Original Article

Comparison of Axial Length and Anterior Chamber Depth Measurement among Optical, Applanation and Immersion Biometry

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Abstract:

Background: *Precise biometry is one of the major key factors for obtaining desired refractive outcome after cataract surgery. Visual outcome strongly depends on accuracy of ocular parameters especially axial length (AL) and anterior chamber depth (ACD). It is very important to evaluate different biometry methods to have accurate measurements for IOL power calculation.*

Objective: *The aim of the study is to compare and analyze the difference between the measurement of axial length (AL) and anterior chamber depth (ACD) using ultrasound applanation, immersion and optical biometry.*

Methodology: *A prospective study conducted on 168 patients enrolled for cataract surgery from January 2018 to December 2018 in Dhaka Eye Care Hospital, Dhaka. 280 eyes have been tested by a single observer. Axial length (AL) and anterior chamber depth (ACD) was measured consecutively by optical, applanation and immersion biometry. The results have been statistically evaluated to establish efficacy and correlation among the three methods of biometry.*

Results: *Statistical analysis showed the mean of axial length (AL) obtained from optical biometry is 23.36 ± 1.99 mm, which is 0.10mm (p=0.00) less by applanation biometry and 0.04 mm (p=0.00) less by immersion biometry. For anterior chamber depth (ACD), the mean value from optical biometry is 3.13 ± 0.47mm. This value is highest in compare to both applanation (0.002 mm less with p = 0.824) and immersion (0.04 mm less with p = 0.00) biometry. Further analysis reveals strong correlation of optical biometry with applanation biometry (r = 0.994 for AL and 0.945 for ACD) and immersion biometry (r = 0.995 for AL and 0.947 for ACD).*

Conclusion: *The study reveals that among optical, applanation and immersion method the optical biometry method appeared to be the most precise way of measuring axial length (AL) and anterior chamber depth (ACD) of eye. The study also shows an excellent agreement and strong positive correlation of optical biometry with applanation and immersion biometry.*

Key Words:
Axial length, anterior chamber depth, optical biometry, applanation biometry, immersion biometry

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Introduction

Precise biometry is one of the major key factors for accurate calculation of intra ocular lens power in cataract surgery. This accuracy is essential to attain satisfactory post-operative refractive outcome. Visual outcome after cataract surgery depends on minimization of measurement error of the ocular parameters. Among the parameters axial length (AL) and anterior chamber depth (ACD) hold utmost importance. According to some study, 54% of error in predicted refraction after intra ocular lens implantation took place due to variability of axial length measurement. Variability in anterior chamber depth measurement causes 38% of predicted refraction error.[1] Axial length means the length of optical path, from the corneal anterior surface to the retinal pigment epithelium. Anterior chamber depth extends from the corneal vertex to the internal limiting membrane.[2] There are two major categories of biometry

based on different working methods.[3] First category is contact ultrasound biometry that use ultrasonic signals for measurement of axial length (AL) and anterior chamber depth (ACD). Ultrasound measurement of the eye can be done by applanation of an ultrasonic probe to the cornea or by immersion of the probe in a saline filled shell.[3] The second category is non-contact swept source optical coherence tomography based optical biometry, IOL Master 700. Optical biometry utilizes a laser for signal transmission through the ocular structures.[4] The technology is called dual- beam partial coherence interferometry. The reflected infrared laser light passes through the internal ocular structures.[5] The difference between the reflected signal and reference signal is used to determine the axial length and anterior chamber depth measurement. Hence, both of the categories have some limitations. The outcome of the ultrasound methods can be altered by variation in the position of ultrasound probe, degree of corneal indentation and patient's movement during the biometry process.[6] Similarly, the performance of optical biometry becomes diminished in very dense cataract and in posterior sub capsular cataract. In such scenario, it is very common to rely upon applanation and immersion biometry method to measure axial length (AL) and anterior chamber depth (ACD) for IOL power calculation.[5] Certainly, it is very important to measure the correlation and agreement between optical, applanation and immersion technique. This study examines the accuracy of the optical method and compares it with the results of ultrasound applanation and immersion methods.

Materials and methods

A prospective study has been conducted on patients with cataract in one or both eyes who enrolled for cataract surgery in Dhaka Eye Care Hospital, Dhaka. Total 280 eyes from 168 patients have been selected for the study. The study patients have been picked from patients scheduled for phacoemulsification and IOL implantation between January 2018 and December 2018. The patients underwent pre phaco investigations, have been informed about the purpose of the study and had to give an informed consent before include them in study. There were some inclusion and exclusion criteria of the patients those have been selected as sample. The inclusion criteria were: patients should be enrolled for cataract surgery, patients had to have age related visually significant cataract in one or both eyes and patients need to give consent to use their data in study. The exclusion criteria are: patients having any history of trauma, patients underwent any ocular surgery, patients having any other ophthalmic condition of eye other than cataract that may hamper the visual acuity, such as glaucoma, retinal detachment etc., patients who could not be positioned for measurement satisfactorily and patients having nystagmus or poor fixation. There was some intraoperative exclusion criteria as well like: patients having any per operative complications such as, inability to achieve IOL placement inside the bag, capsular tear, vitreous loss, zonular rupture etc. All the eyes have been tested by all three methods namely, swept source optical, applanation and immersion biometry.

Out of 168 patients, 88 were male and 80 were female. Mean age was 59.86 yrs. with standard deviation of 11.41 yrs. All the eyes have been tested by all three methods namely, swept source optical applanation and immersion biometry. For all three methods the manufacturer's instruction manual has been followed and was done three times consecutively by a single experienced technician. The mean of the consecutive AL and ACD measurement were recorded. Measurements have been carried out in following order: at first by optical method, secondly by applanation method and at last by immersion method. These sequences of the procedures need to maintain to avoid confounding effect like corneal indentation or abrasion during applanation ultrasound, which may lead to produce shorter AL and ACD measurement.

Optical biometry performed according to the standard protocol. Fixation lights and illumination lights were switched on after entering the patient's data into machine. The patient's chin was placed on a chin rest and the forehead was pressed against the forehead strap. The eyes were aligned along the fixation light and asked to look on the internal light or the target. The device focused based on the image of the eye on monitor. Before image capture, the patients were asked to perform a complete blink to have smooth tear film over the cornea. A cross hair with a circle in the middle appears in the display. AL was measured with four reliable scans within 0.02mm. ACD measurement was automatically generated by the image analysis of anterior corneal pole and anterior surface of crystalline lens distance. Finally average reading was recorded. Applanation ultrasound measurement was done by using 10 MHz applanation probe. Ultrasonic biometric sound was emerged through the aqueous and the vitreous humor of the eye and the reading generated. Immersion technic was done by insertion of a PMMA funnel between the eye lids of a patient in supine position. The funnel then filled with normal saline as a coupling agent. One hand was holding the funnel in position without exerting any pressure on the cornea and the other hand hold the probe in a perpendicular position with the corneal steep to exhibit some measurement which automatically calculated by the instrument for AL and ACD value. The average of three consecutive readings of AL and ACD were recorded.

Statistical analysis

The average measurements have been statistically analyzed to evaluate the difference between AL and ACD by three technics. P values were measured and correlations have been identified between the methods. The comparison and correlation was analyzed between swept source optical, applanation, and immersion biometry of axial length and anterior chamber depth of eye. The statistical analysis of the data was done by SPSS version 23.0. Differences in measurement between three methods were evaluated by paired two-tailed t-test and ANOVA test. The inter-device agreement was analyze by Bland-Altman plots. The correlation among the methods was calculated with 95% confidence interval. A p value of <0.05 indicates statistical significant value.

Result

A total 280 eyes from 168 patients with cataract have been evaluated. Among them 112 patients enrolled for cataract surgery in both eyes and 56 patients have cataract surgery in one eye. Numbers of male patients were 88 and female patients were 80. The mean age of the patients was 59.86 yrs with standard deviation of 11.41 yrs. Figure 1 and 2 shows histogram with normal distribution of the sample and box plot indicate uniformity among the samples with no outlier.

The statistical analysis reveals mean of axial length (AL) by optical biometry was 23.36 mm, with standard deviation of 1.99 mm. By applanation method it was measured 23.26 mm with standard deviation of 1.97 mm. The immersion method showed the axial length measurement as 23.32 mm with standard deviation of 1.97 mm. For anterior chamber depth (ACD), the mean measurement by optical method was 3.13 mm with standard deviation of 0.47 mm. By applanation method the mean value of anterior chamber depth was 3.13 mm with standard deviation of 0.43 mm. At last, by the immersion method the measurement was 3.17 mm with standard deviation of 0.45 mm. (Table 1)

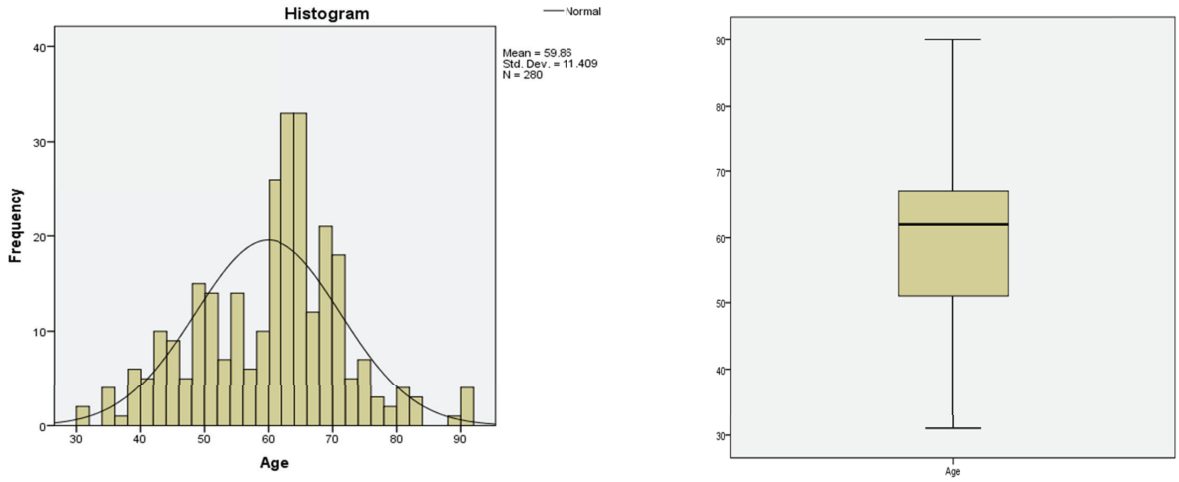

Fig. 1 & 2: *Histogram and Boxplot showing normal distribution of the sample.*

Table 1

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Age	280	31	90	59.86	11.409	130.163
Applanation AL	280	18.91	30.64	23.2604	1.96728	3.870
Immersion AL	280	18.81	30.89	23.3174	1.97397	3.897
Optical AL	280	18.70	31.17	23.3604	1.98946	3.958
Applanation ACD	280	2.19	4.14	3.1272	.43155	.186
Immersion ACD	280	2.09	4.35	3.1676	.44632	.199
Optical ACD	280	2.04	4.51	3.1292	.47069	.222
Valid N (listwise)	280					

Abbreviations: AL, axial length; ACD, anterior chamber depth

The mean difference between optical and applation is 0.10mm ± 0.22 mm (with p=0.00). The difference between optical and immersion biometry in mean axial length (AL) is 0.04 mm ± 0.19 mm (with p=0.00). Mean anterior chamber depth (ACD) difference between optical and applanation method is 0.002 mm ± 0.15 mm (with p=0.824). Lastly, the difference of mean ACD measurement among optical and immersion biometry is 0.04 mm ± 0.15mm (with p = 0.00). There is no statistically significant probabilities are observed except anterior chamber depth difference between optical and applanation methods of biometry which was significant. (Table II) .

In order to establish the correlation among three methods, r value has been calculated. The r value for optical and applanation method is 0.994 (with p = 0.00) for axial length (AL) and 0.945 (with p = 0.00) for anterior chamber depth (ACD). Again, for optical and immersion biometry the r value is 0.995 (with p = 0.00) for axial length (AL) and 0.947 (with p = 0.00) for anterior chamber depth (ACD). These values reveal that there is strong correlation between these methods. So, the agreement between optical, applanation and immersion biometry is excellent. (Table III)

Table-II

Paired Samples Test

Paired Differences	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper	t	df	Sig. (2-tailed)
Optical AL-Applanation AL	.10004	.22278	.01331	.07383	.12624	7.514	279	.000
Optical AL-Immersion AL	.04300	.19379	.01158	.02020	.06579	3.713	279	.000
Optical ACD-Applanation ACD	.00206	.15461	.00924	.01613	.02025	.223	279	.824
Optical ACD -Immersion ACD	.03837	.15111	.00903	.05615	.02059	4.249	279	.000

Abbreviations: AL, axial length; ACD, anterior chamber depth

Table-III

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Optical AL & Applanation AL	280	.994	.000
Pair 2	Optical AL & Immersion AL	280	.995	.000
Pair 3	Optical ACD & Applanation ACD	280	.945	.000
Pair 4	Optical ACD & Immersion ACD	280	.947	.000

Abbreviations: AL, axial length; ACD, anterior chamber depth

ANOVA test has been done to compare optical, applanation and immersion methods which established no significant difference among the techniques. (Table IV).

Table-IV

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.	
Optical AL	Between Groups	683.460	47	14.542	8.017	.000
	Within Groups	420.803	232	1.814		
Applanation AL	Between Groups	676.910	47	14.402	8.294	.000
	Within Groups	402.874	232	1.737		
Immersion AL	Between Groups	681.377	47	14.497	8.289	.000
	Within Groups	405.758	232	1.749		
Optical ACD	Between Groups	23.671	47	.504	3.063	.000
	Within Groups	38.142	232	.164		
Applanation ACD	Between Groups	21.464	47	.457	3.474	.000
	Within Groups	30.495	232	.131		
Immersion ACD	Between Groups	21.698	47	.462	3.162	.000
	Within Groups	33.878	232	.146		

Abbreviations: AL, axial length; ACD, anterior chamber depth

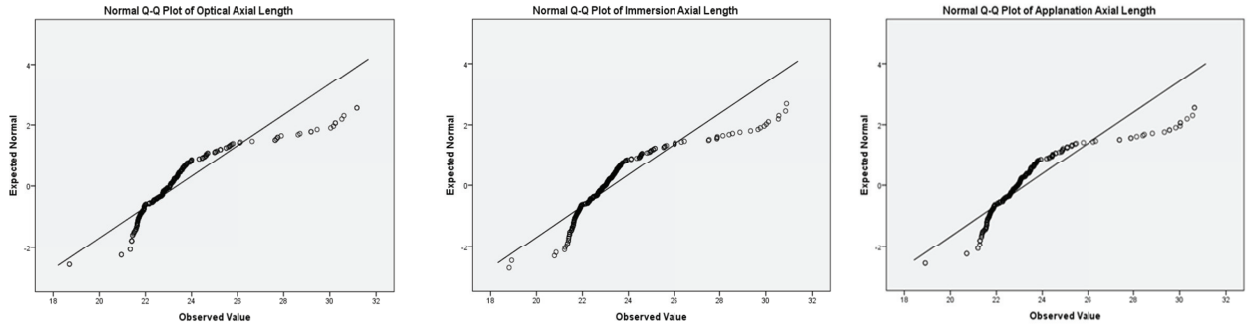

Fig.-3, 4, and 5: *Scatterplot shows similar distribution of axial length measurements by optical, applanation and immersion method of biometry.*

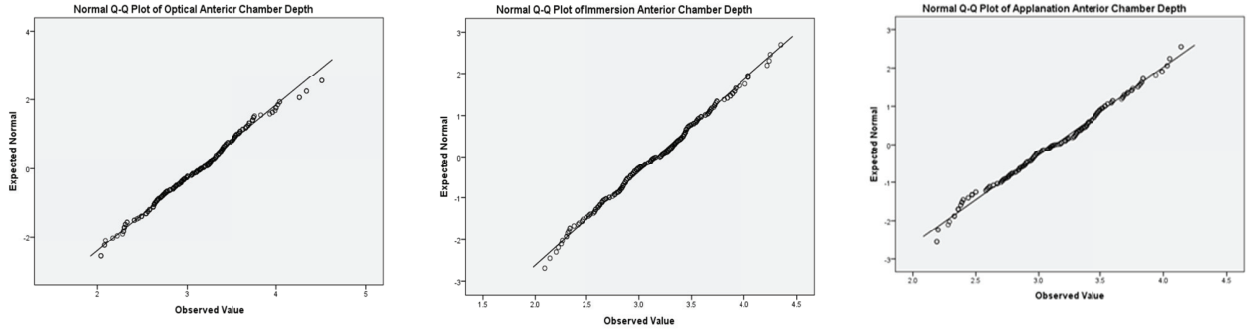

Fig.-6, 7 & 8: *Scatterplot shows similar distribution of anterior chamber depth measurement by optical, applanation and immersion method of biometry.*

Discussion

Day by day patient's expectation regarding post-operative refractive outcome after cataract surgery is increasing.[5] For an effective IOL power calculation proper measurement of axial length and anterior chamber depth is getting mandatory. Different measurement methods like, optical, applanation and immersion biometry can be used to determine these parameters in vivo.[7] By optical biometry, the measurement had done form the tear film over the cornea to the retinal pigment epithelium. On other hand, both by applanation and immersion ultrasound biometry the measurements are done from cornea to vitreo-retinal interface.[8] Certainly there are some clinically significant differences between optical and ultrasound biometry. Considering the scientific fact, "the light has a very short wavelength in compare to sound"- there might be some difference in the measurement outcome by three methods of biometry. Shorter wavelength gives better resolution, so, the measurement is more accurate in optical biometry. In addition, the starting point of the measurement is earlier in optical biometry. Moreover, the optical biometry works along the visual axis; whereas ultrasound measurements work along the anatomical axis (through the center of the cornea), as a result, optical biometry reads longer then ultrasound biometry.[9] Study also shows, axial length obtained by optical method is 0.10 mm longer then applanation and 0.04 mm longer then immersion method. Although, this difference is insignificant but, this occurs mainly due to indentation of the cornea by the ultrasonic probe. Similarly, for anterior chamber depth, the difference between optical and applanation is 0.002 mm and optical and immersion method is 0.04 mm. The difference in anterior chamber depth measurement is mainly due to lack of pupil dilatation.[10] Although, optical method consider as better measurement tool for axial length and anterior chamber depth but all three methods show excellent correlation among them.

All these methods have got some advantages and disadvantages. As optical method is a non-contact technique, it provides comfort to the patient and prevents corneal abrasion and infection induced by probe. On the negative side, optical method cannot perform accurately in presence of mature cataract, posterior sub capsular cataract, vitreous hemorrhage, maculopathy and retinal detachment.[11] In these cases applanation and immersion methods become useful as alternative method that can work under significant media opacities.[5] Sometimes opposite readings of axial length and anterior chamber depth may show in study. In our study anterior chamber depth measured by immersion method was 0.038 mm higher

than the optical method of biometry. This occurs due to difference in measurement methods, difference in accommodation and influence of operator's experience [3]. Overall statistical analysis of the findings of our study shows very insignificant difference in axial length and anterior chamber depth measurement among three different methods of biometry. This insignificant difference is due to single experienced observer involvement in measurement procedure [8]. Further statistical analysis of correlation reveals; there is positive correlation between the three methods with significant p value. So, it can be said that there is excellent correlation and strong agreement between optical, applanation and immersion method of biometry.

Conclusion

Precise and accurate biometric data is fundamental for expected post-operative refractive outcome [6].Based on the outcome of the study, it can be said that, a better prediction of axial length (AL) and anterior chamber depth (ACD) can be done by optical biometry. This may lead to more accurate intra ocular lens power [12]. Hence, there is insignificant difference of applanation and immersion biometric measurement for ocular in vivo parameters in compare with optical when carried out by single experienced observer. Moreover, there is excellent positive correlation between optical, applanation and immersion methods of biometry. Finally, the study analyses also established excellent agreement between the three methods of biometry.

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