

Comparison of intraocular lens power calculation using a standard ultrasonic biometer and a new optical biometer

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比较标准超声波测量仪和新型光学生物测量仪计算人工晶状体屈光度的准确性

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摘要

目的: 比较超乳手术时应用新型光学生物测量仪和标准超声波测量仪计算人工晶状体的屈光度及屈光结果。

方法: 前瞻性研究。研究包含 37 例 37 眼白内障患者接受白内障超声乳化联合人工晶状体植入术。同一测量人员分别使用新型光学生物测量仪(Aladdin)与标准超声波测量仪(Sonomed AB 5500)对白内障患者进行检测。通过这两种设备记录生物测定参数,包括眼轴长度、角膜曲率、前房深度及人工晶状体屈光度数。分析术后实际屈光不正与两台设备根据 SRK/T 公式计算的误差,比较两台设备检查结果的平均估计误差(EE)、平均绝对估计误差(AEE)及生物测定参数。

结果: Aladdin 测量仪(23.45 ± 0.73 mm)较超声波测量仪(23.2 ± 0.75 mm)检测出的眼轴显著较长($P = 0.01$)。Aladdin 测量仪的 EE 与 AEE 均明显小于超声波测量仪($P = 0.0006$ 与 0.03)。应用 Aladdin 测量的大多数眼与目标屈光度相差在 ± 0.5 (67%)及 ± 1.00 (97%)以内。

结论: Aladdin 光学生物测量仪较超声波测量仪更精确, 屈光结果更准确。

关键词: Aladdin 光学生物测量仪; 超声波测量仪; 眼轴长; 人工晶状体屈光度数; 术后屈光不正

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Abstract

• AIM: To compare the intraocular lens (IOL) power calculations and refractive outcomes obtained with a new optical biometer and standard ultrasonic biometer in phacoemulsification surgery.

• METHODS: Thirty – seven eyes of 37 cataract patients who underwent phacoemulsification with IOL implantation were included in this prospective comparative study. The same operator performed biometer measurements in eyes with cataract using a new optical biometer (Aladdin) and a standard ultrasonic biometer (Sonomed AB 5500). Biometric parameters; axial length (AL), keratometric (K) readings, anterior chamber depth (ACD) and IOL power obtained by two devices were recorded. Postoperative actual refractive errors and errors predicted by two devices according to SRK/T formula were analyzed. The mean estimation error (EE), mean absolute estimation error (AEE) and the biometric parameters obtained by two biometers were compared.

• RESULTS: The AL measured by Aladdin (23.45 ± 0.73 mm) was significantly longer than AL by ultrasonic biometer (23.2 ± 0.75 mm) ($P=0.01$). The mean EE and AEE values obtained by Aladdin were significantly smaller than the values by ultrasonic biometer ($P = 0.0006$ and 0.03 respectively). The higher percentage of eyes within ± 0.5 and ± 1.00 D of target refraction was also found by using Aladdin (67% and 97%).

• CONCLUSION: The Aladdin optical biometer showed better accuracy and yielded better refractive outcomes compared with ultrasonic biometer.

• KEYWORDS: Aladdin optical biometer; ultrasonic biometer; axial length; intraocular lens power calculation; postoperative refractive error

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INTRODUCTION

Correct intraocular lens power calculation is important in cataract surgery for successful postoperative refractive outcomes. In cataract surgery ocular biometer is essential for intraocular lens (IOL) power calculation. Chosen IOL formula defines the result of IOL power. For ultrasonic biometers, most of IOL formulas require keratometer (K) values, and axial length (AL)^[1-2]. AL measurement is important for predicting the accuracy of the IOL calculation and it is source of the largest proportion of inaccurate measurements. Immersion A – scan technique is presumably more accurate than contact A – scan ultrasonography as it needs no indentation of the cornea^[3].

Optical biometer devices can measure some other variables. They are fast, non invasive and independent from technician experience. The built in software in these devices gives us more accurate IOL power calculation and multiple choices of IOL formulas^[4-5]. Several new optical biometers can also perform ocular biometry and IOL power calculation as accurate as the first standard optical biometer such as IOL Master (Carl Zeiss Meditec AG, Jena, Germany)^[6]. The Aladdin (Topcon, Tokyo, Japan) is one of the most recently released optical biometer. The device is an optical low coherence interferometer (OLCI) which can measure six variables; K value, AL, anterior chamber depth (ACD), white to white (WTW) diameter, pupil size, corneal topography. AL is measured using OLCI with 820 nm super-luminescent diode. ACD is measured using light emitting diode (LED) making horizontal slit projections across the anterior chamber, similarly to the IOL Master. Corneal topography and keratometer measurements are based on 24 Placido disk reflection^[7]. The IOL power is calculated by five different formulas built into the device.

The purpose of this study is to evaluate and compare the difference of variables K value, AL, ACD and IOL power measured using ultrasonic biometer and optical biometer.

SUBJECTS AND METHODS

Subjects enrolled in this prospective comparative study were patients with cataract who were candidates for phacoemulsification with IOL implantation surgery at Ophthalmology Department of Nisa Hospital, Istanbul, Turkey between Nov. 17th and Dec. 29th, 2014. The study project was approved by Institutional Ethical Board of Istanbul Medipol University. All research and data collection adhered to the tenets of the Declaration of Helsinki. The study was explained to each patient and written informed consent was obtained.

Preoperatively all patients had a complete examination including manifest refraction, best – corrected visual acuity (BCVA) testing, intraocular pressure (IOP) measurements with applanation tonometer, slit lamp, and dilated fundus examinations. Ocular biometer was first performed by Aladdin optical biometer followed by ultrasonic biometer (Sonomed AB 5500, Lake Success, NY, USA). Patients with good quality Aladdin biometer measurements were included in the study.

Exclusion criteria were history of traumatic or uveitic cataracts, previous intraocular or corneal surgery (e. g. refractive surgery or glaucoma surgery), intraoperative complications (e. g. anterior or posterior capsule ruptures, vitreous loss or zonule dehiscence), or postoperative complications (e. g. tilted or decentred IOL).

Each patient underwent biometric measurement on Aladdin optical biometer by the same examiner (Kaya F). After carefully positioning of patient, Aladdin biometer was focused as determined by a clear view of anterior segment and the display of a ‘green eye’ quality control image. Six AL measurements, three K values and three ACD readings were obtained. The goal in IOL power selection was a value that would provide a postoperative refraction nearest to plano, staying on the side of myopia. The power selection of implanted IOLs was determined based on the SRK/T formula. Another experienced ophthalmologist (Koçak I) performed applanation ultrasound biometer after application of one drop topical anesthetic (proparacaine 0.5%). K values requested for ultrasonic biometer were measured using an autorefractometer (Topcon KR 8800, Tokyo, Japan). Mean of five AL and K measurements was used to calculate IOL power based on the SRK/T formula.

All phacoemulsification and IOL implantations were performed under topical anesthesia by one of three experienced surgeons (Kaya F, Koçak I, Aydin A). A standard phacoemulsification was performed through a 2.8 mm temporal clear corneal incision. The monoblock foldable hydrophobic acrylic IOL (Focus force F260, A – constant of 118.4, Zarracom, Turkey) was inserted into the capsular bag using an injector system.

By the end of first postoperative month, ophthalmological examination was carried out for all patients. Postoperative objective refractive error was measured by using autorefractometer. Uncorrected visual acuity (UCVA) and BCVA were also evaluated.

The estimation error (EE) was defined as the difference between the postoperative objective refractive error (spherical equivalent) and the preoperatively predicted refractive errors by two different biometers using SRK/T formulas for the power of IOL implanted. The absolute estimation error (AEE) was defined as the absolute value of the EE. For example, if postoperative objective error is -0.75D and preoperative predicted error is -0.12D, the EE is calculated as $-0.75 - (-0.12) = -0.63$ D. The AEE (the absolute value of EE) is $[-0.63] = 0.63$ D.

Paired student *t* – test and Wilcoxon test are used for comparison of parameters obtained from two devices. We used student *t*–test to compare K value, AL, ACD, EE and AEE as the groups had normal distribution. We used Wilcoxon test to compare percentages of eyes within target refraction for two devices as the groups did not have normal distribution. Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) version 12.0 (SPSS Inc., Chicago, Illinois, USA). $P < 0.05$ were considered to be statistically significant.

Table 1 Clinical characteristics of patients

Parameter	Mean±SD	Range
Age (a)	67.9±7.6	47 to 81
Sex, n (%)		
M	15(40%)	-
F	22(60%)	-
Laterality, n (%)		
R	19(51%)	-
L	18(49%)	-
Implanted IOL power (D)	21.8±2.05	14.5 to 25

Table 2 Comparison of biometric parameters measured by two devices

Parameters	Optical biometer	Ultrasonic biometer (K value by auto ref.)	^a P
K (D), Mean±SD (Range)	43.3±1.4 (40.4 to 46.7)	43.4±1.5 (40.2 to 47)	P=0.78
AL (mm), Mean±SD (Range)	23.4±0.7 (21.7 to 24.7)	23.2±0.7 (21.7 to 24.6)	P=0.01
ACD (mm), Mean±SD (Range)	3.1±0.2 (2.4 to 3.6)	3.0 ±0.3 (2.4 to 3.6)	P=0.08

K:Keratometry;AL:Axial length;ACD:Anterior chamber depth;^aStudent t-test.

Table 3 The results concerning the estimation error, absolute estimation error, and percentages of eyes within target refraction for two devices

Parameters	Optical biometer	Ultrasonic biometer	P
EE (D) Mean±SD (Range)	0.13±0.56 (-1.16 to 0.97)	0.36±0.59 (-0.73 to 1.49)	P=0.0006 ^a
AAE (D) Mean±SD (Range)	0.42±0.30 (0.02 to 1.16)	0.59±0.35 (0 to 1.49)	P=0.03 ^a
Eyes within ±0.50 D (SE)	67%	58%	P=0.18 ^b
Eyes within ±1.00 D (SE)	97%	88%	P=0.14 ^b

EE:Estimation error;AAE:Absolute estimation error;SE:Spherical equivalent;^aStudent t-test;^bWilcoxon test.

RESULTS

Forty eyes of 40 patients were included in the study. Three eyes were excluded due to the intra-operative complications such as posterior capsule rupture, vitreous loss and zonule dehiscence. Characteristics of patients are shown in Table 1. Biometric parameters including K value, AL and ACD are shown on Table 2. The AL measured by Aladdin (23.4±0.7 mm) was significantly longer than AL by ultrasonic biometer (23.2±0.7mm) ($P=0.01$). The mean ACD measurement by Aladdin was also longer than the ACD by ultrasonic biometer, however the difference was not statistically significant ($P=0.08$). There was no statistically significant difference between two devices in measuring the mean K value ($P=0.78$).

The postoperative mean refractive error (spherical equivalent) was 0.13 ± 0.66 D (range -1.50 to +1.25D). The results concerning the estimation error (EE), absolute estimation error (AEE), and percentages of eyes within target refraction for two devices are shown in Table 3. The mean EE obtained by using Aladdin was significantly smaller than EE by ultrasonic biometer (0.13 ± 0.56 D vs 0.36 ± 0.59 D) ($P=0.0006$). Also, the mean AEE obtained by using Aladdin was significantly smaller than AEE by ultrasonic biometer (0.42 ± 0.30 D vs 0.59 ± 0.35 D) ($P=0.03$). Aladdin optical biometer predicted more eyes with EE within ±0.50 and ±1.00 D of target refraction compared to ultrasonic biometer, however the differences were not statistically

significant ($P=0.18$ and $P=0.14$).

DISCUSSION

Today's cataract patients have greater expectations and request irreproachable results, especially about refractive subjects. IOL power calculation is essential for assessing the success of cataract surgery. Incorrect lens power calculation is the main cause of dissatisfaction and lens exchange in cataract surgery, especially in eyes with short or long axial lengths^[8-11]. Ultrasound biometer is still used for IOL calculation; it is more favorable than optical biometer, especially in cases with dense cataract, media or corneal opacity and vitreous opacities. Optical biometer is a newer technology and has some advantages such as high accuracy, non contact and non invasive measurements, higher speed, higher patient comfort. As light has a very short wavelength compared to sound, the laser light has better resolution, because resolution improves as wavelength decreases. Therefore the accuracy of AL measured with ultrasound biometer is approximately 0.10–0.12 mm compared to 0.012 mm for measurement with optical biometer. Optical biometer is recommended to be used especially in cases those premium IOLs such as multifocal or toric IOLs will be used. But high cost of equipment, inability to measure dense cataracts, some corneal abnormalities and eyes with poor fixation are disadvantages of optical biometers^[7].

Previous studies have compared two devices^[3,12-21]. Fontes *et al*^[3] found that both methods had high precision and

reproducibility but there was a trend toward a subtle improvement in the prediction for postoperative refraction with optical biometer. Rajan *et al*^[12] showed that optical biometer improved the predictive value for postoperative refraction in pseudophakic eyes. Kiss *et al*^[13], Packer *et al*^[14], and Haigis *et al*^[15] proved similar improvement in the prediction for postoperative refraction with optical biometer and US biometer. Bhatt *et al*^[16] showed similar results. Optical biometer was a better predictor of postoperative refraction than US biometer, particularly within close ranges. In two study of Gantenbein *et al*^[17-18] and a study of Kutschau and Wiegand^[19]; the accuracy of postoperative refraction compared to the preoperative target was better with US biometer compared to the optical biometer. In Gantenbein *et al*'s^[17-18] study optical biometer measured AL longer than US biometer and measured keratometry lower than Javal keratometer. Landers and Goggin^[20] found that optical biometers predict more correct refractive outcomes compared to US biometer. In optical biometer, AL measurements were longer than US biometer, but they had similar results for ACD measurements. In another study, Nemeth *et al*^[21] showed that, AL and ACD was measured longer by optical biometer compared to US biometer.

Because of optical biometers' high success in prediction of postoperative refraction, there is a widespread use of them for premium IOLs such as multifocal or toric IOLs. As we use commonly monofocal IOLs in our clinic, we wanted to evaluate and compare success of Aladdin and US biometer for monofocal IOLs.

In our study the Aladdin provided shorter ACD, but longer AL than US biometer. Difference in AL was statistically significant, but difference in ACD was not significant statistically. Most of previous studies also predicted longer ALs^[17-18,20-21]. While US biometers use corneal epithelium and internal limiting membrane as reference points in measuring AL, optical biometers use the second principal plane of the cornea (0.05 mm deeper than the corneal apex) and photoreceptor layer (0.25 mm deeper than ILM). This may explain longer AL measurements with optical biometers. The power selection of implanted IOLs was determined based on the SRK/T formula, because it was one of the most common used formulas and it was found as one of the most successful formulas in determining postoperative refractive error^[22]. Although there was no statistically significant difference, the Aladdin optical biometer obtained better refractive outcomes correlated with some previous studies^[3,16,20] and predicted more eyes with EE within target diopters when compared US biometer. Also Aladdin optical biometer predicted smaller EE and AEE than ultrasonic biometer and the difference was statistically significant.

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