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

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

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ABSTRACT

Objective: To evaluate the agreement of biometric parameters measured by the ANTERION and IOLMaster700 devices in a Brazilian population, considering statistical differences and their clinical relevance.

Methods: A retrospective comparative study included cataract patients who underwent biometric examination with ANTERION and IOLMaster700 between September and December 2023. The parameters evaluated were anterior keratometry, axial length, central corneal thickness, anterior chamber depth, white-to-white diameter, and lens thickness. Agreement and correlation were assessed using Bland-Altman and scatter plots.

Results: A total of 26 eyes from 23 patients were analyzed. Mean differences were 0.22 D for K, 0.05 mm for axial length, 7.3 µm for central corneal thickness, 0.47 mm for anterior chamber depth, 0.2 mm for white-to-white diameter, and 0.04 mm for lens thickness ($p < 0.001$ for all). Intraclass correlation coefficients (ICC) indicated excellent agreement (keratometry: 0.993, axial length: 0.999, central corneal thickness: 0.987, anterior chamber depth: 0.810, white-to-white diameter: 0.950, lens thickness: 0.987). Despite statistical significance, Bland-Altman plots demonstrated clinically acceptable agreement for axial length, keratometry, central corneal thickness, and lens thickness, while anterior chamber depth and white-to-white diameter showed higher variability.

Conclusion: ANTERION and IOLMaster700 exhibit excellent agreement. However, anterior chamber depth and white-to-white diameter variability suggest caution in phakic IOL sizing and anterior segment planning. These findings support their interchangeability with context-based clinical judgment.

RESUMO

Objetivo: Avaliar a concordância dos parâmetros biométricos medidos pelos dispositivos ANTERION e IOLMaster700 em uma população brasileira, considerando diferenças estatísticas e sua relevância clínica.

Métodos: Estudo comparativo retrospectivo que incluiu pacientes com catarata submetidos a exame biométrico com ANTERION e IOLMaster700 entre setembro e dezembro de 2023. Os parâmetros avaliados foram ceratometria anterior, comprimento axial, espessura corneana central, profundidade da câmara anterior, diâmetro branco a branco e espessura do cristalino. A concordância e a correlação foram avaliadas por meio dos gráficos de Bland-Altman e gráficos de dispersão.

Resultados: Um total de 26 olhos de 23 pacientes foi analisado. As diferenças médias foram de 0,22 D para K, 0,05 mm para comprimento axial, 7,3 µm para espessura corneana central, 0,47 mm para profundidade da câmara anterior, 0,2 mm para diâmetro branco a branco e 0,04 mm para espessura do cristalino ($p < 0,001$ para todos). Os coeficientes de correlação intraclasse (ICC) indicaram excelente concordância (ceratometria: 0,993; comprimento axial: 0,999; espessura corneana central: 0,987; profundidade da câmara anterior: 0,810; diâmetro branco a branco: 0,950; espessura do cristalino: 0,987). Apesar da significância estatística, os gráficos de Bland-Altman demonstraram concordância clinicamente aceitável para comprimento axial, ceratometria, espessura corneana central e espessura do cristalino, enquanto profundidade da câmara anterior e diâmetro branco a branco apresentaram maior variabilidade.

Conclusão: ANTERION e IOLMaster700 apresentam excelente concordância. No entanto, a variabilidade na profundidade da câmara anterior e no diâmetro branco a branco sugere cautela no dimensionamento de lentes fáquicas e no planejamento do segmento anterior. Esses achados apoiam a intercambialidade entre os dispositivos com julgamento clínico baseado no contexto.

INTRODUCTION

Cataract surgery is widely recognized as one of the world's most performed and successful medical procedures. In this procedure, an artificial intraocular lens replaces the opaque crystalline lens.[1,2] The precise determination of biometric parameters has assumed an essential role in ophthalmology and other areas of visual sciences. Meticulous analysis of these parameters is imperative for success in cataract surgery, especially with the evolution of toric and multifocal intraocular lenses.[3]

The axial size of the eye, anterior chamber depth, and corneal curvature measurements are some of these parameters that significantly impact the intraocular lens calculation.[4] An accurate way to obtain this data is through Swept-source optical coherence tomography (SS-OCT). This non-invasive imaging technique scans biological structures with high resolution, speed, and sensitivity, allowing a three-dimensional analysis of the evaluated tissue.[5,6] ANTERION (Heidelberg Engineering, Germany) is a device that utilizes this technology to obtain anterior segment tomographic imaging, corneal mapping, and biometric measurements.

ANTERION is an anterior segment imaging system with corneal mapping, tomography, and optical coherence biometry capabilities based on SS-OCT technology. The device is fully automated and performs automatic centering and measurement.[3]

The IOLMaster700 (Zeiss, Germany) is based on SS-OCT technology with a scan rate of 2,000 scans/s (wavelength 1055 nm, 1035 to 1095 nm). The source is used to obtain telecentric K in three zones: 1.5, 2.5, and 3.2 mm on an average cornea of 7.9 mm radius, using a refractive index of 1.3375.[7-9]

Although previous studies have compared ANTERION and IOLMaster700, our research adds value by being the first to analyze this comparison, specifically in a Brazilian population. Given the anatomical and demographic variations that may exist, regional studies remain essential for validating device applicability in different populations.[1-10]

As new biometers or updates to existing devices are introduced into clinical practice, it is crucial to obtain comprehensive knowledge about their capabilities, agreement with other devices already on the market, and impact on intraocular lens calculation.[7] The IOLMaster700 is one of the most commonly used biometers in clinical practice, being a reference for biometric comparisons. This study aims to determine whether the agreement between ANTERION and IOLMaster700 is sufficient to allow their interchangeable use in clinical settings.

METHODS

Study design and participants

This retrospective comparative study included cataract patients who underwent optical biometry examination with the ANTERION and IOLMaster700 devices between September 2023 and December 2023 at Hospital de Olhos Paulista (HOlhos) São Paulo, Brazil. This study was approved by the Ethics and Research Committee of Hospital de Olhos Paulista and conducted following the Declaration of Helsinki. Due to the retrospective design and the use of de-identified patient data, the need for written informed consent was waived.

Inclusion and exclusion criteria

The inclusion criteria were patients aged ≥ over 18 diagnosed with cataracts, having a best-corrected visual acuity of 20/40 or worse, having stable fixation during scan acquisition, and being able to cooperate with the examination protocol.

Exclusion criteria included keratoconus, glaucoma, retinal diseases, history of ocular trauma or surgery within six months, recent contact lens use (<4 weeks for soft lenses, < 6 weeks for rigid lenses), significant corneal scarring, pterygium, or dense cataracts (as defined below).

Patients with dense cataracts were excluded based on the LOCS III classification: nuclear opalescence ≥ 4 or posterior subcapsular cataracts ≥ 2, as these conditions could compromise biometric measurements. The severity of cataracts varied among participants, which may have influenced axial length (AL) measurements.

Measurement protocol

Ocular biometric measurements were obtained with ANTERION and IOLMaster700. The parameters evaluated were anterior keratometry (K), axial length (AL), central corneal thickness (CCT), anterior chamber depth (ACD), white-to-white (WTW), and lens thickness (LT).

Measurements were taken in the ANTERION and IOLMaster700 order, with a single experienced examiner performing all measurements to ensure consistency.

A post-hoc analysis of measurement failures revealed that ANTERION failed to acquire AL in six eyes, whereas IOLMaster700 failed in three. Most failures occurred in dense nuclear or subcapsular cataracts, suggesting that device-specific differences in acquisition algorithms and penetration capabilities may explain this discrepancy.

Statistical analysis

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS), version 26 (2019),

Minitab 21.2 (2022), and Excel Office 2010. Intraclass correlation coefficient (ICC) values were interpreted as follows: poor agreement (< 0.25), fair agreement (0.25 to 0.50), good agreement (0.50 to 0.75), and excellent agreement (> 0.75). Paired t-tests were used to compare biometric measurements between devices, with $p < 0.05$ considered statistically significant.

A post-hoc power analysis was performed, indicating that the sample size of 26 eyes provided sufficient statistical power to detect clinically meaningful differences in biometric parameters.

RESULTS

This study included 26 eyes from 23 patients. Table 1 presents the ocular biometric measurements obtained with the two devices, and figures 1-3 visually represent these comparisons. All parameters demonstrated an ICC greater than 0.75, indicating excellent agreement. The ICC values are displayed in table 2.

When measuring AL, ANTERION and IOLMaster700 showed excellent agreement (ICC = 0.999, Figure 2C). The mean difference between devices was 0.05 mm ($p < 0.001$), with tight limits of agreement observed in the Bland-Altman plot (Figure 1D).

For K, the devices demonstrated excellent agreement (ICC = 0.993, Figure 2E), with a mean difference of 0.22 D ($p < 0.001$). The Bland-Altman plot (Figure 1F) shows a slight bias but tight agreement limits.

The CCT variable showed a mean difference of 7.3 µm ($p < 0.001$), with excellent agreement (ICC = 0.987, Figure 2B). The Bland-Altman plot (Figure 1B) suggests that, despite statistical differences, the limits of agreement remain within an acceptable clinical range.

For WTW measurements, the ICC was 0.950 (Figure 2A), and the mean difference was 0.2 mm ($p < 0.001$). However, Figure 1A shows a greater variability, with one extreme outlier.

Table 1. Ocular biometric measurements of the two devices

Variable	Device	Mean	SD	N	p-value
K (D)	ANTERION	42.98	2.56	26	0.003
	IOL MASTER 700	42.75	2.56	26	
AL (MM)	ANTERION	24.16	1.02	26	<0.001
	IOL MASTER 700	24.21	1.01	26	
CCT (m)	ANTERION	543.5	34	26	<0.001
	IOL MASTER 700	550.8	35.1	26	
ACD (MM)	ANTERION	2.80	0.48	25	<0.001
	IOL MASTER 700	3.27	0.49	25	
WTW (MM)	ANTERION	11.87	0.62	25	<0.001
	IOL MASTER 700	12.07	0.60	25	
LT (MM)	ANTERION	4.52	0.35	24	<0.001
	IOL MASTER 700	4.46	0.36	24	

Table 2. Intraclass correction coefficients (ICC)

Variable	Right eye		Left eye		Both eyes	
	ICC	P-VALUE	ICC	P-VALUE	ICC	P-VALUE
K	0.991	<0.001	0.995	<0.001	0.993	<0.001
AL	1.000	<0.001	0.999	<0.001	0.999	<0.001
CCT	0.986	<0.001	0.989	<0.001	0.987	<0.001
ACD	0.744	<0.001	0.848	<0.001	0.810	<0.001
WTW	0.967	<0.001	0.937	<0.001	0.950	<0.001
LT	0.990	<0.001	0.986	<0.001	0.987	<0.001

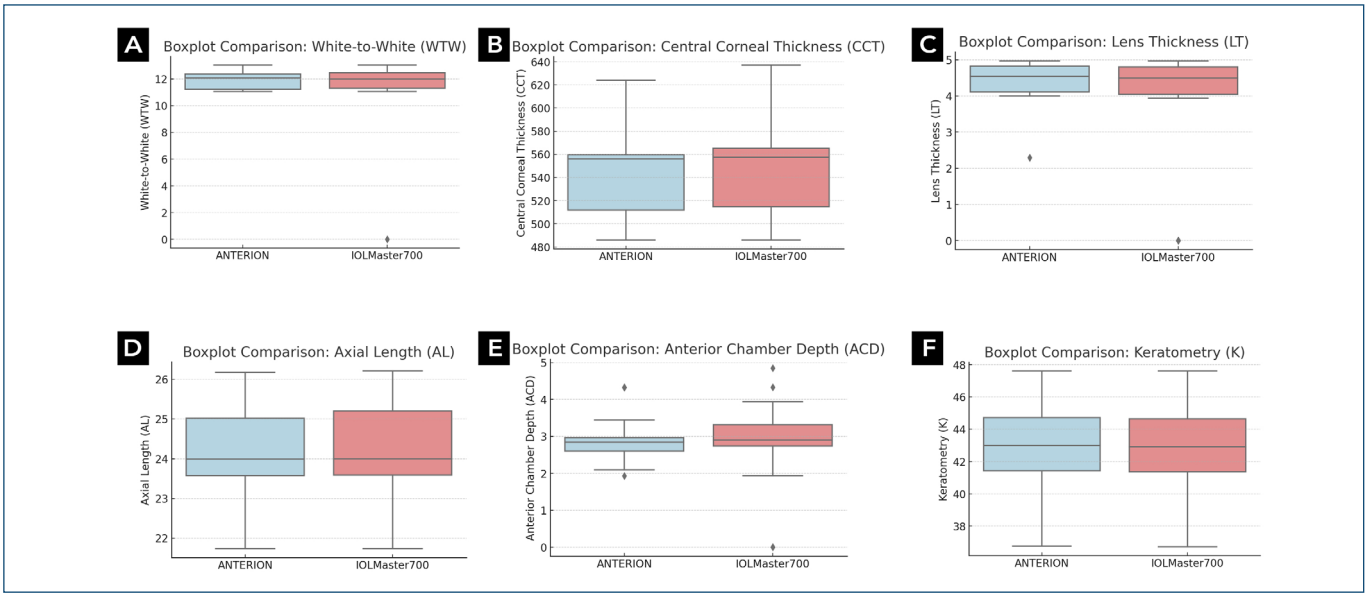

Figure 1. Bland-Altman plots comparing ANTERION and IOLMaster700 measurements. Each plot presents the difference between the two devices (ANTERION and IOLMaster700) against the mean of both measurements. The red dashed line represents the mean difference, while the blue dashed lines indicate ± 1.96 standard deviations, representing the limits of agreement.

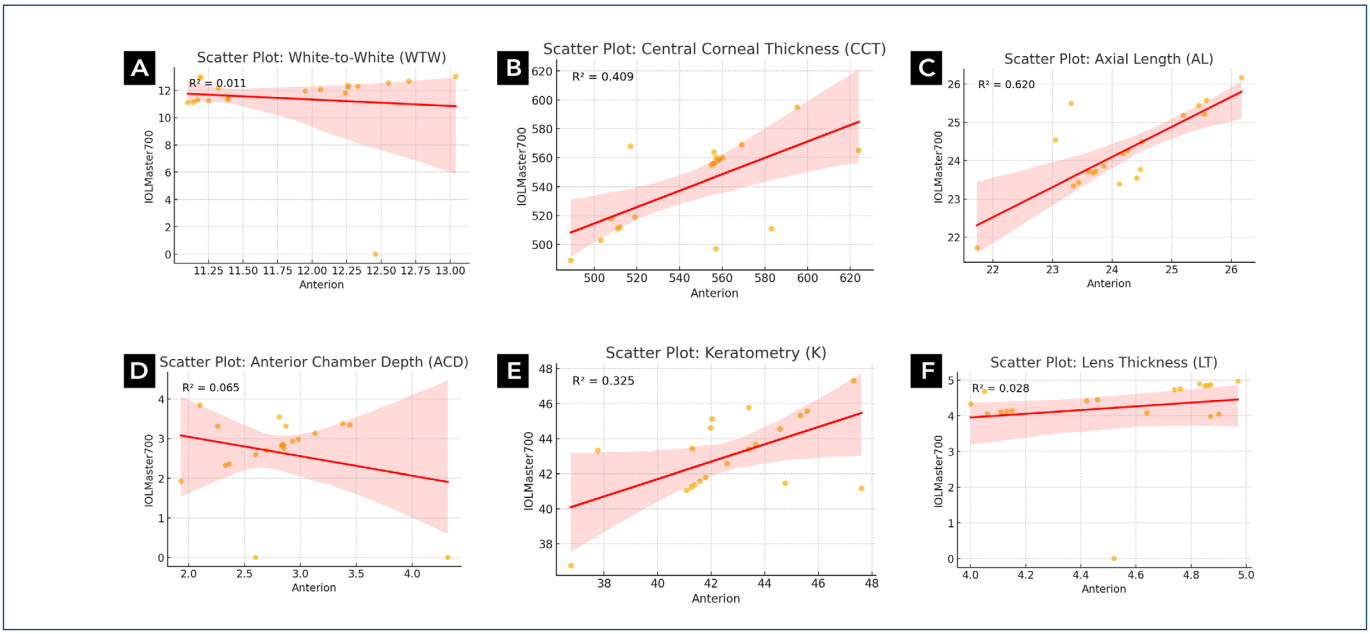

Figure 2. Scatter plots illustrating the correlation between ANTERION and IOLMaster700 measurements. Each plot compares the values obtained from both devices, with a regression line (red) and the coefficient of determination (R^2) indicating the strength of correlation.

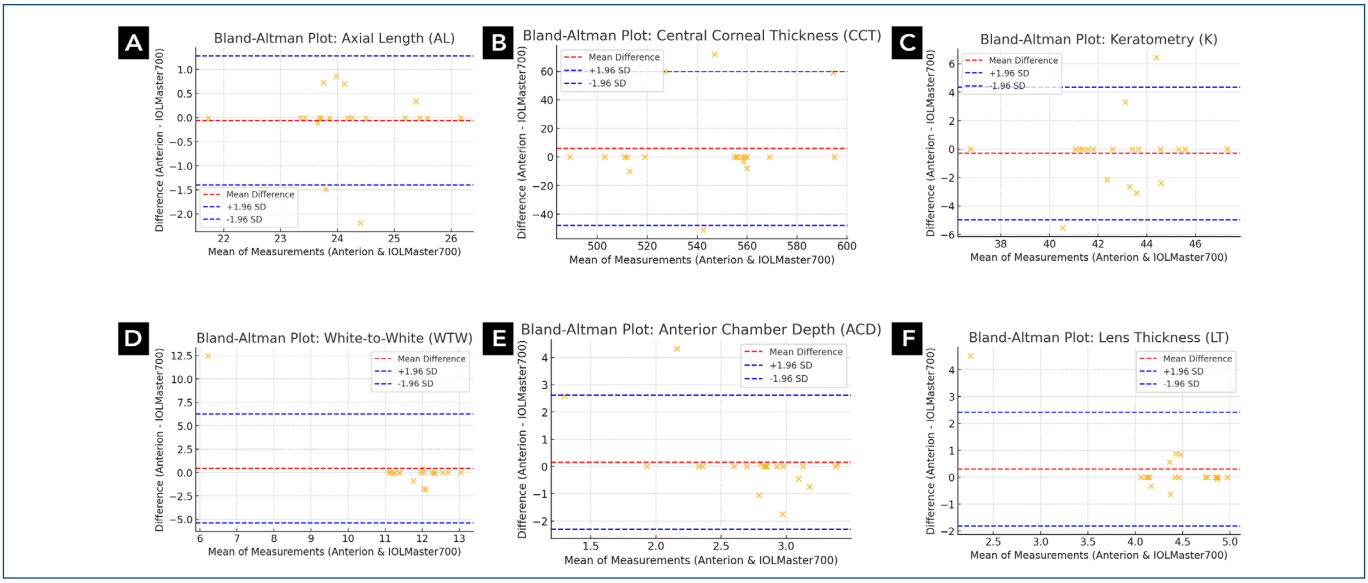

Figure 3. Boxplots comparing measurement distributions between ANTERION and IOLMaster700. The boxplots illustrate the median, interquartile range, and possible outliers for each parameter measured by both devices.

The LT variable demonstrated excellent agreement (ICC = 0.987, Figure 2F), with a mean difference of 0.04 mm ($p < 0.001$). The Bland-Altman plot (Figure 1C) suggests that agreement limits are within an acceptable range, with a slight bias favoring ANTERION.

The ACD variable presented a mean difference of 0.47 mm ($p < 0.001$) but still demonstrated excellent agreement (ICC > 0.75). However, Figure 1E shows a wider spread in the limits of agreement, indicating more variability compared to other parameters.

The ACD, WTW, and LT variables were measured only once per device, and LT was not reassessed in duplicate in either biometer. The standard deviations of the means of the AL, WTW, and LT variables in the ANTERION biometer were 1.02, 0.62, and 0.35, respectively, while in the IOLMaster700, these values were 1.01, 0.60, and 0.36, indicating high consistency between devices (Table 1). This consistency is further supported by the boxplots (Figure 3).

All variables showed excellent agreement (ICC > 0.75; $p < 0.001$) between the devices. However, the scatter plots

(Figure 2) suggest that WTW and ACD had slightly weaker correlations (lower R^2 values), which aligns with the greater variability observed in the Bland-Altman analysis (Figure 1).

DISCUSSION

Keratometry values in ANTERION are calculated using a keratometric index specific to a 3-mm ring, following Gaussian optics principles (keratometric index 1.3375).[11-13] The IOLMaster700 measures anterior K using 18 points in a hexagonal pattern in three zones (1.5 mm, 2.5 mm, and 3.5 mm) and posterior K using SS-OCT tomography14,15. In our study, the mean K measurements differed by 0.22 D ($p < 0.001$), yet agreement remained excellent (ICC = 0.993). The Bland-Altman plot (Figure 1F) confirms tight limits of agreement, suggesting a consistent measurement pattern between devices. The scatter plot (Figure 2E) indicates a strong correlation, reinforcing the agreement despite the statistical difference. These results are consistent with previous studies that have compared keratometric measurements between different biometers, which also found statistically significant but clinically acceptable differences.[12-15]

For AL, inter-device agreement has been well established.[16] A previous study showed excellent agreement (ICC = 0.999) between ANTERION and IOLMaster700, with a mean AL difference of 0.005 mm.[14-17] Considering that a 1-mm error in AL induces a 2.5 D deviation in IOL power calculation for an average AL of 23.5 mm, the 0.05-mm difference found in our study would correspond to a 0.125 D deviation in IOL power. The Bland-Altman plot (Figure 1D) confirms tight limits of agreement, and the scatter plot (Figure 2C) suggests a high correlation, supporting the interchangeable use of these devices in IOL calculations. These findings align with previous reports demonstrating minimal inter-device variation in AL measurements.[16-18]

Optical biometry often fails in eyes with dense nuclear or posterior subcapsular cataracts.[19] In our study, AL measurements were not obtained in six eyes with ANTERION and in three with IOLMaster700. Most of these cases involved dense-core, anterior, or posterior subcapsular cataracts. The higher failure rate in ANTERION was unexpected, given its longer wavelength (1,300 nm versus 1,050 nm in IOLMaster700).[20] This discrepancy may be due to differences in acquisition methodology: IOLMaster700 averages measurements from three scans in six meridians, while ANTERION averages three subsets of consecutive data.[19,20] Similar trends have been reported in studies comparing SS-OCT and PCI-based biometers, where differences in acquisition methods influenced failure rates in dense cataracts.[20]

The devices demonstrated excellent agreement for CCT, ACD, WTW, and LT. ICC values were close to 1.0, and mean differences were statistically significant. Regarding CCT, the mean difference was 7.3 μm ($p < 0.001$), and the Bland-Altman plot confirms good agreement limits, though some outliers were observed. The scatter plot suggests some variability, which could be relevant in specific clinical scenarios, such as keratoconus or post-refractive surgery cases. Previous research has indicated that while CCT values obtained from different imaging modalities may show small but significant differences, they are generally consistent in normal corneas.[21-30]

White-to-white measurements had an ICC of 0.950 and a mean difference of 0.2 mm ($p < 0.001$). However, the Bland-Altman plot shows wider variability compared to other parameters, including an outlier, and the scatter plot indicates a lower correlation ($R^2 = 0.011$). These findings suggest that, while the devices show good agreement, WTW values may depend more on the measurement technique. This should be considered, especially when using these values for phakic IOL sizing or refractive surgery planning. Similar discrepancies in WTW values have been noted in prior studies, emphasizing that differences in measurement principles and algorithms contribute to variability.[21-30]

Anterior chamber depth measurements showed a mean difference of 0.47 mm ($p < 0.001$) but maintained excellent agreement (ICC > 0.75). However, the Bland-Altman plot indicates greater variability, and the scatter plot shows a lower correlation ($R^2 = 0.065$), suggesting that this measurement may differ more between devices. Although statistically significant, the relevance of this difference depends on the clinical context. This variation may not be highly impactful for standard IOL power calculations. Still, caution may be required for phakic IOL sizing or anterior segment procedures. Studies have reported similar findings comparing ACD measurements across different biometers, indicating that variations may exist based on device-specific acquisition techniques.[21-30]

The LT variable showed excellent agreement (ICC = 0.987), with a mean difference of 0.04 mm ($p < 0.001$). The Bland-Altman plot suggests good consistency, and the boxplot shows overlapping distributions, reinforcing the reliability of this measurement across both devices. Prior studies have also demonstrated minimal variation in LT values across SS-OCT and PCI biometers, supporting the reliability of these measurements.[21-30]

A study by McLintock et al. analyzed 159 eyes from 91 patients and found statistically significant differences in anterior, posterior, and total K measurements between devices. Differences in posterior and total K were considered clinically significant, suggesting these parameters are not interchangeable.[28] Similarly, Fişuş et al. examined 389 eyes from 209 patients and found good agreement between devices, with minor differences in ACD and lens thickness LT. Despite these small differences, they concluded that the devices should not be used interchangeably.[29]

The primary limitation of this study is its retrospective design. Additionally, the sample contained few eyes with AL >26 mm or <22 mm, limiting its applicability in extreme cases. All patients had cataracts, which could introduce bias, as cataracts influence optical physics during measurement acquisition. Future studies with normal eyes will provide more robust comparisons between these devices.

AUTHOR'S CONTRIBUTION

Substantial contribution to conception and design: Bernardo Kaplan Moscovici, Luís Armando Vitorino Alves de Souza Gondim, Ivan Corso Teixeira; data acquisition: Luís Armando Vitorino Alves de Souza Gondim, Roberta Kern Menna Barreto, José Maurilio Tavares de Lucena; analysis and interpretation of data: Bernardo Kaplan Moscovici, Luís Armando Vitorino Alves de Souza Gondim, Ivan Corso Teixeira; drafting of the manuscript: Luís Armando Vitorino Alves de Souza Gondim, Roberta Kern Menna Barreto, José Maurilio Tavares de Lucena; critical revision of the manuscript for important intellectual content: Bernardo Kaplan Moscovici, Ivan Corso Teixeira; have given final approval of the submitted manuscript (mandatory participation for all authors): Bernardo Kaplan Moscovici, Luís Armando Vitorino Alves de Souza Gondim, Roberta Kern Menna Barreto, José Maurilio Tavares de Lucena, Ivan Corso Teixeira; Statistical analysis: Bernardo Kaplan Moscovici; administrative, technical, or material support supervision: Ivan Corso Teixeira; research group leadership: Ivan Corso Teixeira, Bernardo Kaplan Moscovici.

CONCLUSION

ANTERION and IOLMaster700 demonstrated excellent agreement across all biometric parameters, supporting their interchangeable use in most clinical scenarios. Although some differences were statistically significant, their clinical relevance varies depending on the application. The variability observed in anterior chamber depth and white-to-white measurements suggests that additional consideration may be needed in cases where these parameters are critical, such as phakic IOL sizing or anterior segment planning. Our findings are consistent with prior research comparing different optical biometers, which have also reported small but significant differences in some parameters that may require clinical judgment in specific situations. Future studies should evaluate these findings in eyes with extreme axial length values, post-refractive surgery corneas, and other complex cases to further assess the broader applicability of these devices.

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