Comparison of measurements of the axial length of the eye using partial coherence interferometry and applanation ultrasound

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Introduction Accurate biometry is an essential component of cataract surgery. Preoperative measurement of axial eye length (AEL), rather than the corneal curvature, is the most critical factor for accurate calculation of the intraocular lens (IOL) power [1].

Aim The aim of this study was to compare axial eye length (AEL) measured by applanation ultrasound (U/S) biometry versus that measured by partial coherence interferometry in eyes with clear crystalline lenses and eyes with cataract.

Patients and methods A prospective, nonrandomized study included 60 eyes which were divided into two groups. Group I: 30 eyes with clear crystalline lenses. Group II: 30 eyes with cataractous lenses. Each group is further subdivided into three groups: group a with short AEL (<22.00 mm), group b with average AEL (22.00–25.00 mm), and group c with long AEL (>25 mm). Complete ophthalmological examination was performed for every patient. AEL was assessed by applanation A-scan U/S and optical biometry using partial coherence interferometry.

Results A total of 60 eyes were included in the study. In group I (clear crystalline lens group), the mean AEL by applantion U/S biometry was 24.23±3.73 mm which is shorter than the mean AEL measured by optical biometry which is 24.48 ±3.66 mm and the difference is statistically highly significant (P=0.002). In group II (cataractous lens group), the mean AEL by applantion U/S biometry was 24.27±3.57 mm which is shorter than the mean AEL measured by optical biometry which is 24.46±3.43 mm and the difference between the two measurements was statistically nonsignificant (P=0.077).

Conclusion Optical biometry provides longer mean measurements than applanation U/S biometry in eyes with cataract or clear lens, which is represented by a negative difference of 0.05 mm in AEL measurements. These results suggest that applanation A-Scan U/S biometry underestimates AEL.

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Introduction

Accurate biometry is an essential component of cataract surgery. Preoperative measurement of axial eye length (AEL), rather than the corneal curvature, is the most critical factor for accurate calculation of the intraocular lens (IOL) power [1].

AEL is routinely measured using ultrasound (U/S) biometry, usually a 10-MHz acoustic wave transducer. The distance between the anterior corneal vertex and internal limiting membrane (ILM) of the retina along the optical axis is measured with a resolution of 200 μm and precision of 150 μm [2]. Partial coherence interferometry (PCI) is a relatively new method for AEL determination. It is a quick, easy-to-use, noncontact device. With the aid of a fixation beam, it measures AEL along the visual axis. Intraexaminer and interexaminer variability of AEL is smaller when measured using PCI than when measured using U/S biometry, because the measurement axis is consistent with the visual axis and there is no indentation of the globe [3].

Patients and methods

A prospective, nonrandomized comparative study was carried out at Al-Zahraa University Hospital between January 2016 and August 2017. The study protocol adhered to the tenets of Declaration of Helsinki and was approved by the ethics board of Al-Azhar University. An informed written consent was taken from each participant in the study.

A total of 60 eyes were selected from the outpatient clinic after complete ophthalmological examination and were divided into two groups:

Group I: included 30 eyes with clear crystalline lenses. This group was subdivided into: group Ia included 10 eyes with short AEL (<22.00 mm); group Ib included 10 eyes with average AEL (22.00–25.00 mm); and group Ic included 10 eyes with long AEL (>25 mm).

Group II: included 30 eyes with cataractous lenses. This group was subdivided into: group IIa which included 10 eyes with short AEL (<22.00 mm); group IIb included 10 eyes with average AEL

(22.00–25.00 mm); and group IIc included 10 eyes with long AEL (>25 mm).

In all eyes AEL was assessed by an U/S A-Scan Biometry (MENTOR Advent A/B system equipped with 10 MHz real-time high frequency probe) and optical biometry using PCI (NIDEK-AL-Scan Optical Biometer, Nidek Co., Gemagori, Japan).

Statistical analysis

All data were analyzed using SAS (release 6.12 for Windows). The collected data were revised, coded, and tabulated using the statistical package for social sciences (15.01 for Windows, 2001; SPSS Inc., Chicago, Illinois, USA).

Results

The study included 60 eyes.

In group I (clear lens group) the mean AEL by applantion U/S biometry was 24.23±3.73 mm which is lower than the mean AEL measured by optical biometry which is 24.48±3.66 mm. The difference between the two measurements was statistically highly significant (P=0.002) (Table 1).

In group Ia (short AEL) the mean AEL by applantion U/S biometry was 20.73±1.00 mm, which is lower than the mean AEL measured by optical biometry which is 20.92±0.81 mm. The difference between the two measurements was statistically significant (P=0.023).

Table 1 Comparison between ultrasound biometry and optical biometry group I

	Ultrasound		Optical		Paired *t*-test	
	Mean	SD	Mean	SD	*P* value	Significance
Clear lens	24.23	3.73	24.48	3.66	0.002	Significant

In group Ib (average AEL), the mean AEL by applantion U/S biometry was 22.86±0.78 mm which is lower than the mean AEL measured by optical biometry which is 23.33±0.76 mm. The difference between the two measurements was statistically significant (P<0.001).

In group Ic (long AEL), the mean AEL by U/S biometry was 29.12±1.02 mm which is lower than the mean AEL measured by optical biometry which is 29.18±1.38 mm. The difference between the two measurements was statistically nonsignificant (P=0.717) (Table 2).

In group II (eyes with cataractous lens), the mean AEL by U/S biometry was 24.27±3.57 mm which is lower than the mean AEL measured by optical biometry which is 24.46±3.43 mm. The difference between the two measurements was statistically nonsignificant (P=0.077) (Table 3).

In group IIa (short AEL), the mean AEL by U/S biometry was 20.90±0.66 mm which is lower than the mean AEL measured by optical biometry which is 21.42±0.65 mm. The difference between the two measurements was statistically highly significant (P=0.001).

In group IIb (average AEL), the mean AEL by U/S biometry was 23.63±0.98 mm which is lower than the mean AEL measured by optical biometry which is 23.62±0.85 mm. The difference between the two measurements was statistically nonsignificant (P=0.996).

In group IIc (long AEL), the mean AEL by U/S biometry was 28.28±2.94 mm which is lower than the mean AEL measured by optical biometry which is 28.34±2.99 mm. The difference between the two measurements was statistically nonsignificant (P=0.771) (Table 4).

Table 2 Comparison of ultrasound biometry and optical biometry in group I (eyes with clear lens)

Clear lens group	U/S		Optical		Paired *t*-test	
	Mean	SD	Mean	SD	*P* value	Significance
Ia – short AEL	20.73	1.00	20.92	0.81	0.023	Significant
Ib – average AEL	22.86	0.78	23.33	0.76	<0.001	Significant
Ic – long AEL	29.12	1.02	29.18	1.38	0.717	NS

AEL, axial eye length; U/S, ultrasound.

Table 3 Comparison between ultrasound biometry and optical biometry group II

	Ultrasound		Optical		Paired *t*-test	
	Mean	SD	Mean	SD	*P* value	Significance
Cataractous lens	24.27	3.57	24.46	3.43	0.077	NS

Table 4 Comparison of ultrasound biometry and optical biometry in group II (eyes with cataract)

Cataractous group	U/S		Optical		Paired *t*-test	
	Mean	SD	Mean	SD	*P* value	Significance
IIa – short AEL	20.90	0.66	21.42	0.65	0.001	Significant
IIb – average AEL	23.63	0.98	23.62	0.85	0.996	NS
IIc – long AEL	28.28	2.94	28.34	2.99	0.771	NS

AEL, axial eye length; U/S, ultrasound.

The results of this study showed that optical biometry provides longer mean measurements than applanation U/S biometry in eyes with cataract or clear lens, which is represented by a negative difference of 0.05 mm in AEL measurements. There was a statistically significant difference in AEL measurements between methods in groups Ia and Ib and IIa. The Spearman test for a significant correlation (i.e. reproducibility) between the two methods was statistically significant in the two subgroups only in groups Ia and Ib and IIa. These results suggest that applanation U/S biometry underestimates the AEL.

Discussion

For optimal refractive outcomes after cataract surgery, proper calculation of IOL power is essential. Accurate biometry is crucial in decreasing errors in IOL power calculation. Other than using accurate formulas, the most critical step in accurate IOL power calculation is AEL measurement [4]. Also AEL is a more critical factor than the corneal curvature [5]. An error in AEL measurement of 100 μm can result in a postoperative refractive error of 0.28 D [6]. Applanation A-scan U/S biometry was the most widely used technique for AEL measurement. However, this method is not optimal in all situations [7]. Optical biometry is virtually synonymous with the PCI. The measurement principle is based on the principle of partially coherent light [8]. Optical biometry measures the true AEL from the anterior corneal vertex to the photoreceptors. Standard U/S biometry measures AEL from the corneal vertex to the ILM [7], whereas optical biometry measures AEL from the second principal plane of the cornea (0.05 mm deeper than the corneal apex) to the photoreceptor layer (0.25 mm deeper than ILM of the fovea) [9]. This occurs because the patient fixates on a beam within the instrument. In contrast, in U/S biometry, measurements are made along the anatomic or optical axis. This can result in erroneous measurements. For example, in an eye with a staphyloma, a measurement taken along the anatomic axis can result in an error of 3.0 mm, which can lead to a refractive error of up to 8 D. Optical biometry may decrease the rate of potential IOL miscalculation and lead to better refractive outcomes and better patient satisfaction. However, optical biometry cannot fully replace U/S biometry because 10–20% of eyes with dense cataract cannot be measured with it [10]. Therefore, in cases of moderate cataract without other pathology, eyes filled with silicone oil, and children, the optical biometry provides precise and accurate readings. In cases of poor visual acuity, dense cataract, and other pathology creating poor clarity of media, an A-scan U/S would be indicated [11]. This study suggested that U/S biometry underestimates the AEL which may be due to the indentation effect of the probe upon the cornea. Another possible explanation is light reflection, In U/S biometry, light is reflected at the ILM, whereas in optical biometry, light is reflected at the retinal pigment epithelium. The resulting difference is about 130 μm and may increase if the light does not directly spot the fovea [12]. Tehrani *et al.* [13] compared AEL measurements assessed by U/S biometry and optical biometry. In their results, optical biometry provided larger mean measurements than U/S biometry in eyes with cataract or clear crystalline lens, which was represented by a negative difference of 0.05 mm in AEL measurements, with higher measurements produced by optical biometry. Kiss *et al.* [14] reported statistically significant differences in AEL measurement in patients with cataract and clear crystalline lenses [14]. Our results showed that, in general, optical biometry and U/S biometry give statistically significant differences in AEL measurement in patients with clear lens. The difference between the two measurements was statistically highly significant (P=0.002), whereas in cataractous eyes the difference is statistically nonsignificant except in short eyes. Our results agree with Nakhli [10] who found that the difference between devices was mainly in short eyes (P=0.031), optical biometry is preferable in short eyes.

Eleftheriadis [15] performed phacoemulsification with IOL implantation in 100 patients. He found AEL obtained by optical biometry was significantly longer in cataractous eyes (23.36±0.85 mm) than the AEL by U/S biometry (22.89±0.83 mm). He concluded that optical biometry improves the refractive results of selected cataract surgery patients and it was more accurate than U/S biometry. Our results are the same as Eleftheriadis [15], which proved that optical biometry provided larger mean measurements than U/S biometry in eyes with cataract and clear lens. This is in contrast to Gaballa *et al.* [16]; they stated that there is no significant difference between IOL master and A-scan biometry, with the noncontact IOL master being preferred by patients. Pongsachareonnont and Tangjanyatam [17] found significant underestimation of AEL measurements when using optical biometry in eyes with rhegmatogenous retinal detachment with macular involvement.

Conclusion

Optical biometry provides longer mean measurements than applanation U/S biometry in eyes with cataract or clear lens, which is represented by a negative difference of 0.05 mm in AEL measurements. These results suggest that applanation A-Scan U/S biometry underestimates the AEL.

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Conflicts of interest

There are no conflicts of interest.

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