

Biometric accuracy in cataract surgery: a comparative study between the IOLMaster 500 and Argos

Precisão biométrica em cirurgia de catarata: um estudo comparativo entre IOLMaster 500 e Argos

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ABSTRACT

Purpose: To assess the agreement between IOLMaster 500 and Argos for ocular biometry parameters

Methods: This retrospective study included 104 patients (205 eyes) who underwent biometry with both devices. Measurements included axial length (AL), keratometry (K1, K2), and ACD. Anterior chamber depth (ACD) measurements were compared directly as reported by each device, without additional correction for corneal thickness.

Results: No significant differences were found for AL (23.49 ± 1.29 mm versus 23.63 ± 1.35 mm; $p = 0.737$), K1 (43.36 ± 1.68 D versus 43.41 ± 1.61 D; $p = 0.769$), or K2 (44.28 ± 1.60 D versus 44.17 ± 1.58 D; $p = 0.575$). However, ACD values differed significantly (2.98 ± 0.41 mm versus 3.18 ± 0.36 mm; $p = 0.009$).

Conclusion: IOLMaster 500 and Argos yield comparable AL and keratometry values, supporting their interchangeable use for these parameters. However, due to significant differences and bias in ACD, this parameter should be interpreted with caution and should not be considered directly interchangeable between devices. These results highlight the importance of consistent biometry protocols in IOL power calculation.

RESUMO

Objetivo: Avaliar a concordância entre os biometradores IOLMaster 500 (interferometria de coerência parcial) e Argos (OCT Swept-Source) para parâmetros de biometria ocular em pacientes submetidos à cirurgia de catarata, com ênfase na profundidade da câmara anterior, variável relevante para a predição do poder da lente intraocular.

Métodos: Estudo retrospectivo comparativo com 104 pacientes (205 olhos) que realizaram biometria em ambos os aparelhos. Foram analisados o comprimento axial, as ceratometrias mínima e máxima e a profundidade da câmara anterior. As medidas de profundidade da câmara anterior foram comparadas diretamente, conforme fornecidas por cada equipamento, sem correção adicional com base na espessura corneana. A análise estatística incluiu comparações pareadas, gráficos de Bland-Altman e regressão linear para avaliar a concordância e o viés proporcional.

Resultados: Não foram encontradas diferenças significativas para o comprimento axial ($23,49 \pm 1,29$ mm versus $23,63 \pm 1,35$ mm; $p = 0,737$), ceratometria mínima ($43,36 \pm 1,68$ D versus $43,41 \pm 1,61$ D; $p = 0,769$) ou ceratometria máxima ($44,28 \pm 1,60$ D versus $44,17 \pm 1,58$ D; $p = 0,575$). Em contraste, a profundidade da câmara anterior apresentou diferença significativa entre os dispositivos ($2,98 \pm 0,41$ mm versus $3,18 \pm 0,36$ mm; $p = 0,009$). Foi identificado um viés proporcional para profundidade da câmara anterior, indicando que a divergência entre os aparelhos aumentou em valores extremos.

Conclusão: IOLMaster 500 e Argos fornecem medidas comparáveis de comprimento axial e de ceratometria. Entretanto, devido às diferenças significativas e ao viés na profundidade da câmara anterior, esse parâmetro deve ser interpretado com cautela e não considerado diretamente intercambiável entre os dispositivos. Esses achados reforçam a importância de protocolos biométricos consistentes para o cálculo do poder de lentes intraoculares na prática clínica.

INTRODUCTION

Accurate ocular biometry is crucial for achieving optimal refractive outcomes in cataract surgery, particularly with the increasing use of premium intraocular lenses (IOLs), such as toric, multifocal, and extended-depth-of-focus models. Biometric measurements, including axial length (AL), anterior chamber depth (ACD), and corneal curvature (K1 and K2), are fundamental components in predicting the effective lens position (ELP) and calculating the appropriate intraocular lens (IOL) power using modern formulas, such as Barrett Universal II and Holladay 2.^(1,2)

The IOLMaster 500 (Carl Zeiss Meditec, Germany) is a well-established biometer based on partial coherence interferometry (PCI), providing reliable AL and keratometry measurements for many years. However, its performance may be limited in eyes with dense cataracts due to the reduced penetration depth of the PCI signal.⁽³⁻⁵⁾ In contrast, the Argos biometer (Movu Inc., Japan) employs swept-source optical coherence tomography (SS-OCT) at 1060 nm. It uses refractive index-based segmental analysis, thereby enhancing its ability to accurately measure biometric parameters, even in highly opaque media.⁽⁶⁻¹¹⁾

Comparative studies between PCI and SS-OCT devices are crucial for validating the interchangeability of biometric measurements in clinical settings. Previous research has demonstrated excellent agreement between SS-OCT biometers, such as the ANTERION, Eyestar 900, and IOLMaster 700, especially for AL and keratometry; however, variable results are often observed for ACD due to differences in measurement algorithms and acquisition methods.⁽⁷⁻¹¹⁾ Although both the IOLMaster 500 and Argos provide ACD measurements for clinical biometry, differences between the devices may still occur due to variations in optical technology and measurement processing.⁽⁸⁾

Despite the widespread use of both devices, few studies have directly compared the IOLMaster 500 and Argos, particularly in Latin American populations where demographic and anatomical variability may influence measurement reproducibility.⁽⁹⁾ Evaluating the agreement between these devices is especially relevant when transitioning from PCI-based to SS-OCT-based technologies in routine cataract care.

The objective of this study was to assess the agreement between the IOLMaster 500 and Argos biometers for AL, ACD, and keratometry (K1 and K2), and to determine whether these differences are statistically and clinically significant. Emphasis was placed on ACD due to its critical role in accurate IOL power calculation,

especially in eyes requiring premium IOLs or complex surgical planning.^(2,10-13)

METHODS

Study design and ethical considerations

This was a retrospective, observational, comparative study conducted at Hospital Visão Laser (Santos, Brazil). This retrospective study was approved by the local Research Ethics Committee under number 88089725.0.0000.5496, in accordance with CNS Resolution 466/2012, and followed the tenets of the Declaration of Helsinki. Given the retrospective nature of the study and the use of anonymized data, the requirement for informed consent was waived.

Participants and inclusion criteria

The sample consisted of 104 patients (205 eyes) evaluated preoperatively between December 2023 and August 2024. Inclusion criteria were age ≥ 18 years, diagnosis of senile cataract, and the ability to cooperate with the examination protocol. Exclusion criteria included history of ocular trauma or intraocular surgery within six months, corneal pathologies (e.g., keratoconus, scarring), pterygium affecting the visual axis, macular or retinal disease, recent use of contact lenses (≤ 4 weeks for soft lenses or ≤ 6 weeks for rigid lenses), or the presence of dense cataracts that precluded reliable signal acquisition by either device.

Biometric measurements

All patients underwent biometry using two devices in the same session: the IOLMaster 500 (Carl Zeiss Meditec, Germany) and the Argos biometer (Movu Inc., Japan). The IOLMaster 500 uses PCI. In contrast, the Argos uses SS-OCT, which enables deeper tissue penetration and axial segmentation based on the individual refractive indices of the ocular media.⁽⁸⁻¹⁴⁾

Measured parameters included AL, ACD, and anterior keratometry (K1 and K2). Anterior chamber depth was analyzed as reported by each device, without additional correction for corneal thickness.

Examinations were performed in a dimly lit room by a single trained ophthalmologist. Measurements were conducted first with the IOLMaster 500, followed by the Argos. Only high-quality scans were accepted for analysis. For each eye, only one reliable reading per device was recorded and included in the statistical evaluation to minimize bias and inter-device variability.⁽¹⁵⁻¹⁷⁾ This sequence reflected the routine workflow of the service.

Statistical analysis

Statistical analysis was performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA) and GraphPad Prism version 9.0 (GraphPad Software, San Diego, CA, USA). Normality was assessed with the Kolmogorov-Smirnov test. Based on the data distribution, paired t-tests or Wilcoxon signed-rank tests were used to compare measurements between devices, with $p < 0.05$ as the significance threshold.

Agreement between devices was evaluated using Bland-Altman plots to assess mean differences and 95% limits of agreement (LoA), as described by Bland and Altman.⁽¹⁸⁾ Linear regression analysis was performed to evaluate for proportional bias. Results were expressed as mean $\pm$ standard deviation (SD). Cases with failed acquisition in either device were excluded from comparative analysis.⁽¹⁹⁾ Because both eyes from the same patient could be included, the results were interpreted with the potential inter-eye correlation inherent to eye-based analyses in mind.

A post hoc power analysis confirmed that the sample size of 205 eyes was adequate to detect small but clinically relevant differences in AL, ACD, and keratometry with 80% power at a 5% significance level.⁽²⁰⁾

RESULTS

A total of 104 patients (205 eyes) were included in the final analysis. The mean age was 68.31 ± 10.08 years, and 62.5% of the participants were female. All eyes underwent biometric evaluation using both the IOLMaster 500 and Argos biometers. Table 1 presents the descriptive statistics and comparative analysis of the measured parameters.

Table 1. Comparison of biometric parameters measured by IOLMaster 500 and Argos

Parameter	IOLMaster 500	Argos	p-value
Axial length, mm	23.49 ± 1.29	23.63 ± 1.35	0.737
K1, D	43.36 ± 1.68	43.41 ± 1.61	0.769
K2, D	44.28 ± 1.60	44.17 ± 1.58	0.575
Anterior chamber depth, mm	2.98 ± 0.41	3.26 ± 1.47	0.009

Results expressed as mean $\pm$ standard deviation. Comparisons between devices were performed using paired statistical analysis.

There were no statistically significant differences between devices for AL, minimum keratometry (K1), or maximum keratometry (K2). The mean AL was 23.49 ± 1.29 mm with the IOLMaster 500 and 23.63 ± 1.35 mm with the Argos ($p = 0.737$). K1 values were 43.36 ± 1.68 D and 43.41 ± 1.61 D, respectively ($p = 0.769$), while K2 values were 44.28 ± 1.60 D (IOLMaster 500) and 44.17 ± 1.58 D (Argos) ($p = 0.575$).

A significant difference was observed in ACD measurements. The Argos device consistently reported greater ACD values than the IOLMaster 500 (3.18 ± 0.36 mm versus 2.98 ± 0.41 mm; $p = 0.009$). When eyes were stratified by laterality, no significant difference in ACD was found in right eyes ($p = 0.196$); however, the difference was statistically significant in left eyes (Argos: 3.16 ± 0.39 mm versus IOLMaster 500: 3.00 ± 0.40 mm; $p = 0.006$). These findings are shown in Table 2.

Table 2. Comparison of anterior chamber depth measurements according to laterality

Eye	IOLMaster 500	Argos	p-value
Right eye	2.97 ± 0.41	3.08 ± 1.49	0.196
Left eye	3.00 ± 0.40	3.16 ± 0.39	0.006

Results expressed as mean $\pm$ standard deviation. Comparisons between devices were performed using paired statistical analysis.

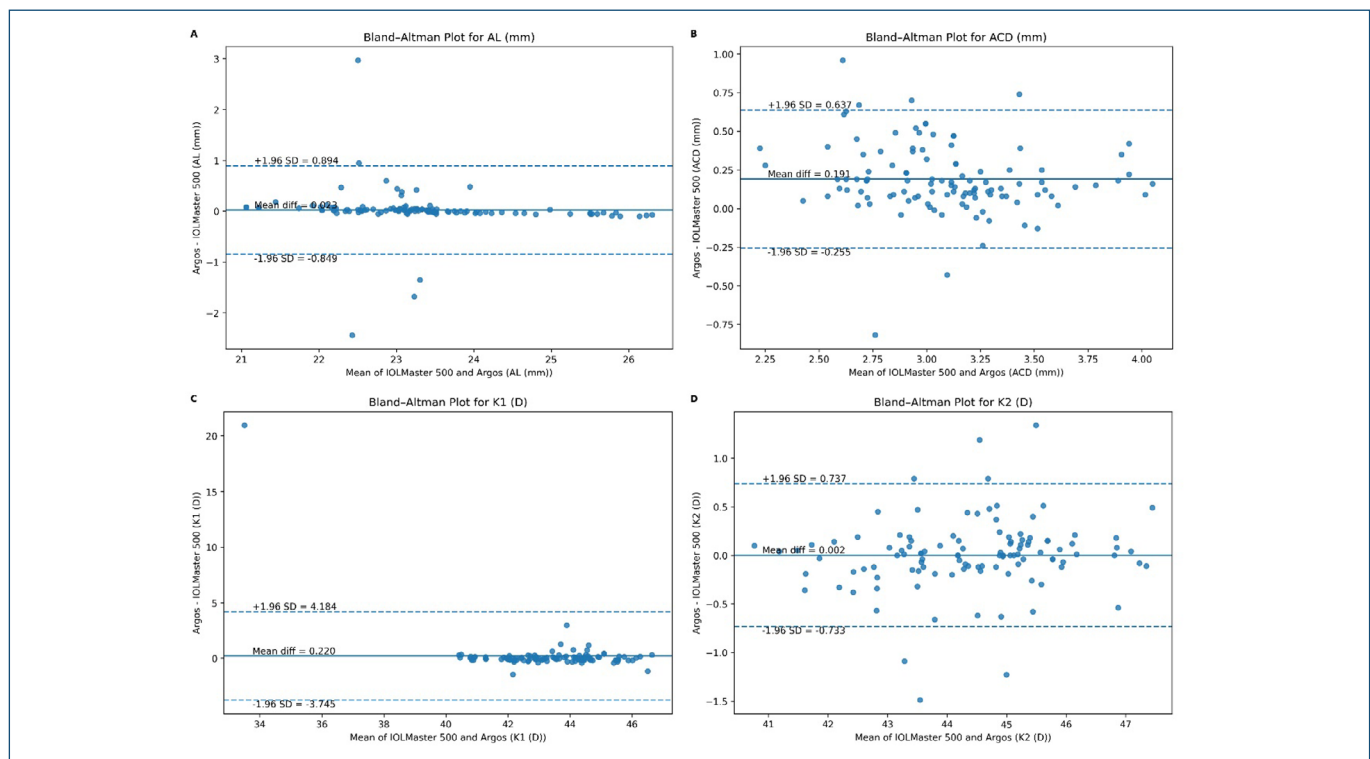
Bland-Altman analysis demonstrated excellent agreement between the devices for AL, K1, and K2, with 95% LoA ranging from -0.849 to 0.894 mm for AL, -3.745 to 4.184 D for K1, and -0.733 to 0.737 D for K2. In contrast, ACD exhibited wider variability, with a mean inter-device difference of 0.191 mm and 95% LoA ranging from -0.255 to 0.637 mm. The corresponding Bland-Altman plots are presented in figure 1A-D.

Regression analysis indicated proportional bias for AL ($p < 0.001$), K2 ($p = 0.022$), and ACD ($p = 0.039$). No proportional bias was observed for K1 ($p = 0.890$), supporting its robust agreement across devices.

DISCUSSION

This study compared biometric measurements obtained with the IOLMaster 500 and Argos devices in patients undergoing cataract surgery evaluation. The results demonstrated excellent agreement for AL and keratometry (K1 and K2), whereas significant differences were observed in ACD. These findings suggest that AL and keratometry measurements may be used interchangeably between the two devices in most clinical settings, while caution is warranted when interpreting ACD values.

The high agreement in AL measurements between the devices is consistent with previous studies comparing optical biometers based on different technologies.^(7-16,21,22) AL remains the most critical variable in IOL power calculations, and even minor discrepancies can affect refractive outcomes. In this study, the mean AL difference between the devices was 0.023 mm, which remained small despite the presence of proportional bias. Similarly, K1 and K2 showed no statistically significant differences between



AL: axial length; ACD: anterior chamber depth; K: keratometry.

Figure 1. Bland-Altman plots comparing IOLMaster 500 and Argos measurements for (A) axial length, (B) anterior chamber depth, (C) flat keratometry, and (D) steep keratometry. The solid line represents the mean difference, and the dashed lines represent the 95% limits of agreement.

devices, reinforcing the reliability of corneal power measurements across both platforms.^(7-14,23,24)

In contrast, ACD showed significant disagreement, with higher values obtained by Argos. This difference should be interpreted as an inter-device measurement discrepancy rather than a discrepancy caused by fundamentally different anatomical definitions of ACD. This methodological discrepancy may have direct clinical implications, particularly in formulas that incorporate ACD as an important predictor of ELP.^(2,13,15,25,26)

No corneal-thickness adjustment was applied in the present study, and ACD values were analyzed as reported by each device. According to estimates, 0.1 mm error in ACD may result in approximately 0.1 to 0.15 D of refractive prediction error, depending on AL and the formula used.⁽²⁷⁾ Thus, the observed mean ACD difference of 0.191 mm could theoretically lead to errors of up to approximately 0.5 D in selected cases. This reinforces the recommendation to use the same device consistently throughout the preoperative workflow whenever ACD is expected to influence IOL selection significantly.

The proportional bias observed for K2 and ACD indicates that the magnitude of disagreement between devices may vary across the measurement range. Although K1 did not show proportional bias, the presence of such

bias in AL, K2, and ACD suggests that agreement should be assessed not only by mean differences but also by evaluating the distribution of differences across the range of measurements.⁽¹⁸⁾ Similar observations have been reported in studies comparing SS-OCT biometers with PCI devices, especially in eyes with longer AL or atypical anterior segment anatomy.^(7-16,28-30)

This study has some limitations. First, its retrospective design may have introduced selection bias. Second, both eyes from the same patient could be included in the analysis, which may reduce strict statistical independence between observations. Third, measurements were performed in a fixed order, with the IOLMaster 500 always preceding Argos, reflecting the routine clinical workflow; therefore, a sequence effect cannot be entirely ruled out. Additionally, only one reliable measurement per device was recorded for each eye, which may limit the assessment of intra-device repeatability. Finally, this was a single-center study, which may limit generalizability to other populations and clinical settings.

Despite these limitations, this study provides relevant information regarding the comparability of two commonly used optical biometers. The findings support the interchangeability of AL and keratometry values between the IOLMaster 500 and the Argos. However, for

ACD, clinicians should be aware of the systematic differences between devices and interpret the results accordingly. These results emphasize the need for caution when transitioning between technologies in routine cataract surgery planning, particularly when formulas sensitive to anterior segment parameters are used.

CONCLUSION

IOLMaster 500 and Argos yield comparable AL and keratometry values, supporting their interchangeable use for these parameters. However, because of significant differences and bias in ACD, this parameter should be interpreted with caution and should not be considered directly interchangeable between devices. These results highlight the importance of consistent biometry protocols in IOL power calculation and support the thoughtful integration of SS-OCT technologies into established preoperative workflows.

AUTHORS' CONTRIBUTION

Nicoli Lopes de Oliveira: conceptualization, data curation, formal analysis, investigation, methodology, writing – original draft. Bernardo Kaplan Moscovici: data analysis, supervision, validation, writing, review and editing. Camyla Lemos Budib: data collection, review, clinical resources. Guilherme Novoa Colombo-Barboza: supervision, clinical validation. Juliana Carolina Contrera: supervision, mentorship, senior guidance (advisor). Marcello Novoa Colombo-Barboza: supervision, mentorship, senior guidance (advisor).

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