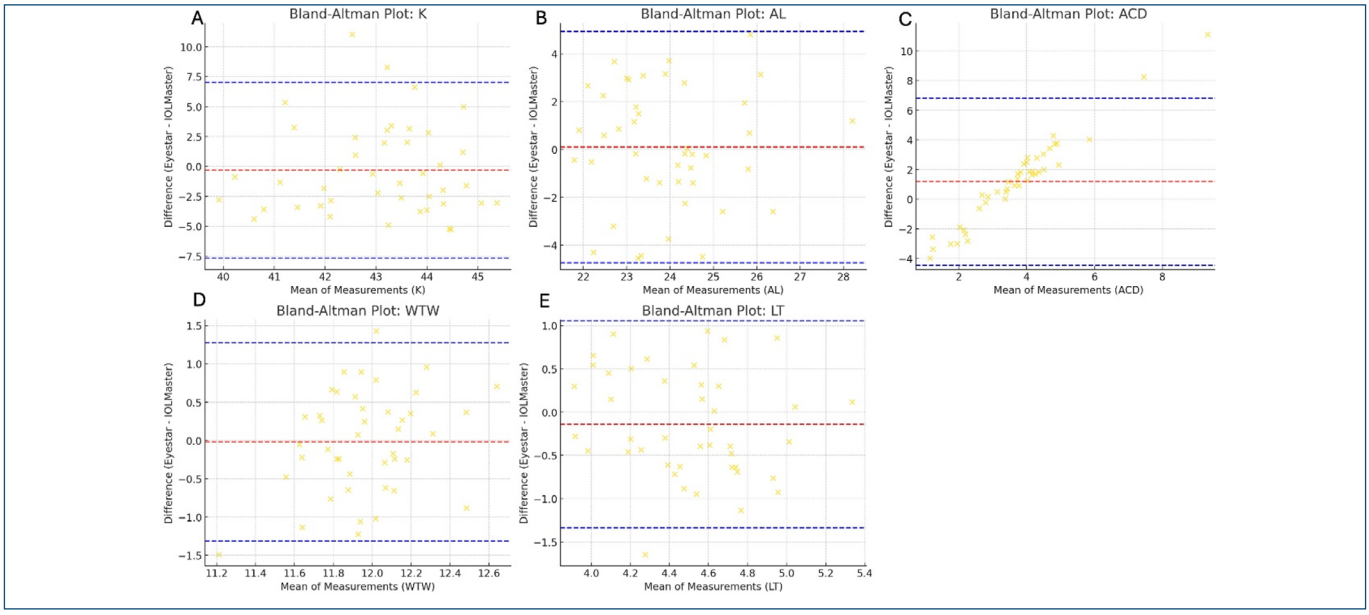
Anterior chamber depth showed the greatest discrepancy between devices, with a mean difference of 0.48 mm ($p = 0.294$) and an ICC of -0.081. The Bland-Altman plot revealed wide limits of agreement, and the scatter plot showed a weaker correlation. The boxplot illustrated greater measurement variability across devices.

White-to-white

White-to-white diameter exhibited a mean difference of 0.07 mm ($p = 0.006$) and an ICC of 0.944. The Bland-Altman plot indicated slight variability between device measurements. The scatter plot demonstrated a high correlation, and the boxplot showed a similar distribution.

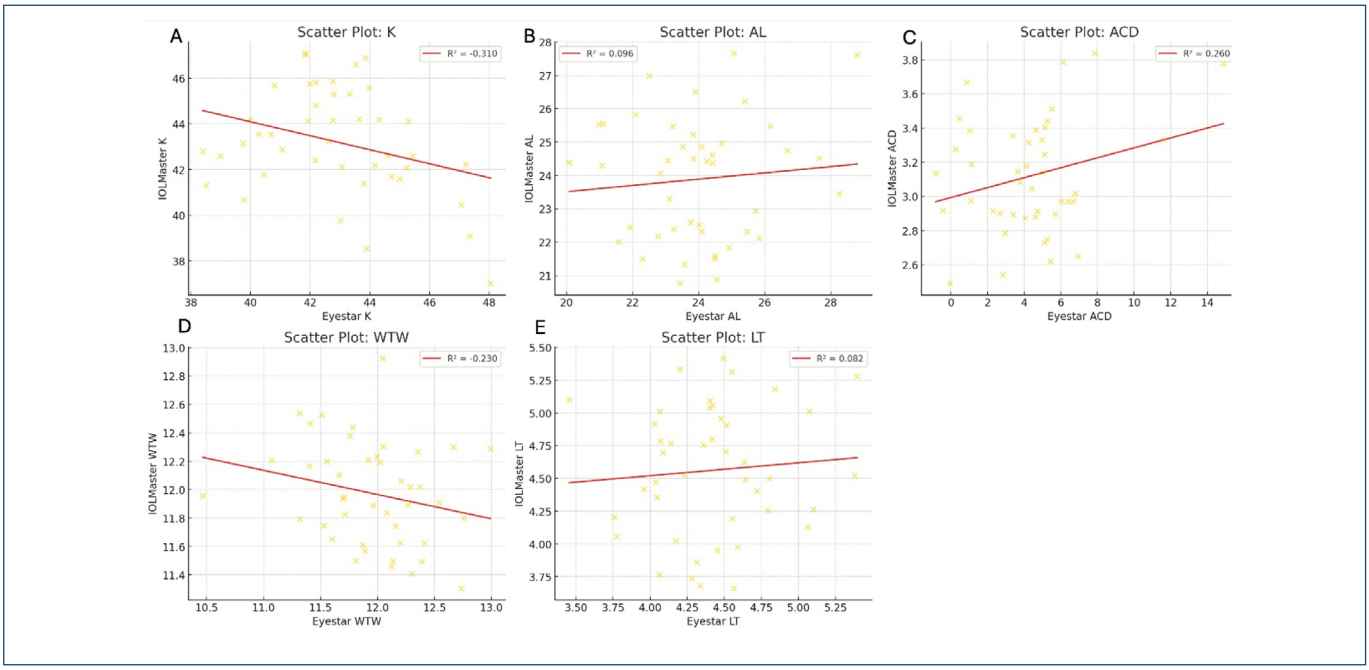
Lens thickness

Lens thickness had a mean difference of 0.06 mm ($p < 0.001$) and an ICC of 0.994. The Bland-Altman plot showed tight limits of agreement. The scatter plot demonstrated a



K: keratometry; AL: axial length; ACD: anterior chamber depth; WTW: white-to-white; LT: lens thickness.

Figure 1. Bland-Altman plots comparing Eyestar 900 and IOLMaster 700 measurements. Each plot presents the difference between the two devices (Eyestar 900-IOLMaster 700) against the mean of both measurements. The red dashed line represents the mean difference, while the blue dashed lines indicate ± 1.96 standard deviations, representing the limits of agreement. (A) Keratometry; (B) axial length; (C) anterior chamber depth; (D) white-to-white; (E) lens thickness.



K: keratometry; AL: axial length; ACD: anterior chamber depth; WTW: white-to-white; LT: lens thickness.

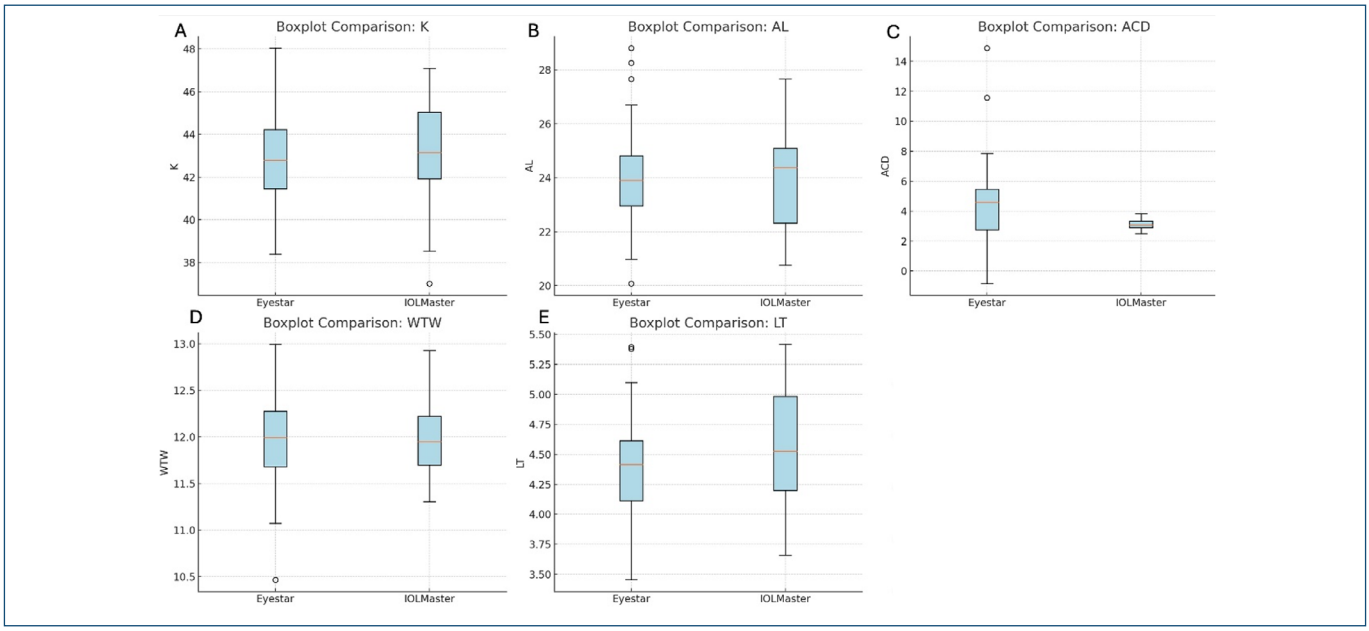
Figure 2. Scatter plots illustrate the correlation between Eyestar 900 and IOLMaster 700 measurements. Each plot compares the values obtained from both devices, with a regression line (red) and the coefficient of determination (R^2) indicating the strength of correlation. (A) Keratometry; (B) axial length; (C) anterior chamber depth; (D) white-to-white; (E) lens thickness.

strong correlation between devices, and the boxplot presented a similar measurement distribution.

DISCUSSION

Accurate ocular biometry is essential for optimal IOL power calculation and for achieving predictable refractive outcomes in cataract surgery. This study compared the Eyestar900 and the IOLMaster700, both SS-OCT biometers, to evaluate their agreement in key biometric parameters and their potential interchangeability in clinical practice.

The results demonstrated excellent agreement between the devices for most parameters, including AL,



K: keratometry; AL: axial length; ACD: anterior chamber depth; WTW: white-to-white; LT: lens thickness

Figure 3. Boxplots comparing measurement distributions between Eyestar 900 and IOLMaster 700.

WTW, K, and LT. However, ACD showed lower concordance, which requires careful interpretation. The observed mean differences for these parameters were statistically significant but remained within clinically acceptable limits, confirming previous findings that swept-source optical coherence tomography (SS-OCT) biometers provide highly consistent measurements across different platforms. The strong correlation coefficients obtained further support the reliability of both devices for routine biometric assessments.[1-3]

AL measurements exhibited nearly perfect agreement, with an ICC of 1.000 and a mean difference of 0.08 mm. These results align with previous studies comparing SS-OCT-based biometers, which have shown similarly high levels of reproducibility.[4] Given that a 0.1 mm error in AL measurement corresponds to approximately 0.27 diopters of IOL power error, the minor discrepancy between the two devices is unlikely to impact clinical decision-making significantly. Furthermore, the tight limits of agreement in the Bland-Altman plot reinforce the interchangeability of these devices for AL measurement. Other studies have also demonstrated high repeatability in AL measurements between these devices, with differences that are not clinically significant.[5,6]

Anterior K also demonstrated excellent agreement, with a mean difference of 0.03 D and an ICC of 0.990. Sorkin et al. [16] found that both devices exhibited high consistency in anterior K measurements, supporting their use in IOL calculations with the Barrett Universal II formula. Other investigations have reported similar findings, with limits of agreement within ± 0.5 diopters, indicating that these devices can be used interchangeably in clinical practice. The agreement in K measurements is critical for Toric IOL calculations, as even small variations can influence refractive outcomes. A study by Asena et al. further confirmed that the IOLMaster700 showed strong agreement with other keratometric devices, reinforcing its reliability.[7-9]

The largest discrepancy between devices was observed in ACD, with a mean difference of 0.48 mm and an ICC of -0.081. The Bland-Altman analysis revealed wider limits of agreement, suggesting significant measurement variability. These findings are consistent with previous reports showing that ACD measurements can differ between biometers, likely due to differences in image acquisition methods and reference points for measurement. [10,11] Given that a 0.5 mm-error in ACD can correspond to a refractive error of approximately 0.3-0.5 D in IOL power calculation, especially in premium lenses (e.g., EDOF, trifocal), this discrepancy is clinically relevant and should not be overlooked.

To mitigate the impact of ACD variability, two strategies may be considered in clinical practice: standardizing ACD measurements using a single device within the same institution and applying conversion equations derived from inter-device differences when measurements are obtained from different biometers. Additionally, cross-validation of IOL calculations using modern formulas such as Barrett Universal II can help minimize the influence of single-parameter variability, as these formulas

incorporate multiple biometric values simultaneously. Recent evidence suggests that omitting parameters such as ACD, LT, or WTW in the Barrett Universal II formula results in minimal and clinically insignificant changes in predictive accuracy in eyes with normal biometry, provided that results are cross-checked with other formulas.[27] Moreover, a modified version of the Barrett Universal II incorporating total corneal power and virtual AL demonstrated improved refractive prediction accuracy in intermediate biometric profiles.[28-31]

Lens thickness measurements showed excellent agreement between the two biometers, with a high intraclass correlation coefficient. Previous studies have also demonstrated that differences in LT measurements between the Eyestar900 and the IOLMaster700 are statistically significant but clinically negligible. Galzignato et al. reported that the agreement in measuring LT was strong, with small mean differences that do not impact IOL power calculations. These findings suggest that both devices can be used interchangeably for this parameter in routine clinical practice.[12,13]

Regarding IOL power prediction, both the Eyestar900 and IOLMaster700 have been shown to yield comparable accuracy when using modern formulas such as Barrett Universal II. A recent study evaluating IOL power prediction accuracy between SS-OCT-based biometers found no statistically significant differences in spherical equivalent prediction error when comparing devices, with agreement in power selection within ± 0.5 diopters in most cases. Given the high degree of agreement in AL and K measurements, both devices are likely to provide similar predictive accuracy when used with contemporary IOL formulas. However, studies have noted that adjustments to lens factor calculations may be necessary when incorporating posterior corneal curvature into IOL power calculations.[2,3,14-26]

Despite the overall high level of agreement observed, some biases were identified. The main concern was related to ACD, which showed greater variability between devices. This suggests that while AL, K, WTW, and LT can be used interchangeably, ACD should be interpreted with caution, particularly in cases where this parameter is critical for effective lens position estimation or phakic IOL sizing.[2,3,9]

This study has limitations. Its retrospective design may introduce selection bias and non-standardized measurement conditions. Additionally, the relatively small sample size (n = 43) may reduce statistical power and limit generalizability, particularly for eyes with extreme AL (e.g., high myopia or hyperopia). Future prospective studies with larger and more diverse populations are recommended to determine whether inter-device differences, particularly in ACD, can influence IOL selection and postoperative refractive outcomes.[1,4,10,27-31]

CONCLUSION

In conclusion, the Eyestar900 and IOLMaster700 demonstrated excellent agreement in most biometric parameters, supporting their interchangeability for routine clinical applications. However, the variability observed in ACD measurements highlights the need for caution when using this parameter for IOL power selection or phakic lens planning. Given the increasing reliance on SS-OCT biometers for preoperative planning, further research is warranted to refine calibration methods, develop conversion models, and optimize IOL prediction accuracy across different platforms.

AUTHORS' CONTRIBUTION

Substantial contribution to conception and design: BKM, LAVASG, ICT; acquisition of data: LAVASG, RKMB, JMTL; analysis and interpretation of data: BKM, LAVASG, ICT; drafting of the manuscript: LAVASG, RKMB, JMTL; critical revision of the manuscript for important intellectual content: BKM, ICT; final approval of the submitted manuscript (mandatory participation for all authors): BKM, LAVASG, RKMB, JMTL, ICT; statistical analysis: BKM; administrative, technical, or material support supervision: ICT research group leadership: ICT, BKM.

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