Measurement of Axial Length by Applanation Ultrasound Relative to Optical Biometry in Normal Eye

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ABSTRACT:

BACKGROUND:

The precision of axial length measurement has great impact on successful cataract surgery and refractive outcome besides its diagnostic role of many ophthalmic conditions. There are various methods for axial length measurement which differ in their operating principle and technology beside the difference in their advantage and limitation.

AIM OF STUDY:

To compare the axial length measurement performed with optical biometry IOLMaster 500(Carl-Zeiss Meditec,Jena, Germany) with those obtained by applanation ultrasound (A-Scan biometer AL-100) in three groups.

METHODS:

207 eyes of 104 candidates with age range (20-40 year) were included. These candidates divided into three groups according to axial length; group 1 (22 - 24 mm), group 2 (24.1 – 26 mm) and group 3 (26.1 – 28 mm). Axial length was measured in three groups, firstly by optical biometry then by applanation ultrasound by the same examiner.

RESULTS:

The axial length measured by IOLMaster was longer than by applanation ultrasound in all groups. The mean differences were (0.15mm, 0.15mm and 0.2 mm) in three groups respectively, which were statistically significant p-value < 0.05. Bland-Altman plots shows there is good agreement between measurements of two devices for all groups.

CONCLUSION:

The results show optical biometry provided longer axial length than applanation ultrasound with hypermetropic shift (0.35D-0.5D) by applanation ultrasound in normal eye.

KEY WORDS: Axial Length, Ultrasound biometry, IOLMaster biometry

INTRODUCTION:

The Axial Length (AL) is the distance from the corneal surface to an interference peak corresponding to the retinal pigment epithelium/Bruch's membrane.[1,2] The average newborn's eyeball is about 16 millimeters in diameter, from front to back (axial length). In an infant, the eye grows slightly to a length of approximately 19½ millimeters. The eye continues to grow, gradually, to the length of about 24-25 millimeters.[3] The majority of axial length elongation takes place in the first three to 6 months of life and a gradual reducing rate of growth over the next two years [4], and by three years the adult eye size is attained.[5] It is considered that the axial length reaches adult length by the age of 13 years.[6]

Axial length (AL) is one of the major variable basic ocular biometric parameters.[7] AL has great impact on successful cataract surgery and refractive outcome [5,8,9], besides its diagnostic role of many ophthalmic conditions. Error in AL measurements is the most significant error in intraocular lens (IOL) power calculation [10], which can have an effect on the surgical outcome and expected results.

An error of 1mm in preoperative AL measurement results in about 2.5 D in the calculated IOL power in an eye with average AL, and this tends to vary significantly in hyperopic and myopic eyes. [8,11,12]

Axial length (AL) measurement utilizes the principle of signal reflection to measure the difference between the various ocular structures and the overall length of the eye. The time a signal is reflected back from an interface is measured and divided by two and multiplied by speed of signal in

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the corresponding medium. Distance is calculated using the formula:

Distance= speed * time/2

The transmitting signal can be ultrasonic. Ultrasound measurements (ultrasonography) can be performed by applanation of an ultrasound probe to the cornea or by immersion of the probe in a saline filled shell. Ideal measurements consist of three readings within 0.02 mm of each other, maximally high, with steeply rising anterior and posterior lens and retina spikes.[13]

Over a decade ago, optical biometry was introduced into clinical practice. Optical biometry is based on partial coherence interferometry (PCI). There are currently many optical biometry devices on the market.[14,15] The first commercially available device was the IOLMaster (Carl Zeiss Meditec, Jena, Germany) and more recently, the Lenstar (Haag-Streit AG, Koeniz, Switzerland) was introduced. Lenstar allows higher resolution compared with the IOLMaster. The measurement includes corneal thickness, ACD, LT, AL, K, white-to-white distance, pupillometry, eccentricity of the visual axis and retinal thickness at the point of fixation.[10] Over time optical biometry has replaced ultrasonography as the standard technique for axial length measurements of the eye. Optical biometry utilizes a laser for the signal transmission. Interference phenomenon between the reflected signal and reference signal is utilized to determine distances between interfaces.[16]

AIM OF THE STUDY:

To compare axial length measurements by optical biometry IOLMaster 500 and applanation ultrasound and to determine the agreement between two devices.

MATERIALS AND METHODS:

In this comparative study, 207 eyes of 104 candidates were enrolled including staff members volunteers, candidates for routine ophthalmological examination, in outpatient clinic at Ibn-Alhaitham eye teaching hospital in Baghdad during the period from June 2017 to February 2018.

The inclusion criteria were: normal eyes, age (20-40) year and the candidates were divided into three groups according to axial length, based on IOL Master:

1. Group 1 AL (22 - 24 mm).
2. Group 2 AL (24.1 – 26 mm).
3. Group 3 AL (26.1 – 28 mm).

The exclusion criteria include; age younger than 20 and above 40 years, history of any ocular surgery or anterior segment pathology, current topical medication. Ophthalmic examinations were done for candidates: VA using snellen chart, refraction using autorefractometer (RC-5000), anterior segment examination using slit lamp, dilated posterior pole for fundus examination, intraocular pressure measured by air puff method.Each volunteer in this study was sent for axial length measurement by optical biometry IOLMaster (Carl zeiss meditec AG, 07740 Jena Germany) and applanation ultrasound (AL-100 Tomey Corporation) by the same examiner.

Optical biometry was done first then by applanation to avoid the potential effect of corneal aberration. Optical biometry was performed with patient seated at IOL Master and asked to fixate on fixation target. Applanation biometry was performed after the cornea was anesthetized with one drop of 0.5% topical proparacaine hydrochloride (Alcaine, Alcon, Belgium). The A-scan unite was equipped with a 10 MHZ transducer probe, electronic caliper was used and velocities were set by device per medium e.g. 1640 m/s for cornea and lens, 1530 for aqueous and vitreous.

The statistical analysis was performed using commercial software (SPSS V.22). the p-value < 0.05 was statistically significant.Paired t-test analysis was used to compare the differences in AL measurements between two devices.The correlation between the measurements using two instruments was calculated and expressed as (Pearson correlation coefficients).The (ANOVA) test was used to compare the difference in the measurements between three groups for each device. A Bland- Altman plot is used with 95% limits of agreement (LoA) to assess the agreement measurements between two devices [17].

RESULTS:

This study was performed on 207 eyes in 104 candidates (56 male, 48 female) were divided into three groups which were examined by two device; IOL master and Applanation A-scan. The mean age of patients in group 1, group 2 and group 3 were 27.1± 6.78, 28.5± 6.83 and 28.47± 6.34 years, respectively (range, 20–40 years). Regarding the gender distribution, male were 56 represent (54%) of studied groups and the remaining 48 patients (46%), were females. However, no statically significant differences have been found between both genders regarding the age, (p>0.05), as showed in Table1.

Table 1: Distribution of patients according to age & gender.

Groups	Age (Mean ±SD)	Male		Female		Total		P. value
		No.	%	No.	%	No.	%	
Group 1	27.1± 6.78	23	22.1 %	16	15.2%	39	37 %	0.92
Group 2	28.5± 6.83	17	16.2%	14	13.3%	31	30 %	0.16
Group 3	28.47±6.34	16	15.7%	18	17.5 %	34	33 %	0.15
Total		56	54 %	48	46 %	104	100%	

The mean AL of group (1) was 23.03± 0.52 mm (range, 22.04 – 24 mm) with optical biometry (IOL Master) and 22.88 ± 0.51 mm (range, 21.87 mm to 23.95 mm) with applanation A-scan. The mean axial lengths with IOLMaster in the group (2) was 24.96 ±0.56 mm (range, 24.15– 25.95 mm) compared to 24.81 ±0.56 mm (range, 24.11–25.89 mm) measured by applanation A-scan. The mean axial lengths with IOL Master in the group (3) was 26.98 ± 0.6 mm (range, 26.1– 28 mm) compared to 26.78 ± 0.57mm (range, 25.98–27.96mm) measured by applanation A-scan. Significant differences in AL measurements between group (1), group (2) and group (3) were found with statistically significant ($p < 0.05$). Average of axial length measurements and the difference between measuring devices for the three groups are listed in Table 2.

Table 2: Axial length measurements with optical biometry (IOL Master) and applanation ultrasound in group (1), group (2) and group (3).

Groups	Number of eyes	Optical biometry (Mean ±SD)mm	Applanation A-scan (Mean ±SD)mm	Significant difference P-value
Group 1	78	23.03± 0.52	22.88 ± 0.51	P<0.05
Group 2	62	24.96 ±0.56	24.81 ±0.56	P<0.05
Group 3	67	26.98 ± 0.6	26.78 ± 0.57	P<0.05

P-value from paired t-test

Table 3: Limits of agreement (95% LoA) , Difference of mean and Pearson Correlation in three groups.

Groups	95% LoA	Difference (mm)	Pearson Correlation
Group 1	-0.075 to 0.38	0.15	0.98
Group 2	-0.19 to 0.50	0.15	0.95
Group 3	-0.34 to 0.74	0.20	0.89

The result show in normal eye, there is hypermetropic shift (0.35D-0.5D) by applanation ultrasound. To assess the agreement between devices Bland-Altman analyses was used. Figure.1, 2 and 3 shows the Bland-Altman plots to verify the agreement between devices. The difference of mean axial length and 95% limits of agreement (means difference±1.96 SD) are presented with lines.

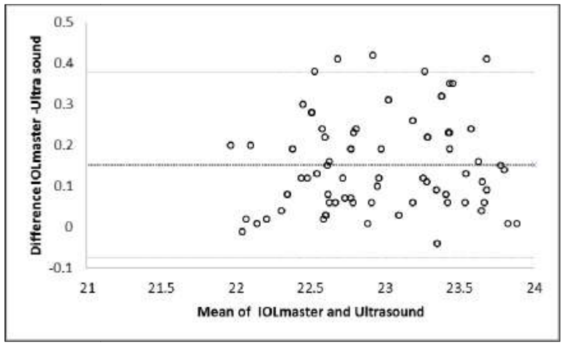

Figure 1:Bland-Altman plots comparing mean AL for group (1) and mean difference.

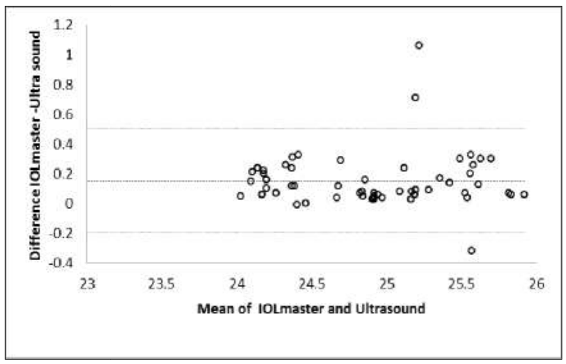

Figure 2: Bland-Altman plots comparing mean AL for group (2) and mean difference.

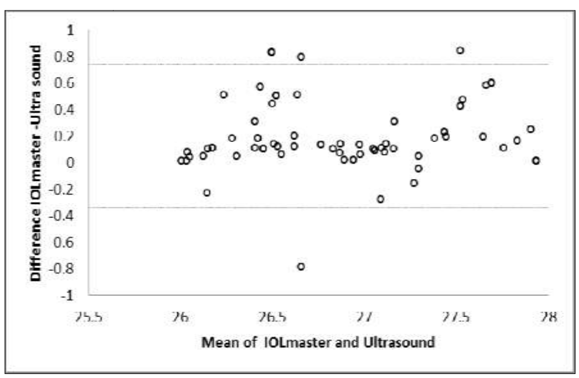

Figure 3: Bland-Altman plots comparing mean AL for group (3) and mean difference.

DISCUSSION:

Axial length measurement is the most critical step in accurate IOL power calculation. An error of 100 μm in AL measurement can result in a postoperative refractive error of 0.28D.[18]

In this study, we compared the axial length of eyes measured by optical and applanation ultrasound in three groups. There was difference between measurements of two devices in all groups. The measurements of axial length values with optical biometry were longer compared with ultrasound device. This is consistent with what has been found in previous studies. [13,18]

The result showed a statistically significant difference between two devices for group1

(p<0.05) with a high correlation between axial lengths (Pearson correlation= 0.98). The difference between mean AL measurements was 0.15 mm which agrees with the results found in previous research; Loreto T Rose et al. obtained an average difference between IOL master and Ultrasound of AL values 0.15 mm. [19] Similarly, R. Goyal et al. found the difference was statically significant with of average difference of 0.2 mm. [20] Čech R et al also found that there was a significant difference between the measurements of the axial length of the two devices and the difference was 0.15 mm. [21]
The difference in AL measurement between pair of device (IOL master and Ultrasound) in group1 were compared by Xiao Gang Wang et al [22]. They found that IOL Master longer than Ultrasound by 0.24 mm and significant differences were found. Mana Tehrani et al [18] Compared the AL measurements between optical and ultrasound device. The results show that statistically significant mean difference in AL measurement in normal eyes of 0.05 mm.
Some previous studies found disagreement with the current research; Liat Attas et al [23] Measured the axial length in normal eyes as a control group in their study, they found no significant difference in AL measurement using applanation ultrasound and IOL master. Their results showed that mean AL value was (0.071mm) which is statistically not-significant. This difference may be due to small sample size and old age group. Similarly, Andrew K. Lam et al [24] reported that the mean difference between two devices was (0.099 mm) with no statistical significance were found. This difference may be due to measurement done by multiple examiners.
For group 2 the result showed a statistically significant difference between two devices (p<0.05) with of average difference of 0.15 mm with correlation between axial lengths (Pearson correlation= 0.95). This is consistent with what was found in the previous study. [21]
Statistically significant difference between two devices for group 3 was found (p<0.05) with correlation between axial lengths (Pearson correlation= 0.89). The AL measured by IOL Master longer than that measured by applanation Ultrasound, the mean difference in this group was (0.2 mm). This is consistent with previous studies that have been achieved to measure differences for the same group. The AL values obtained by the IOL Master are longer compared to the Ultrasound device by (0.24mm) with a significant difference and this was concluded by the researchers in their study. [22] Similar to previous studies [18, 21], also were found a statistically significant mean difference of (0.27 mm) and (0.29 mm), respectively. This agrees with that reported by Soheir H.Gadalla [25] were found a significant mean difference of (0.2 mm) between AL measurements for two devices.
Another study presented by Peiyang shen etal [26], they found that there is no significant differences between the readings on the two devices and a difference of 0.01 mm and disagree with what found in our study might be due to sample size and different age groups.
Bland-Altman plots shows there is good agreement between measurements of two devices for all groups. From result as shown in figure 1, 2 and 3, 95% limits of agreement was smaller between IOLmaster and Ultrasonic in group1 than group2 and group3 depending on the measurements (-0.075 to 0.38, -0.19 to 0.50 and -0.34 to 0.74 respectively) and the mean difference between AL measurements from the optical and ultrasound devices for were 0.15 mm, 0.15 mm and 0.2 mm respectively. The result showed the small range of variation were found in group1 and group2 and followed by group 3. The plots showed high agreement between the two devices with some values out the agreement limits.

CONCLUSION:

This comparative study revealed statistically significant difference in AL measurements using optical and applanation ultrasound with longer axial length using optical device and hypermetropic shift (0.35D-0.5D) by applanation ultrasound in normal eye. IOL-Master has advantage over applanation ultrasound; it is a non-contact technique with no risk of infection or corneal aberration, faster and easy to use.

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