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Accuracy of the Postoperative Refractive Prediction in Optical Biometry Versus Ultrasound Biometry in Preoperative Intraocular Lens Power Calculation

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Contact A-scan ultrasonic biometry is the most frequently utilized technique for determining axial length (AXL). Optical biometry is a technique that utilises partial coherence interferometry to determine ocular biometry parameters. The aim of this research was to compare the efficacy in estimating postoperative refraction by measuring intraocular lens (IOL) power by the optical biometry (IOL Master) and contact A-scan ultrasound plus Bausch & Lomb (B&L) keratometry after phacoemulsification surgery.

Methods: This prospective, comparative, interventional and randomized study involved 40 eyes with uneventful phacoemulsification surgery and in the bag IOL of adult patients with cataract. Subjects were allocated into 2 equal groups: group A: implanted the IOL power estimated by the automated method and group B: implanted the IOL power estimated by the manual method. All patients were subjected to complete ophthalmic examination, best-corrected visual acuity (BCVA), uncorrected visual acuity (UCVA), snellen visual acuity, cycloplegics refraction and slit lamp examination.

Results: The mean predicted error of IOLM was -0.108 ± 0.462 (P= 0.311) in group A and was 0.053 ±1.092 (P= 0.830) in group B, and the Predicted error of A scan was -0.661 ± 0.686 (P= <0.001) in group A which is statistically significant and -0.340 ± 0.972 (P= <0.134) in group B. IOL power measured by IOLM in group A was significantly lower than IOL power measured by A-Scan

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(p =0.004). While the mean IOL power measured by IOLM in group B was significantly lower than IOL power measured by A-Scan (p =0.008).
Conclusions: The IOL Master accurately assesses the axial length of the lens and thus provides a significantly better prediction of IOL power and thus refractive outcome in cataract surgery than US biometry.

Keywords: Postoperative refractive prediction; optical biometry; ultrasound biometry; preoperative intraocular lens power calculation.

1. INTRODUCTION

Contact A-scan ultrasonic biometry is the most frequently utilized technique for determining axial length (AXL). Optical biometry is a technique that utilises partial coherence interferometry to determine ocular biometry parameters [1].

Contact ultrasonography measures the AXL as the distance along the optical axis between the anterior corneal vertex and the retina's internal limiting membrane. This technique necessitates. The application of a local anaesthetic applied topically and direct attached with the cornea via a probe [2].

The AXL when assessed by contact A-scan ultrasound leads to inaccurate AXL measurement and an unsought postoperative refractive consequence. This could be explained by the globe's indentation and the transducer's off-axis measurement of the AXL, which is especially important in highly myopic eyes [3].

The refractive power of the anterior corneal curvature can be measured by the manual keratometer and the refractive power is expressed in diopters (D) [4].

The Bausch & Lomb (B & L) manual keratometer has remained essentially unchanged and is most commonly used [5]. It helps in measuring the curvature of the central 3 mm (mm) of the cornea with readings ranging from 36 D to 52 D [6].

Optical biometry intraocular lens (IOL) Master uses a laser for signal transferring. The interference between the reflected and reference signals is used to calculate the distance between interfaces [7,8].

It uses a red fixation beam to determine the ocular AXL between the corneal vertex and the retinal pigment epithelium along the visual axis [9,10].

Being noncontact, avoiding globe compression, the measurement of AXL with optical biometry has been proved to create more significant specific IOL power calculation and refractive result in cataract surgery [11].

Keratometers that operate automatically have gained widespread acceptance in the field of ophthalmology., it assesses corneal curvature by estimating three beams of near-infrared light with light-emitting diode as a source in a triangular pattern onto a central corneal area of about 3–3.3 mm in diameter [12]. The readings range between 33.75 D and 67.50 D [13].

In this study, AXL, keratometry and IOL measurements obtained by the optical biometry were compared to those of the contact ultrasonography and manual keratometer in patients who had cataract surgery. The refractive accuracy of the patient following surgery was assesed and compared to that of ultrasonography.

The aim of this research was to compare the exactness in expecting refraction postoperatively by measuring IOL power by the optical biometry (IOL Master) and contact A-scan ultrasound plus B&L keratometry after phacoemulsification surgery.

2. PATIENTS AND METHODS

This is a prospective, interventional and randomized research that involved 40 eyes with uneventful phacoemulsification surgery and in the bag IOL of adult patients suffering from cataract and prepared for phacoemulsification with IOL implantation and with a preoperative regular corneal astigmatism less than 2 D.

Exclusion criteria were any patient below the age of 18 years, All cases with dense medial opacities, including those with mature cataracts, dense posterior sub capsular cataract (PSC), cataracts of the posterior polar region in which IOL master couldn’t be performed, corneal or intraocular surgery performed previously (involving refractive surgery), or trauma, corneal opaqueness or abnormalities: previous damaging, dystrophy, dysgenesis and ectasis, lens subluxation and any neurological condition, that interfered with performance of required tests.

Cases were allocated into two equal groups: group A: implanted the IOL power measured by the automated method and group B: implanted the IOL power calculated by the manual method.

All patients were exposed to complete ophthalmic evaluation through obtaining the history (age, sex, occupation, working environment, history of ocular diseases as glaucoma surgery and any ocular medications and history of blurred vision), uncorrected visual acuity (UCVA), best-corrected visual acuity (BCVA), snellen visual acuity were measured and each case was examined using a cycloplegic refraction and a slit lamp.for the purpose of determining the morphology of cataracts, as well as fundus examinations.

2.1 Preoperative Biometry

AXL measurements were first achieved by IOL Master (AXLM) then by applanation ultrasonography (Sonomed US). Five AXL measurements were obtained by applanation ultrasonography and a mean of at least three acceptable measurements was utilized as the AXL.

2.2 IOL Power Calculation

IOL power calculation in all patients was done with automated and manual methods, targeting emmetropia. Automated method using optical biometry (the Zeiss IOL Master 500). Manual method in which keratometry was done with (B&L) and AXL was measured using contact A-scan ultrasound (Sonomed US). The calculation formulas were Holladay I for globes with axial length <22 mm, SRK/II for globes with axial length 22-25 mm and SRK/T for globes with axial length>25 mm.

2.3 Surgery

In the capsular bag, a monofocal foldable IOL was inserted. Each operation was accomplished by the same skilled surgeon. Power of implanted IOL was selected according to the optical and contact biometry results and was compared postoperatively with pre-operative values of ultrasound biometry.

Follow Up: Objective refraction with autorefractometer determining the spherical equivalent was taken 1 month postoperatively and best corrected visual acuities (BCVA) were confirmed using a Snellen chart and compared with the predicted refractive errors in both methods.

2.4 Statistical Analysis

Data were encrypted and enrolled using the statistical package SPSS version 21. In quantitative data, the mean, standard deviation, minimum, and maximum values were calculated; in categorical data, the frequency (count) and relative frequency (%) values were calculated. Numerical error (NE) was calculated as the variance between measured error and the predicted error and absolute error was considered as the complete variation between measured error and the predicted error for each method. Comparisons among variables calculated by IOL master and A-scan were achieved utilizing paired T test in normally distributed data while non-parametrical Wilcoxon test was utilized for non-normally distributed data. Correlation was made to assess for linear interactions between quantitative variables measured by IOL master and A-scan by spearman correlation coefficient (r). P-values less than 0.05 were counted as statistically significant.

3. RESULTS

There was no statistical variance among both groups regarding age, gender and type of cataract Table 1.

There were significant variations in visual acuity preoperatively and postoperatively in both groups regarding to BCVA (p<0.001) and there was no statistical variation regarding to spherical equivalent Table 2.

Axial length measurements were insignificantly different between both groups and there was no variation regarding to pre-operative keratometry. Axial length measurements by IOL master were significantly increase than by A scan in group B (P=0.007) Table 3.

IOL power measured by IOLM in group A was significantly lower than IOL power measured by A-Scan (p =0.004). While the mean IOL power measured by IOLM in group B was significantly lower than IOL power measured by A-Scan (p =0.008). Mean absolute error was insignificantly different between two groups and significantly higher in mean absolute error A scan than mean absolute error in group A (p=0.012) Table 4.

The mean predicted error of IOLM was -0.108 ± 0.462 (P= 0.311) in group A and was 0.053 ±1.092 (P= 0.830) in group B, and the Predicted error of A scan was -0.661 ± 0.686 (P= <0.001) in group A which is statistically significant and -0.340 ± 0.972 (P= <0.134) in group B Table 5.

4. DISCUSSION

The mean axial length in group B calculated using IOL master (AXLM) was 24.353 mm ±1.750 (range 22.6–29.8 mm), while the mean axial length measured using A- scan (AXLUS) 24.222 ± 1.710 mm (range 22.53–29.3 mm). The axial length measured using the IOL master was significantly more 0.13 mm than axial length calculated using A- scan, that is statistically significant (p- value =0.007).

This result agrees with that of Gojal et al 2003 who found in his study that axial length determined with A scan is less than that determined by laser interferometry by a mean of (0.2 mm) [14].

On the other hand, Lam et al (2001) reported that IOL master provided reading lower than those obtained by ultrasound. Lam et al observed 26 young participants with normal media but in our study the contributors were older and had cataract [15].

In our study we found a slight difference in average K readings between both methods. The mean difference was 0.289 ± 0.701 in group A (P-value 0.081), and it was 0.088 ± 0.210 in group B (P-value 0.078).

In this study the average predicted IOL power was significantly lower using IOL master (+18.300 D) compared to ultrasonic technique (where IOL power is +18.800 D) in group A with a difference of 0.500 diopter (P value 0.004*), and also was significantly less in group B using IOL master (+18.075D) compared to ultrasonic technique (where IOL power is +18.600 D) with a difference of 0.525 diopter (P value 0.008*).

The IOL M also provides a faintly well estimation of the refraction postoperatively compared to ultrasound biometry, the postoperative BCVA range was (0.0– 0.3 log MAR) in group A, and it was (0.0– 0.5 log MAR) in group B. (p=0.002*), Both groups had significant disparities in preoperative and after visual acuity (p<0.001*), and the average of postoperative SE was -0.963 ± 0.439 D (range -2 to +0.25 D) in group A and -1.163 ± 0.854 D (range -2.25 to +1.75D) in group B (p=0.356).

This result agrees with other findings of H. Eleftheriadias and S.Gaballa who showen a change of 0.4 diopter in IOL power computation by IOL master and A scan biometry [7,15,16].

Table 1. Age, gender and type of cataract distribution in the study group

		Group A (n=20)	Group B (n=20)	t	P-value
Age		63.650 ± 7.457	65.100 ± 7.553	-0.611	0.545
Gender	Male	10 (50%)	9 (45%)	X^2	0.752
	Female	10 (50%)	11 (55%)	0.100	
Type of cataract	Nuclear	10 (50%)	9 (45%)	X^2	0.092
	Posterior subcapsular	7 (35%)	2 (10%)	6.430	
	Anterior corstical	1 (5%)	1 (5%)		
	Nuclear, Cortical	2 (10%)	8 (40%)		

Data are presented as mean ± SD or frequency (%)

Table 2. Pre-operative and postoperative BCVA and spherical equivalent in the study groups

		Group A (n=20)	Group B (n=20)	t	P-value
BCVA (log MAR)	Preoperative	0.980 ± 0.233	1.015 ± 0.150	-0.565	0.575
	Postoperative	0.185 ± 0.088	0.300 ± 0.126	-3.359	0.002*
	P-value	<0.001*	<0.001*		
Spherical equivalent	Preoperative	-0.625 ± 4.124	-0.500 ± 3.850	-0.073	0.943
	Postoperative	-0.963 ± 0.439	-1.163 ± 0.854	0.934	0.356
	P-value	0.732	0.574		

Data are presented as mean ± SD, BCVA: best corrected visual acuity, log MAR: logarithm of minimal angle of resolution

Table 3. Axial length measurements and pre-operative keratometry in the study groups

		Group A (n=20)	Group B (n=20)	t	P-value
Axial length measurements	by IOL master	24.098 ± 2.527	24.353 ± 1.750	-0.371	0.713
	by A scan	24.016 ± 2.416	24.222 ± 1.710	-0.311	0.757
	P-value	0.280	0.007*		
Pre-operative keratometry	K IOL master	44.744 ± 1.351	44.572 ± 1.462	0.386	0.701
	K Bausch and Lomb keratometry	44.455 ± 1.487	44.484 ± 1.563	-0.061	0.952
	P-value	0.081	0.078		

Data are presented as mean ± SD, IOL: intraocular lens

Table 4. IOL power calculation and mean absolute error in the study groups

		Group A	Group B	t	P-value
IOL power calculation	by A scan	18.800 ± 7.094	18.600 ± 4.035	0.110	0.913
	IOL master	18.300 ± 7.219	18.075 ± 4.363	0.119	0.906
	P-value	0.004*	0.008*		
Mean absolute error	Mean Absolute error IOL master	0.389 ± 0.363	0.592 ± 0.494	-1.481	0.147
	Mean Absolute error A scan	0.616 ± 0.537	0.608 ± 0.573	0.043	0.966
	P-value	0.012*	0.903		

Data are presented as mean ± SD, IOL: intraocular lens

Table 5. Comparison between predicted errors measured by IOL master and those measured by A-scan

Comparison		Differences		Paired Test	
		Mean	SD	t	P-value
Group A	The Predicted error of IOLM	-0.108	0.462	-1.040	0.311
	the Predicted error of A scan	-0.661	0.686	-4.308	<0.001*
	PE IOL master- P A scan	-0.553	0.380	-6.506	<0.001*
Group B	The Predicted error of IOLM	0.053	1.092	0.217	0.830
	the Predicted error of A scan	-0.340	0.972	-1.564	0.134
	PE IOL master- P A scan	-0.393	0.592	-2.969	0.008*

Data are presented as mean ± SD, IOL: intraocular lens, PE: predicted error

The Predicted error (PE) is also referred to as variability from intended refraction and the difference between preoperatively predicted and postoperatively obtained refraction. A negative mean PE implies a proclivity toward myopic refractive results, whereas a positive one reveals a proclivity toward hyperopic refractive outcomes [16].

We noticed that PE proved a small propensity to myopic shift more with A scan method.

In group A the Predicted error of IOLM was -0.108 ± 0.462 D. (P= 311) which is statistically insignificant, and The Predicted error of A scan was -0.661 ± 0.686 D (P= <0.001) which is statistically significant.

The mean difference between means of PEs of the two procedures was -0.553D (P<0.001*) which is statistically significant.

In group B the Predicted error of IOLM was 0.053 ± 1.092 D. (P= 0.830) which is statistically insignificant, and The Predicted error of A scan was -0.340 ± 0.972 D (P= < 0.134) which is statistically insignificant.

The mean difference between means of PEs of the two methods was -0.393 D (P= 0.008*) which is statistically significant.

In general, the whole study showed shorter PEs in IOLM - 0.027 D than A scan -0.500 D.

In group A, mean of absolute errors (MAE) measured by IOLM was 0.389 ± 0.363 D (range 0.0 to 1.10). while the average of absolute of errors (MAE) measured by A Scan was 0.616 ± 0.537 D (range 0.0 to 1.90). (p=0.012*).

In group B Mean of absolute errors (MAE) measured by IOLM was 0.389 ± 0.363 D (range 0.0 to 1.55). Mean of absolute of errors (MAE) measured by A Scan was 0.608 ± 0.573 D (range 0.0 to 1.70). (p=0.903).

The MAE variation between ultrasound and the IOL Master, a further valuable indicator of the correct range of the error, was statistically significant in group A improving a 0.616 D error to 0.389 D and improving a 0.608 D error to 0.389D in group B.

H. Eleftheriadis et al reported that the mean absolute prediction error of IOL Master biometry was significantly lower (p<0.0001) than that of ultrasound 0.25 (0.27) *v* 0.41 (0.38) D .This signifies an enhancement in the refractive result of 39%. [16] Rajan et al., revealed a 16% progress on retrospective IOL power assesment by the IOL Master [7].

Loreto T Rose., et al, reported similar results where MAE alteration between ultrasound and the IOL Master was statistically significant increase a 0.65 D error to 0.42 D. This reproduces a 35% enhancement in absolute refractive error postoperatively with IOL Master than with applanation ultrasound.

Simon R et al, reported that the MAE in patients with implanted PCI-calculated IOLs was 0.40 ± 0.37 D against 0.45 ± 0.41 D for patients with implanted AUS-calculated IOLs. In analyses of best possible results, there was no statistically significant difference in MAE between subjects with implanted PCI-calculated IOLs and those with AUS-calculated IOLs. (t 167 = 1.0, P = 0.315) [17].

5. CONCLUSIONS

The IOL Master accurately estimates the axial length of the lens and thus shows a significantly higher prediction of IOL power and thus refractive outcome in cataract surgery than US biometry. It is simple to utilize and offers a non-contact technique that eliminates the risk of contamination or corneal abrasion.

ETHICAL APPROVAL AND CONSENT

An informed written consent was taken from the patient or relatives of the patients. The study was done after approval from the Ethical Committee Tanta University Hospitals.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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