OTJHS
Online Turkish Journal of Health Sciences

e-ISSN: 2459-1467

OTSBD
Online Türk Sağlık Bilimleri Dergisi

Online Turkish Journal of Health Sciences 2022;7(2):278-285 *Online Türk Sağlık Bilimleri Dergisi 2022;7(2):278-285*

Aladdin HW2.0 Optik Düşük Koherens İnterferometre ile Oküler Biyometri ve Pupillometrinin Yeniden Üretilebilirliği

Reproducibility of Ocular Biometry and Pupillometry with the Aladdin HW2.0 Optical Low-Coherence Interferometer

[1]Yunus KARABELA, [2]Bulent AYAN

[1] University of Health Sciences, Hamidiye Vocational School of Health Services, Opticianry Program, Uskudar, Istanbul, Turkey
[2] Dunyagoz Hospitals Group, Istanbul, Turkey

Yunus Karabela: https://orcid.org/0000-0002-2267-6656
Bülent Ayan: https://orcid.org/0000-0002-5857-0706

ÖZ

Amaç: Çalışmanın amacı kataraktlı hastalarda ve sağlıklı bireylerde Aladdin HW2.0 (Topcon, Tokyo, Japan) ile oküler biyometri ve pupillometrinin yeniden üretilebilirliğini değerlendirmekti.

Materyal ve Metot: Bu prospektif çalışma sağlıklı bireylerin ve kataraktlı hastaların gözlerinde gerçekleştirildi. Tam bir oftalmolojik muayeneden sonra, iki operator tarafından Aladdin biyometre ile aksiyel uzunluk (AU), ön kamara derinliği (ÖKD), keratometri (K değerleri), limbus-limbus mesafesi (LLM), göz içi lens (GİL) güçleri ve pupillometrik parametreler ölçüldü.

Bulgular: Kataraktlı 40 hastanın 72 gözü, 29 sağlıklı bireyin 57 gözü değerlendirildi. İki grupta da AU, ÖKD, K değerleri, LLM ve GİL güç formülleri yüksek düzeyde yeniden üretilebilirliğe sahipti [sınıf içi korelasyon katsayısı (SKK)>0,900]. Kataraktlı hastalarda AU, sağlıklı bireylerde ÖKD en yüksek yeniden üretilebilirlik gösteren parametreydi. Kataraktlı hastalarda pupillometrinin SKK değerleri 0,900'den daha düşüktü (0,100 ile 0,882 aralığında). Yeniden üretilebilirliği en kötü parametre dinamik pupillometri maksimum çaptı. Sağlıklı gruptan elde edilen fotopik pupil çapı dışındaki pupillometri parametreleri % 95 LoA için oldukça geniş bir aralıkta dağılıyordu.

Sonuç: Aladdin HW2.0 optik düşük koherens interferometre, pupillometri ölçümleri hariç AU, ÖKD, K değerleri, LLM ve IOL güç formülleri için mükemmel operatörler arası yeniden üretilebilirlik gösterdi.

Anahtar Kelimeler: Biyometri, interferometri, optik cihazlar, pupillometri

ABSTRACT

Objective: The purpose of the study was to evaluate the reproducibility of ocular biometry and pupillometry with the Aladdin HW2.0 (Topcon, Tokyo, Japan) in patients with cataracts and healthy subjects.

Materials and Methods: This prospective study was performed in eyes of healthy subjects and patients with cataracts. After a full ophthalmological examination; axial length (AL), anterior chamber depth (ACD), keratometry (K values), white-to-white (WTW), intraocular lens (IOL) powers, and pupillometric parameters were measured with the Aladdin biometer by two operators.

Results: 72 eyes of 40 patients with cataracts and 57 eyes of 29 healthy subjects were evaluated. AL, ACD, K values, WTW and IOL power formulas were highly reproducible [intraclass correlation coefficient (ICC)>0.900] in two groups. AL was the most reproducible parameter in patients with cataracts, ACD in the healthy subjects. The ICC values of pupillometry were lower than 0.900 (range from 0.100 to 0.882) in patients with cataracts. The worst reproducible parameter was the maximum diameter of dynamic pupillometry. Except for the photopic pupil diameter from the healthy group, pupillometry parameters were within a quite wide range for 95% LoA.

Conclusion: The Aladdin HW2.0 optical low coherence interferometer showed excellent inter-operator reproducibility for AL, ACD, K values, WTW and IOL power formulas except for pupillometry measurements.

Keywords: Biometry, interferometry, optical devices, pupillometry

Sorumlu Yazar / Corresponding Author:
Yunus Karabela,
University of Health Sciences, Hamidiye Vocational School of Health Sciences, Mekteb-i Tibbiye-i Sahane (Haydarpasa) Kulliyesi, Opticianry Program, Selimiye Mah. Tibbiye Cad. No: 38, 34668 Uskudar, Istanbul, Turkey.
Tel: +905325770615
E-mail: drykarabela@gmail.com, yunus.karabela@sbu.edu.tr

Yayın Bilgisi / Article Info:
Gönderi Tarihi/ Received: 13/01/2022
Kabul Tarihi/ Accepted: 19/03/2022
Online Yayın Tarihi/ Published: 01/06/2022

Atıf / Cited: Karabela Y and Ayan B. Reproducibility of Ocular Biometry and Pupillometry with the Aladdin HW2.0 Optical Low-Coherence Interferometer. *Online Türk Sağlık Bilimleri Dergisi* 2022;7(2):278-285 doi: 10.26453/otjhs.1057079

INTRODUCTION

Precise biometric measurement is extremely important in ensuring successful outcomes following cataract and refractive surgery.[1] Since the IOLMaster 500 (Carl Zeiss Meditec, Jena, Germany) was first introduced in 1999 and approved by the United States FDA in March of 2000, the technology has undergone continuous evolution and optical biometry devices with different technologies have been produced to measure ocular parameters with the most accuracy.[1-4]

The Aladdin HW2.0 (Topcon, Tokyo, Japan) is an optical low-coherence interferometer (OLCI) with 830 nm super-luminescent diode laser and is combined with Placido disc-based topographer, Zernike corneal wavefront analyser, and pupillometer. This device was released in 2012. The Aladdin HW2.0 can automatically and quickly measure six biometric parameters; axial length (AL), keratometry (K values), topography, anterior chamber depth (ACD), pupillometry, and horizontal white-to-white (WTW) distance. This device is capable of screening the corneal surface for keratoconus probability.[1-7]

There were few studies about the reproducibility and repeatability of the Aladdin HW2.0.[2,4,8-10]

The study aimed to evaluate the inter-operator reproducibility of biometry and pupillometry with the Aladdin HW2.0 biometer in patients with cataracts and healthy subjects.

MATERIALS AND METHODS

Ethical Status: The study was approved by the Ethics Committee of the Istanbul Medipol University (Date: 24.02.2016, decision no: 119). Written informed consent was obtained from the patients and healthy subjects and the study was conducted according to Helsinki and other international declarations.

This prospective study was performed on patients with cataracts and on healthy subjects between February 2016 and April 2017 at Istanbul Medipol University Esenler Hospital, Istanbul, Turkey. All subjects underwent a complete ophthalmologic evaluation, including unaided/aided distant visual acuity, refraction with the Auto Kerato-Refractometer KR-8900 (Topcon, Tokyo, Japan), intraocular pressure, slit-lamp examination, and fundoscopy. The exclusion criteria for both groups were as follows: (1) previous ocular surgery and trauma, (2) ocular abnormalities or diseases, (3) contact lens wearing and (4) presence of systemic diseases such as diabetes mellitus. Apart from these, patients with dense cataracts were not included in this study.

Instrument: The measurement methods of the Aladdin HW2.0 can be summarized as follows: AL is measured by a low-coherence interferometry system with a range of 15-38.00 mm. ACD is measured by the reflection principle of a 473 nm blue light-emitting diode (LED) horizontal slit light projected onto the anterior chamber with a range of 1.50 -5.50 mm.[1,2,5] WTW is calculated by distinguishing the light and shade interface between cornea and sclera and similar to the AL-scan by fitting the best circle with the lowest error square to the detected edge (6.00-18.00 mm). Corneal topography is based on the reflection of 24 Placido disk rings on a 43.00 diopter (D) sphere with a diameter of 8.00 mm. K values are not derived from simulated K, but from automated keratometry which is generated from the reflection of 4 dedicated Placido rings.[1,2,4,5] The Placido-based technology can also convert corneal curvature into power values with the paraxial formula [P = (n-1)/r]. The range of corneal radii is 6.75-9.64 mm (35-50 D).[5,11,12] Pupillometry is performed with LEDs at various wavelengths. The device uses infrared LEDs to dilate the pupil and white LEDs to reproduce photopic light conditions and to constrict the pupil. The pupillometry module allows displaying and analyzing the dynamic and static pupillometry (pupil size range: 0.50-10.00 mm). Decentralization, latency and statistics graphs are also provided.[1,2,5-8] With the intraocular lens (IOL) calculation module, IOL power with the conventional formulas (SRK II, SRK/T, Hoffer Q, Holladay I, Haigis), toric IOL power, multifocal IOL power and post-refractive IOL power with the Camellin-Calossi and Shammas formulas can be calculated.[1,5,6]

Measurements: The subject was asked to place her/his forehead and chin in the appropriate position on the device and look directly at the red target in the center of the 24 Placido rings. To begin with, biometric parameters and then pupillometric parameters were measured. With each click on the machine, automatically 6 AL (average value was used), 1 K value for the flat meridian and 1 K value for the steep meridian, 1 ACD and 1 WTW were obtained. Following each measurement, the device was moved backward and realigned for the next scan. IOL powers were calculated based on Alcon Acrysof SN60WF IOL (Alcon Inc.) to reach emmetropia within±0.25 D. Then, a complete pupillometry scanning [dynamic and static (mesopic and photopic)] was performed. For the pupillometry, the blue rectangle in the image was first centered on the reflection of the four LEDs. All measurements were repeated at least 15 minutes later by another experienced operator under similar conditions. Both operators executed at least two valid scans for the biometry and one scan for pupillometry.

Statistical Analysis: All analyses were performed with SPSS Statistical Software Version 24.0 for Windows (IBM Corp., Armonk, New York, USA).

The results were expressed as the mean ±standard deviation (SD). The Kolmogorov-Smirnov test was used to assess the normality of the data distribution. Differences between the measurements of the two operators were evaluated with the Paired Samples t-test or Wilcoxon signed-rank test, and the inter-operator reproducibility was evaluated with the Bland-Altman plots. The 95% limits of agreement (LoA) were calculated by the mean difference±1.96xSD. The intraclass correlation coefficient (ICC) was used to evaluate the consistency of measurements by each operator.[13] A p-value < 0.05 was considered statistically significant.

RESULTS

The cataract group consisted of 72 eyes (36 right and 36 left) of 40 patients (20 men+20 women) with a mean age of 64.23±10.07 (35-84) years and the healthy group consisted of 57 eyes (29 right+28 left) of 29 healthy subjects (12 men+17 women) with a mean age of 50.21±6.52 (30-63) years. Measurement parameters obtained by two operators in the cataract and healthy groups with the Aladdin are shown in Table 1.

No statistically significant difference was found between the two operators' measurements (p values>0.05) except for K1 and ACD (p=0.037 and p=0.022, respectively) in the cataract group as seen in Table 2.

The inter-operator reproducibility of the parameters was excellent (ICC values>0.900) except for pupillometry. Bland Altman plots showed narrower 95% LoA for AL (0.096 mm) and ACD (0.12 mm) compared to K1 (0.25 mm), K2 (0.44 mm) and WTW (0.57 mm); for SRK II (0.60 D), SRK/T (0.72 D), Holliday I (0.77 D), Hoffer (0.81 D) compared to

Table 1. Measurement parameters with the Aladdin in the cataract and healthy groups.

		The Cataract Group			The Healthy Group		
Parameter	**Operator**	**Mean±SD**	**Min**	**Max**	**Mean±SD**	**Min**	**Max**
AL (mm)	1	23.16±0.95	21.29	26.89	23.32±0.92	21.53	25.49
	2	23.17±0.95	21.29	26.89	23.31±0.92	21.51	25.47
ACD (mm)	1	2.98±0.33	1.73	3.60	3.22±0.36	2.49	3.94
	2	2.97±0.33	1.69	3.54	3.22±0.36	2.51	3.94
K1 (mm)	1	7.77±0.27	7.19	8.32	7.91±0.29	7.23	8.78
	2	7.78±0.27	7.17	8.36	7.90±0.30	7.23	8.82
K2 (mm)	1	7.64±0.28	7.02	8.24	7.80±0.32	7.14	8.84
	2	7.66±0.29	7.10	8.25	7.79±0.32	7.12	8.74
WTW (mm)	1	11.58±0.41	10.62	12.47	11.84±0.38	10.89	12.44
	2	11.57±0.41	10.69	12.45	11.81±0.42	10.78	12.54
SRK II (D)	1	21.84±2.03	12.52	27.94	22.11±1.88	17.92	27.28
	2	21.85±2.02	12.55	27.94	22.10±1.87	17.98	26.95
SRK/T (D)	1	22.06±2.31	11.41	29.00	22.40±2.24	17.67	28.64
	2	22.09±2.36	11.18	29.00	22.40±2.25	17.75	28.49
Holladay I (D)	1	22.18±2.45	10.72	29.62	22.64±2.35	17.69	29.43
	2	22.20±2.47	10.77	29.61	22.64±2.35	17.76	29.27
Hoffer Q (D)	1	22.27±2.52	10.77	30.14	22.80±2.49	17.45	30.11
	2	22.30±2.56	10.82	30.14	22.79±2.50	17.53	29.94
Haigis (D)	1	22.22±2.45	11.32	30.07	22.91±2.43	17.88	30.81
	2	22.24±2.46	11.36	30.06	22.89±2.43	17.95	30.62
Dyn PG min dia (mm)	1	1.64±0.92	0.13	3.60	2.52±0.76	0.70	3.96
	2	1.64±0.89	0.06	3.90	2.39±0.92	0.08	3.90
Dyn PG max dia (mm)	1	5.00±1.61	2.69	11.93	5.16±0.78	3.67	7.30
	2	5.00±1.59	2.63	12.61	5.23±1.20	3.58	9.94
St PG mesopic dia (mm)	1	3.37±1.17	1.11	5.94	4.55±0.63	3.18	5.94
	2	3.31±1.16	0.82	5.69	4.33±0.65	3.18	5.88
St PG photopic dia (mm)	1	3.10±0.54	1.38	4.32	3.37±0.47	2.46	4.66
	2	3.03±0.51	1.13	4.20	3.32±0.43	2.46	4.44

SD: Standart deviation; Min: Minimum; Max: Maximum, AL: Axial length; ACD: Anterior chamber depth; K1: Flattest K; K2: Steepest K; WTW: White to white; Dyn: Dynamic; PG: Pupillography; dia: diameter; St: Static

Haigis (0.99 D); for dynamic pupil minimum diameter (2.83 mm), mesopic diameter (2.11 mm) and photopic diameter (2.28 mm) compared to dynamic pupil maximum diameter (7.53 mm). Bland–Altman plots of the differences in all biometric and pupillometric parameters in the cataract and healthy groups are shown in Figure 1.

In the healthy group, no statistically significant difference was found between the two operators' measurements (p>0.05) except for K2 and mesopic diameter (p=0.008 and p=0.000, respectively). The inter-operator reproducibility of the parameters in the healthy group is shown in Table 3 and Figure 1.

The inter-operator reproducibility for the parameters was excellent except for the dynamic pupillometry in the healthy group. Bland Altman plots showed narrower 95% LoA for the ACD (0.11 mm), K1 (0.13 mm) and K2 (0.13 mm) compared to AL (0.39 mm) and WTW (0.51 mm); for SRK II formula (1.06 D) compared to SRK/T (1.44 D), Holladay I (1.44 D), Hoffer (1,56 D), and Haigis (1.53 D) formulas; for mesopic diameter (1,35 mm) and photopic diameter (0.94 mm) compared to dynamic pupil min/max diameters (3,29 mm, 3,99 mm, respectively). These results are shown in Table 3 and Figure 1.

Neither in the cataract group nor the healthy group, there was a statistically significant difference between the IOL powers calculated with different power formulas between the two operators. The inter-operator reproducibility of IOL power formulas in both groups was excellent as seen in Table 2 and Table 3. The 95% LoA of AL, IOL power calculation formulas, and dynamic pupillometry min diameter were found wider in the healthy group than in

Table 2. MD, 95% LoA, and ICC for differences between two operators in cataracts.

			95% LoA		ICC (95% CI)		
Parameters	**MD±SD**	**p**	**Lower**	**Upper**	**ICC**	**Lower**	**Upper**
AL (mm)	-0.004±0.024	0.363	-0.052	0.044	1.000	1.000	1.000
ACD (mm)	0.008±0.031	0.022	-0.052	0.068	0.998	0.997	0.999
K1 (mm)	-0.016±0.065	0.037	-0.144	0.111	0.986	0.977	0.991
K2 (mm)	-0.146±0.113	0.055	-0.367	0.075	0.976	0.961	0.981
WTW (mm)	0.003±0.145	0.872	-0.282	0.288	0.967	0.947	0.979
SRK II (D)	-0.012±0.152	0.297	-0.311	0.286	0.999	0.998	0.999
SRK/T (D)	-0.031±0.185	0.084	-0.393	0.331	0.998	0.997	0.999
HOLLADAY I (D)	-0.024±0.196	0.409	-0.409	0.360	0.998	0.997	0.999
HOFFER Q (D)	-0.029±0.208	0.281	-0.436	0.378	0.998	0.997	0.999
HAIGIS (D)	-0.027±0.252	0.557	-0.522	0.467	0.997	0.996	0.998
Dyn PG min dia (mm)	-0.001±0.722	0.739	-1.416	1.415	0.812	0.699	0.882
Dyn PG max dia (mm)	0.002±1.922	0.900	-3.765	3.769	0.437	0.100	0.648
St PG mesopic dia (mm)	0.064±0.538	0.234	-0.991	1.118	0.753	0.605	0.845
St PG photopic dia (mm)	0.070±0.583	0.719	-1.072	1.212	0.554	0.288	0.720

MD: Mean difference; SD: Standart deviation; LoA: Limits of agreement; CI: Confidence interval; ICC: Intraclass correlation coefficient; AL: Axial length; ACD: Anterior chamber depth; K1: Flattest K; K2: Steepest K; WTW: White to white; min: minimum; max: maximum; Dyn: Dynamic; PG: Pupillography; dia: diameter; St: Static.

Table 3. MD, 95% LoA, and ICC for differences between two operators in the healthy group.

			95% LoA		ICC (95% CI)		
Parameter	**MD±SD**	**p**	**Lower**	**Upper**	**ICC**	**Lower**	**Upper**
AL (mm)	0.014±0.099	0.302	-0.181	0.208	0.997	0.995	0.998
ACD (mm)	-0.005±0.028	0.222	-0.059	0.050	0.998	0.997	0.999
K1 (mm)	0.002±0.032	0.622	-0.061	0.065	0.997	0.995	0.998
K2 (mm)	0.011±0.031	0.008	-0.050	0.072	0.998	0.996	0.999
WTWC (mm)	0.027±0.130	0.122	-0.227	0.281	0.973	0.954	0.984
SRK II (D)	0.012±0.272	0.749	-0.521	0.544	0.995	0.991	0.997
SRK/T (D)	-0.001±0.367	0.989	-0.720	0.719	0.993	0.989	0.996
HOLLADAY I (D)	0.007±0.367	0.891	-0.713	0.727	0.994	0.990	0.960
HOFFER Q (D)	0.011±0.399	0.843	-0.771	0.792	0.994	0.989	0.996
HAİGİS (D)	0.020±0.390	0.698	-0.745	0.785	0.994	0.989	0.996
Dyn PG min dia (mm)	0.128±0.839	0.254	-1.517	1.773	0.671	0.442	0.806
Dyn PG max dia (mm)	-0.069±1.019	0.613	-2.065	1.928	0.660	0.424	0.800
St PG mesopic dia (mm)	0.227±0.345	0.000	-0.449	0.903	0.922	0.868	0.954
St PG photopic dia (mm)	0.043±0.239	0.182	-0.426	0.512	0.926	0.874	0.956

MD: Mean difference; SD: Standart deviation; LoA: Limits of agreement; CI: Confidence interval; ICC: Intraclass correlation coefficient; AL: Axial length; ACD: Anterior chamber depth; K1: Flattest K; K2: Steepest K; WTW: White to white; min: minimum; max: maximum; Dyn: Dynamic; PG: Pupillography; dia: diameter; St: Static.

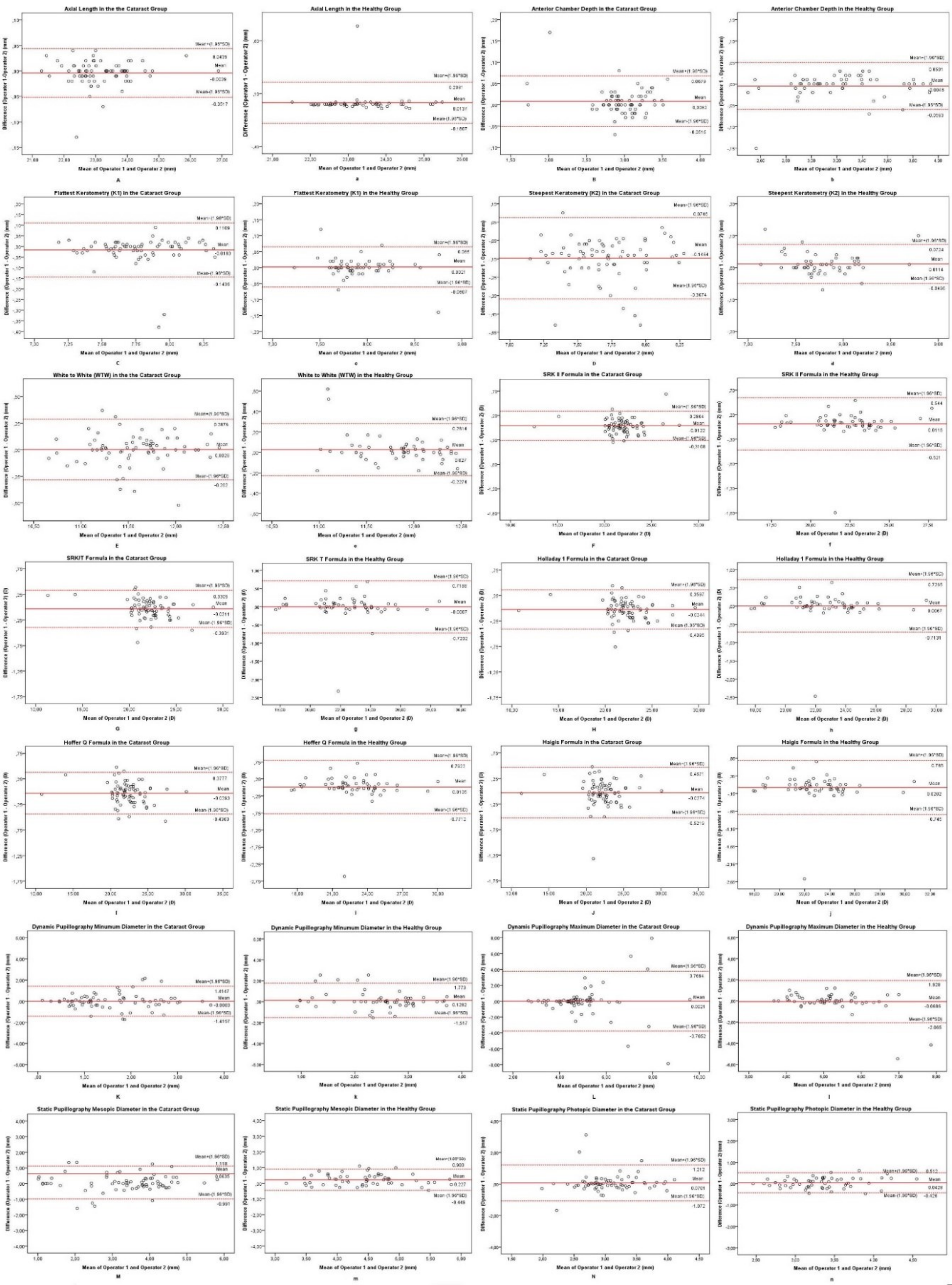

Figure 1. Bland–Altman plots of the differences in all parameters between two operators in the cataract and healthy groups. Dashed lines in Bland–Altman plot indicate the mean difference±1.96xSD, whereas the solid horizontal red line indicates the mean value of the differences.

the cataract group (Figure 1). The 95 % LoA of K1, K2, dynamic pupillometry max diameter, static pupillometry mesopic diameter, and photopic diameter were narrower in the healthy group than the in cataract group. ACD and WTW were almost the same in both groups (Figure 1).

DISCUSSION AND CONCLUSION

Optical biometry devices are used to meet the needs and solve the problems of modern cataract and refractive surgery with their superior features and advantages.[1-4] In the present study, the Aladdin HW2.0 optical biometer, the first version of the Aladdin series, was used. The Aladdin HW2.0 is an optical biometer based on OLCI, a Placido-disc ring topographer, a Zernike corneal wavefront analyser, and a pupillometer.[1-5]

Repeatability and reproducibility are the two important components of precision in a measurement system. While repeatability is defined as the variation in measurements taken by a single instrument or person under the same conditions, reproducibility is defined as whether an entire study or experiment can be reproduced under different conditions (different operators, laboratories and/or after different time intervals).[14]

Similar and compatible results were reported in previous studies between the Aladdin HW2.0 and the US biometer,[6] the IOLMaster 500 (Carl Zeiss Meditec, Jena, Germany),[2,4,9,15-19] the IOLMaster 700 (Carl Zeiss Meditec, Jena, Germany),[7] OA-2000 (Tomey, Nagoya, Japan),[18] the Lenstar LS 900 (Haag-Streit, Koeniz, Switzerland)[8,19] and the Sirius (Costruzione Strumenti Oftalmici, Florence, Italy),[20] The study by Mandal et al.[4] was the first study to evaluate the reproducibility of AL, ACD and K readings with the Aladdin. The study by Huang et al.[2] was the first study to evaluate the intra-operator repeatability of AL, ACD, K readings, and WTW with the Aladdin. In both studies mentioned, only one IOL power formula (SRK/T) was calculated. In our study, the mean age of the healthy subjects was 50.21±6.52 (30-63) years and the mean age of cataracts was 64.23±10.07 (35-84) years. The healthy group was slightly younger than the patients with cataracts but older than the healthy groups of Huang et al.[2] and Mandal et al.[4]

The accurate measurement of WTW is important to estimate the horizontal diameter of the anterior chamber and to select accurate IOL size based on WTW value for anterior chamber intraocular lens implantation and sulcus fixated posterior chamber intraocular implantation and to reduce their perioperative and/or postoperative complications.[2,5] Huang et al.[2] reported that the mean WTW was 11.61±0.42 and 11.63±0.42 (operator 1 and 2, respectively) in the healthy group and 11.28±0.52 and 11.24±0.60 (operator 1 and 2, respectively) in the cataract group with the Aladdin HW2.0 biometer. The mean WTW was found as 11.84±0.38 mm and 11.81±0.42 mm (operator 1 and 2, respectively) for the healthy and 11.58±0.41 mm and 11.57±0.41 mm (operator 1 and 2) for the cataract groups in our study. There is no statistical difference between the measurements (p values>0.005). In a study conducted by Garza-Leon et al.[7] in myopic patients who underwent clear lensectomy, the mean WTW was found 12.03±0.36 mm with the Aladdin HW2.0 and 12.32±0.40 mm with the IOLMaster 700.

In a prospective study of 75 patients with cataracts (mean age 74.9±8.5 years) and 22 healthy subjects (mean age 36.6±13.3 years) conducted by Mandal et al.,[4] the average AL was found as 23.65±1.36 mm, the average ACD was 3.28±0.47 mm, and the average keratometry was as 43.80±1.47 D with the Aladdin biometer. They reported that the Aladdin produced high reproducible results similar to the IOLMaster 500. Garza-Leon et al.[7] compared ocular biometric measurements performed with the IOLMaster 700 and the Aladdin HW2.0 and they found that IOLMaster 700 correlated well with the Aladdin HW2.0; although a statistical difference was found in KM, Ks and WTW. In a study by Ortiz et al.,[19] only AL, mean K, and ACD in 231 eyes were assessed and they reported no clinically significant difference between Aladdin and Lenstar LS 900. In another study conducted by McAlinden et al.,[8] high levels of repeatability and agreement were found between the Aladdin and Lenstar. The results from other past studies showed that the Aladdin HW2.0 had high predictability and a capacity to produce accurate results.[6,8-10,15-18] In our study, the inter-operator reproducibility of AL, ACD, K readings, WTW and IOL power formulas was excellent in both groups. No statistically significant difference was found between the two operators' measurements, except for ACD and K1 in the cataract group (Table 2) and K2 and mesopic diameter in the healthy group (Table 3). In a similar study,[2] no statistically significant difference between the 2 operators' measurements (AL, ACD, K values, WTW) was found in the cataract and healthy groups.

Accurate determination of pupil diameter is an important clinical variable in corneal refractive surgery, post-refractive IOL surgery, and premium IOLs' surgery.[5,21-23] Pupillary measurement methods have varied from direct observation using rulers, photographic techniques, and electronic pupillographs, to computerized pupillometry.[24] Nowadays, pupillometry function has been incorporated in most anterior segment diagnostic technologies. Theoretically, the main goal of these devices is to provide the ability to perform automatic, multiple, repeatable, and reproducible pupillary measurements statically and dynamically under different lighting conditions.[21-25] However, studies to address the precision and agreement on the pupillary function under static and dynamic conditions among these technologies were not verified.[21,23] Our study differed from the past studies by evaluating the reproducibility of pupillometry parameters. To our knowledge, no study has analysed the inter-operator reproducibility of pupillometry with Aladdin HW2.0 in patients with cataracts and healthy subjects. In this study, the reproducibility of pupillometry was poor, especially in the cataract group. ICC values for all ocular pupillometry parameters were considerably lower than 0.900 and the ranges were quite wide. The maximum difference between the upper and lower values in %95 LoA was 2.83 mm for dynamic pupil min diameter, 7.53 mm for dynamic pupil max diameter, 2.11 mm for mesopic diameter and 2.28 mm for photopic diameter. (Table 2, Figure 1). In the healthy group, the ICC values for dynamic pupil min and max diameters were lower than 0.900 and the ranges were quite wide. However, the ICC values for static pupillometry parameters were higher than 0.900, but the ranges were slightly wide. The maximum difference between the upper and lower values in %95LoA was 3.29 mm for dynamic pupil min diameter, 3.99 mm for dynamic pupil max diameter, 1.35 mm for mesopic diameter and 0.938 mm for photopic diameter (Table 3, Figure 1). According to our study, the dynamic pupil max diameter was the parameter with the worst reproducibility. In a study by Ceran et al.,[20] a poor agreement was reported between the Aladdin and Sirius in terms of pupillometric measurements (photopic and mesopic diameters). The mean pupil diameters of the two parameters were similar to those in the healthy group of our study. However, the inter-operator reproducibility of measurements was not studied in that study. In another study by Kanchez et al., a significant difference in pupil diameter measurements between Lenstar LS-900 and Nidek ARK-1 (Nidek Co. Ltd., Aichi, Japan) was found.[21] According to Md-Muziman-Syah et al.,[23] Hartmann-Shack aberrometer demonstrated higher repeatability and reproducibility than Placido-disc topographer in mesopic pupillometry. Studies show that pupil dynamics remains a challenge in standardizing measurement methods for different light conditions and different populations.

In the present study, although AL for the cataract group and ACD for the healthy group were the best reproducible parameters, the reproducibility of all biometry parameters was almost the same. Similar to our study, Huang et al.[2] reported that the best reproducible parameter was the AL in the cataract and healthy groups. In that study, the Bland-Altman plot showed good agreement between the two operators for biometric parameters, except that the WTW in patients with cataracts. The WTW had wider 95% LoA (-0.88 to 0.95) and ICC of reproducibility was 0.653 (0.449 to 0.792). According to Mandal et al.,[4] the inter-operator reproducibility of AL and ACD was excellent and healthy subjects had a slightly narrower 95% LoA compared to patients with cataracts.

This study has some limitations: First, intra-operator repeatability was not studied. Second, no comparison with another optical biometer or pupillometer was done.

In conclusion, the study showed that the inter-operator reproducibility of biometric parameters in eyes with cataracts was excellent with the Aladdin HW2.0. However, the reproducibility of pupillometry parameters was quite poor. The two pupillometric parameters with the worst reproducibility were dynamic pupil max diameter and static pupil photopic diameter in patients with cataracts. Further studies, including pupillometry, are needed to evaluate the performance of the Aladdin optical biometer.

Ethics Committee Approval: Our study was approved by the Istanbul Medipol University Ethics Committee (Date: 24.02.2016, decision no: 119). The study was carried out by Helsinki and other international declarations. Written informed consent was obtained from all subjects.

Conflict of Interest: No conflict of interest was declared by the authors.

Author Contributions: Concept – YK, BA; Supervision – YK; Materials – YK, BA; Data Collection and/or Processing – YK; Analysis and/or Interpretation – YK, BA; Writing –YK, BA.

Peer-review: Externally peer-reviewed.

Other Information: The study was previously presented as a poster (abstract presentation) at the Turkish Ophthalmology Association-15th March Symposium, March 16-18, 2018, in Adana, Turkey.

REFERENCES

1. Turczynowska M, Koźlik-Nowakowska K, Gaca-Wysocka M, Grzybowski A. Effective ocular biometry and intraocular lens power calculation. Eur Ophthalmic Rev. 2016;10(2):94–100. doi:10.17925/EOR.2016.10.02.94
2. Huang J, Savini G, Wu F, et al. Repeatability and reproducibility of ocular biometry using a new noncontact optical low-coherence interferometer. J Cataract and Refract Surg. 2015;41(10):2233-2241. doi:10.1016/j.jcrs.2015.10.062
3. Savini G, Hoffer KJ, Barboni P, et al. Correction: Accuracy of optical biometry combined with placido disc corneal topography for intraocular lens power calculation. PLoS One. 2017;12 (3):e0175145. doi:10.1371/journal.pone.0175145

4. Mandal P, Berrow EJ, Naroo SA, et al. Validity and repeatability of the Aladdin ocular biometer. B J Ophthalmol. 2014;98(2):256-258. doi:10.1136/bjophthalmol-2013-304002
5. Optical biometry & topography system Aladdin series. Available at:http://www.topcon.com.hr/pdf/topcon-aladdin-brochure-EN.pdf. Accessed October 2, 2015.
6. Kaya F, Kocak I, Aydin A, Baybora H, Karabela Y. Comparison of different formulas for intraocular lens power calculation using a new optical biometer. J Fr Ophthalmol. 2015;38(8):717-722. doi:10.1016/j.jfo.2015.03.006
7. Garza-Leon M, Fuentes-de la Fuente HA, García-Treviño AV. Comparison of ocular biometry using the new SC-OCT-based optical biometer and OLCI in patients with clear lens. Vis. Pan-Am. 2016;15(3):75-79.
8. McAlinden C, Gao R, Yu A, et al. Repeatability and agreement of ocular biometry measurements: Aladdin versus Lenstar. B J Ophthalmol. 2017;101(9):1223-1229. doi:10.1136/bjophthalmol-2016-309365
9. Hoffer KJ, Shammas HJ, Savini G, Huang J. Multicenter study of optical low-coherence interferometry and partial-coherence interferometry optical biometers with patients from the United States and China. J Cataract Refract Surg. 2016;42(1):62-67. doi:10.1016/j.jcrs.2015.07.041
10. Sabatino F, Findl O, Maurino V. Comparative analysis of optical biometers. J Cataract Refract Surg. 2016;42(5):685-693. doi:10.1016/j.jcrs.2016.01.051
11. Tang M, Chen A, Li Y, Huang D. Corneal power measurement with Fourier-domain optical coherence tomography. J Cataract Refract Surg. 2010;36(12):2115-2122. doi:10.1016/j.jcrs.2010.07.018
12. Dharwadkar S, Nayak B K. Corneal topography and tomography. J Clin Ophthalmol Res. 2015;3(1):45-62. doi:10.4103/2320-3897.149379
13. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet. 1986;327(8476):307–310. doi:10.1016/S0140-6736(86)90837-8
14. Currie LA. and Svehla G. Nomenclature for the presentation of results of chemical analysis (IUPAC Recommendations 1994). Pure Appl. Chem. 1994;66:595-608. doi:10.1351/pac199466030595
15. Milka M, Wylegala E, Nowinska A, Janiszewska D, Weglarz B. Comparison of the biometric measurements obtained using IOL Master and ALADDIN systems. Acta Ophthalmol. 2013;91:S252. doi:10.1111/j.1755-3768.2013.4451.x
16. Sorkin N, Rosenblatt A, Barequet IS. Predictability of biometry in patients undergoing cataract surgery. Optom Vis Sci. 2016;93(12):1545-1551. doi:10.1097/OPX.0000000000000990
17. Huang Y, Tang X, Deng J. Comparison of biometric measurements of ALADDIN versus IOL Master 500 in cataract patients. J Clin Ophthalmol. 2015;23:21-23.
18. McAlinden C, Wang Q, Gao R, et al. Axial length measurement failure rates with biometers using swept-source optical coherence tomography compared to partial-coherence interferometry and optical low-coherence interferometry. Am J Ophthalmol. 2017;173:64-69. doi:10.1016/j.ajo.2016.09.019
19. Ortiz A, Galvis V, Tello A, et al. Comparison of three optical biometers: IOLMaster 500, Lenstar LS 900 and Aladdin. Int Ophthalmol. 2019;39(8):1809-1818. doi:10.1007/s10792-018-1006-z
20. Ceran BB, Hashas Karatepe AS, Tasindi E. Can we use anterior segment parameters of an optical biometer and a combined topography system interchangeably? Glo-Kat. 2020;15(1)):38-44. doi:10.37844/glauc.cat.2020.15.8
21. Kanclerz P, Przewłócka K, Wang X. Inter-device measurement variability of vital data parameters for keratorefractive and cataract refractive surgery. Ther Adv Ophthalmol. 2021;13. doi:10.1177/25158414211045750
22. Rosen E. The Pupil and refractive surgery. In: Kohnen T, Koch DD, eds. Cataract and refractive surgery. Essentials in Ophthalmology. Springer, Berlin, Heidelberg. 2005;289-302. doi:10.1007/3-540-26678-X_18
23. Md-Muziman-Syah MM, Suhaimi MA, Sulaiman UH, et al. Mesopic pupillometry in pre-LASIK patients by a Placido-disc topographer and Hartmann-shack aberrometer. Mal J Med Health Sci. 2021;17(2):197-202.
24. Espinosa J, Roig AB, Pérez J, Mas D. A high-resolution binocular video-oculography system: assessment of pupillary light reflex and detection of an early incomplete blink and an upward eye movement. Biomed Eng Online. 2015;14(1):1-12. doi:10.1186/s12938-015-0016-6
25. Kiziltoprak H, Tekin K, Yetkin E, Sekeroglu MA. Static and dynamic pupil characteristics in myopic anisometropic amblyopia. Beyoglu Eye J. 2020;5(2):86-92. doi:10.14744/bej.2020.08760