Original Article

Comparison of anterior segment measurements using Sirius Topographer® and Nidek Axial Length-Scan® with assessing repeatability in patients with cataracts

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Purpose: The purpose of this study is to evaluate anterior segment measurements obtained using CSO Sirius Topographer® (CSO, Firenze, Italy) and Nidek Axial Length (AL)-Scan® (Nidek CO., Gamagori, Japan). **Methods:** A total of 43 eyes of 43 patients were included in this prospective study. The central corneal thickness (CCT), anterior chamber depth (ACD), white-to-white distance (WTW), flat keratometry (K1), steep keratometry (K2), and mean keratometry (K) values were randomly measured three times with each device by the same examiner. The intraclass correlation coefficient of repeatability was analyzed. The compatibility of both devices was evaluated using the 95% limits of the agreement proposed by Bland and Altman. **Results:** Examiner achieved high repeatability for all parameters on each device except the WTW measured by Sirius. All measurements except WTW and K1 taken with the Sirius were higher than that taken with the Nidek AL-Scan®. The difference in CCT, ACD, and WTW values was statistically significant. **Conclusion:** High repeatability of the measurements was achieved on both devices. Although Km, K1, and K2 measurements of the Sirius and the AL-Scan® showed good agreement, WTW, CCT, and ACD measurements significantly differed between two devices. Thus, anterior segment measurements except for Km, K1, and K2 cannot be used interchangeably between Sirius and Nidek AL-Scan® devices.

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It is important to acquire repeatable measurements of anterior segment parameters, to obtain good vision after cataract surgery. Anterior chamber depth (ACD), keratometry (K), and white-to-white (WTW) are required while calculating some of the intraocular lens (IOL) power formulas.[1-3] These measurements can be obtained by a number of instruments, including manual and automated keratometers, corneal topographers, Scheimpflug cameras, and optical coherence tomography presently.[1] Knowledge of the differences in measurements among instruments is mandatory in clinical practice. Axial Length (AL)-Scan® (Nidek Co., Ltd.,) is an optical biometry device, which measures several variables including the flat keratometry (K1) value (flatter K), the K2 value (steeper K) value, AL, ACD including the K value, AL, ACD, WTW diameter, pupil size, and central corneal thickness (CCT). The Sirius provides measurements of ACD, anterior chamber volume (ACV), CCT, pupil size, corneal volume, and keratometry. The authors are unaware of other papers in the literature, and this seems to be the first study to compare anterior segment parameters measurements obtained from the Nidek AL-Scan® and Sirius Scheimpflug/Placido photography-based topography system in cataract surgery candidates. The purpose of this study was to evaluate the consistency of the repeatability of variables (CCT ACD, WTW, K1, K2, and K) measured using the AL-Scan® optical biometer device and Sirius Scheimpflug/Placido photography-based topography system and compare the results.

Methods

Patients

This prospective observational study enrolled adult patients scheduled for cataract surgery between February 15 and May 15, 2016. A total of 43 eyes of 43 patients (19 men and 24 women) with a mean age of 71.79 ± 7.91 years (range, 56–87 years) were included in this study. All patients received a full ophthalmologic examination, and all eyes involved in the study had clinically significant cataracts. The major criteria for inclusion were cataract and age 40-year-old or older. The exclusion criteria were ocular surface disorders, corneal disease, previous corneal surgery, contact lens wearer, history of ocular trauma and inflammation. This prospective study was approved by the Research Review Board at Yuksek Ihtisas Training and Research Hospital. All patients provided informed consent.

Measurement devices

The AL-Scan® optical biometer (new biometer) Nidek AL-Scan® (Nidek CO., Gamagori, Japan) uses optical low-coherence interferometry and measures K values using double-mire rings

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projected onto the cornea at the 2.4 mm zone and 3.3 mm zone. It uses a light-emitting diode for corneal keratometry readings and WTW assessment. The Scheimpflug imaging technique is applied to CCT and ACD measurements. It measures ACD by measuring the distance between light reflections on the anterior corneal surface and the anterior surface of the lens. The WTW of the patient's eye is measured based on a captured anterior eye segment image.

The CSO Sirius Topographer® (CSO, Firenze, Italy) combines 2 monochromatic 360° rotating Scheimpflug cameras with Placido disc topography and enables 25 radial sections of the cornea and anterior chamber in seconds. This imaging provides measurements of ACD, ACV, Anterior Chamber Angle width, CCT, pupil size, corneal volume, and keratometry. The system acquires keratometry measurements on a 3.0 mm diameter field of the central cornea.[4]

Measurement technique

Measurements were taken by the AL-Scan® and Sirius in a random order. Measurements for both devices were performed according to their respective manufacturer's guidelines. After the first device's measurements were taken, the patients were asked to rest with their eyes before undergoing an examination by the other one 15 min later. Same trained examiner performed all measurements. Three measurements were taken in each eye with both units. between 10 a.m and 5 p.m to eliminate operator-induced error and diurnal variations. Six major parameters (CCT, ACD, WTW, in K, K1, and K2) were recorded.

Statistical analysis

Statistical analyses were performed using SPSS software (version 16; SPSS Inc., Chicago, IL, USA). $P < 0.05$ was considered statistically significant. Distributions of normality of the ocular biometric parameters were checked with the Kolmogorov–Smirnov test ($P > 0.05$).

Interclass correlation coefficients (ICC) were calculated to evaluate the repeatability of anterior segment measurements. Averages of 3 measurements were taken for each parameter and comparisons between the Sirius and AL-Scan® measurements were conducted using one-sample *t*-tests to assess the mean differences in the anterior segment parameters and Bland-Altman plots to assess the degree of agreement between the two methods.

Results

Repeatability

The repeatability results of measured parameters: CCT, ACD, WTW, K, K1, and K2 were compared in cataractous eyes [Table 1]. Examiner achieved high repeatability for all parameters in each group except the WTW measured by Sirius.

Comparison of devices

The plots of the reproducibility differences in the ocular components for both devices were compared in cataractous eyes [Figs. 1 and 2]. The mean difference values, 95% limits of agreement (LoA), and *P* values. All measurements except WTW and K1 took with the Sirius were higher than that taken with the Nidek AL-Scan® [Table 2]. The difference in CCT, WTW, ACD and Km and K2 in 3.3 mm zone values was statistically significant. The smallest range of agreement was in CCT (mean difference: 19.75 ± 8.25, $P = 0.00$), whereas the largest was in K1 in zone 3 (mean difference: −0.013 ± 0.32, $P = 0.782$). The 95% LoA for all measurements except CCT values indicate

Table 1: Repeatability results in cataractous eyes for both devices

	R-1	R-2	R-3	ICC 1-2	ICC 1-3	ICC 2-3
Sirius						
CCT	545.32±41.38	542.82±43.52	544.78±45.26	0.990	0.983	0.986
ACD	3.19±0.42	3.20±0.42	3.21±0.41	0.983	0.986	0.998
WTW	11.36±0.70	11.47±0.91	11.32±0.63	0.496	0.703	0.695
K	44.01±1.88	43.99±1.94	44.00±1.89	0.987	0.990	0.989
K1	43.54±1.96	43.51±1.99	43.53±1.97	0.986	0.988	0.986
K2	44.48±1.91	44.49±1.97	44.49±1.89	0.983	0.986	0.988
AL-Scan						
CCT	523.46±40.58	523.55±40.76	523.88±42.21	0.997	0.996	0.995
ACD	3.15±0.52	3.15±0.51	3.15±0.51	0.998	0.999	0.998
WTW	11.51±0.63	11.51±0.58	11.53±0.59	0.884	0.988	0.910
AL-Scan 2.4						
K	43.85±1.92	43.86±1.86	43.85±1.92	0.998	0.999	0.997
K1	43.47±1.98	43.47±1.94	43.48±1.95	0.996	0.999	0.996
K2	44.27±1.92	44.31±1.85	44.28±1.93	0.997	0.997	0.997
AL-Scan 3.3						
K	43.79±1.90	43.82±1.85	43.83±1.95	0.998	0.997	0.996
K1	43.45±1.96	43.48±1.92	43.45±1.94	0.996	0.998	0.996
K2	44.17±1.90	44.22±1.84	44.20±1.92	0.997	0.998	0.998

R-1: Mean value for the first measurement, R-2: Mean value for the second measurement, R-3: Mean value for the third measurement, ICC 1-2: Interclass correlation coefficients of repeatability (R1-R2), ICC 1-3: Interclass correlation coefficients of repeatability (R1-R3), ICC 2-3: Interclass correlation coefficients of repeatability (R2-R3), K1: Corneal dioptric power in the flattest meridian, K2: Corneal dioptric power in the steepest meridian. CCT: Central corneal thickness, ACD: Anterior chamber depth; WTW: White-to-white distance, AL: Axial Length, ICC: İntraclass correlation coefficient, K: Mean keratometry, K1: Flat keratometry, K2: Steep keratometry

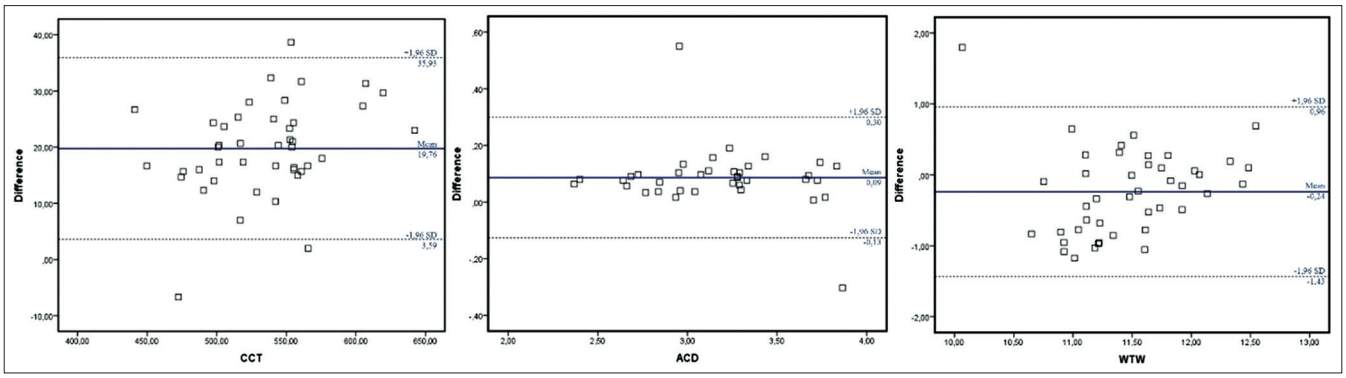

Figure 1: A Bland–Altman plot showing differences in central corneal thickness, anterior chamber depth and white-to-white distance between the Sirius Scheimpflug/Placido photography-based topography system and Axial Length-Scan®. The bold horizontal line shows the mean differences between devices. The dotted lines above and below that line represent the 95% limits of agreement

Table 2: The mean difference, limits of agreement, one-sample *t*-test for these differences, and their significance for difference parameters between Sirius Scheimpflug/Placido photography-based topography system and axial length-scan

Device pairings	Mean difference	95% LoA	*P**
CCT	19.759	17.220-22.299	0.00
ACD	0.086	0.049-0.122	0.00
WTW	−0.238	−0.425-−0.051	0.014
Km 2.4	0.040	−0.030-0.110	0.257
K1 2.4	−0.027	−0.109-0.054	0.502
K2 2.4	0.073	−0.003-0.149	0.061
Km 3.3	0.090	0.011-0.168	0.026
K1 3.3	−0.013	−0.115-0.087	0.782
K2 3.3	0.173	0.100-0.245	0.00

*One-sample *t*-test. CCT: Central corneal thickness, ACD: Anterior chamber depth, K1: Flattest keratometry, K2: Steepest keratometry, Km: Mean keratometry, WTW: White to white, LoA: Limits of agreement

very small discrepancies between measurements. Keratometric values obtained from 2.4 mm to 3.3 mm with Nidek AL-Scan® and the values with Sirius were investigated and compared. However, good agreement was found for all of the parameters in zone 2.4, the keratometry values obtained from 2.4 mm, and Sirius was found to be closer.

Discussion

Anterior segment parameters have been obtained by optical biometry devices since 1999.[5] The IOLMaster (Carl Zeiss Meditec), the Lenstar (Haag-Streit AG), the AL-Scan® (Nidek Co. Ltd.,) the Galilei G6 (Ziemer), and the Aladdin (Topcon EU Visia Imaging) are the optical biometry devices that use different optical methods. Although there were a lot of devices, achieving similar measurement, is important to use the devices interchangeably. To the best of our knowledge, this is the first prospectively designed comparative study of the agreement of the measurement of the anterior segment using both devices in patients with cataracts.

Few studies have evaluated the repeatability of these devices, and the results of the studies have shown that Sirius and Nidek AL-Scan® devices have got a good repeatability of anterior segment measurements in healthy and keratoconus eyes.[6-9] Similar to previous reports, in our study, the measurements obtained with these devices showed high repeatability in cataractous eyes.

The studies which compared Sirius and Nidek AL-Scan® with another device found that these devices have good agreement with each other.[8,9] In a previous study, Huang *et al*. compared the anterior segment measurements using the Sirius and the IOLMaster and found that with the exception of astigmatism axis and WTW, the anterior segment measurements are similar, which means that they show good agreement and may be used interchangeably in patients with cataracts.[1] Yağcı *et al*. evaluated the repeatability and reproducibility of measurements obtained by the new optical biometer (Nidek AL-Scan®) in normal eyes and keratoconus eyes and found high precision of the measurements obtained by the new optical biometer.[9]

There are a lot of methods to measure CCT, but ultrasound pachymetry is the gold standard method. CCT is measured with Nidek AL-Scan® and Sirius by Scheimpflug cameras. The Sirius measures CCT in a central 10-mm area of the cornea, and Nidek AL-Scan® measures CCT in 6-mm areas. The measurements were obtained when a vertical white line along the center of the cornea was visible. There was not a good agreement for CCT in our study. CCT taken with the Sirius was higher than the Nidek AL-Scan® and the difference was statistically significant (mean difference = 19.75, $P = 0.000$). Çağlar *et al*. enrolled 43 healthy volunteers to evaluate the accuracy of Nidek AL-Scan® and Sirius and showed that AL-Scan® tends to measure CCT less than Sirius with the moderate agreement.[10] However, they did not explain this. We attributed this divergence to alignment differences, measurement area, and study population. In this study, we included patients with cataracts, moreover, the age range was also different from that in the previous study (mean age, 71.79 ± 7.91 vs. 24.6 ± 1.64 years).

The axial distance from the anterior surface of the cornea to the anterior surface of the lens is called as ACD. ACD is important when planning the IOL power and refractive surgery. Scheimpflug cameras measure ACD with the noncontact methods and have no need of topical anesthesia and do not indent cornea. In this study, the mean values of ACD measurements were 3.21 ± 0.39.4 mm and 3.10 ± 0.39 mm by the Sirius and the Nidek AL-Scan®, respectively. However,

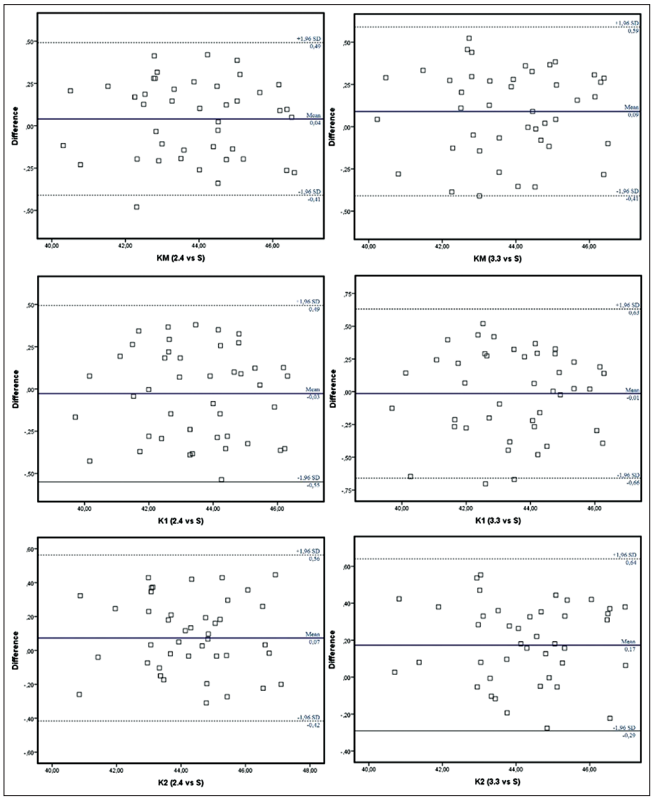

Figure 2: A Bland–Altman plot showing differences in K1, K2, and K2 between the Sirius Scheimpflug/Placido photography-based topography system and Axial Length-Scan® 2.4 mm and 3.3 mm. The bold horizontal line shows the mean differences between devices. The dotted lines above and below that line represent the 95% limits of agreement. Km: mean keratometry, S: Sirius

no good agreement was found for ACD. It was a little bit higher when the ACD was measured with the Sirius, and the difference was statistically significant (mean difference = 0.086, $P = 0.00$). Although the AL-Scan® performs the CCT and ACD measurements using the Scheimpflug principle as Sirius, we attributed this divergence to alignment differences, as the Nidek AL-Scan® measures ACD along the visual axis whereas the Sirius measures ACD along the optical axis, which represents the deepest central ACD. Çağlar *et al*. found AL-Scan® tends to measure ACD greater than Sirius. Huang *et al*. compared ACD measurements taken with Sirius and IOLMaster and found that a little bit higher ACD with the Sirius.[1]

Some of the IOL calculation formulas use WTW, and it is important to calculate the IOL diameter.[11,12] In our study, the mean values of WTW measurements were taken with Sirius and Nidek AL-Scan® and we found a little bit lower WTW with Sirius. Huang *et al*. compared Sirius and IOLaster and found that Sirius measured WTW lower than IOL master.[1] In another study; Çağlar *et al*. found good agreement with Nidek AL-Scan® and Sirius in a healthy population.[10] In our study, there was no good agreement in WTW between Sirius and AL-Scan® (mean difference = −0.23, $P = 0.014$).

The AL-Scan® derives the keratometry values by detecting ring images projected on the patient's cornea with a photodetector and calculating the image. Sirius also employs the Scheimpflug principle. In our study, the corneal power measurements (K, K1, K2) obtained by the Sirius and AL-Scan® showed a high level of agreement in zone 2.4. The K value obtained by the Sirius device was slightly flatter than that produced by the AL-Scan®, but the difference in averages was too small to be clinically relevant. The values which were obtained by Nidek AL-Scan® from 2.4 mm were too closer to the Sirius values. This finding implied that 2.4 mm corneal measurements might be more suitable for calculating the lens power in clinical application. The values obtained from the Sirius device in our study were a little bit different from those in the previous study of Çağlar *et al*., which might be due to several reasons. That study compared the anterior segment parameters in healthy eyes, while we included patients with cataracts and moreover, the age range was also different. Fledelius and Stubgaard showed that corneal curvature tended to increase with age, the discrepancy would be due to the differences in study populations.[13]

Conclusion

A high level of repeatability with excellent ICC was achieved on both of the devices. The Sirius measured a thicker CCT, a deeper ACD, a lower WTW, and a slightly more steep K, K1, and K2. According to the present study findings, only Km, K1, and K2 measurements of the Sirius and the AL-Scan® show good agreement and may be used interchangeably in patients with cataracts. However, WTW, CCT, and ACD measurements cannot be used interchangeably. There is still lack of a gold standard method for analyzing anterior segment parameters. Thus, further studies are needed to standardize anterior segment measurement parameters obtained using CSO Sirius Topographer® (CSO, Firenze, Italy) and Nidek AL-Scan® (Nidek CO., Gamagori, Japan).

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Conflicts of interest

There are no conflicts of interest.

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