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Optical Biometry versus Conventional Acoustic Biometry in Post Operative Refraction in Silicon Filled Eyes

Prof. Dr. Hossam Eldein Mohamed Khalil [1], Dr. Sahar Ibrahim Mohammed [1], Dr. Hesham Foad Kamel [2] & Osama Khedr Ibrahim [2]*

[1] *Ophthalmology Department, Faculty of Medicine, Beni-Suef University*

[2] *Ophthalmology Department, Research Institute of Ophthalmology*

Article Info

Corresponding Author:

Osama Khedr Ibrahim

osamakhedr98@gmail.com

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Abstract

Background: The use of traditional ultrasound biometry for intraocular lens (IOL) selection before cataract surgery requires a skilled operator, good corneal surface contact, and significant time expenditure. The introduction of non-contact optical biometry has revolutionized preoperative IOL calculation by eliminating these obstacles. One instrument (Intraocular Lens Master [IOLm]; Carl Zeiss Meditec, Jena, Germany), which uses partial coherence interferometry (PCI) technology, was introduced in 2000. Since then, it had been touted for its fast operation without requiring corneal Contact. ***Aim of the Work:*** To compare intraocular lens (IOL) power calculations for cataract surgery in silicon filled eyes by evaluating postoperative refraction using A-scan biometry versus PCI-based optical biometry. ***Patients and Methods:*** This prospective observational study included 30 eyes scheduled for phacoemulsification and silicon oil removal which was conducted at Ophthalmology Department of Beni-Suef University Hospital on January 2023. Patients came seeking biometry using IOL master & A scan, 30 eyes were chosen. ***Results:*** This study was demonstrated that there is statistically non-significant difference between the studied groups regarding baseline Logmar best corrected visual acuity. While postoperatively, there is statistically significant difference between both groups regarding Logmar BCVA (median postoperative Logmar BCVA was 0.3 versus 0.7 with IOL master and A scan groups respectively). This study was cleared that on assessing predicted SE and actual postoperative SE in both groups, there was statistically non-significant difference. ***Conclusion:*** IOL master is more accurate and reliable method of IOL power calculation resulting in better visual outcomes as compared to A scan acoustic biometry in silicon filled eyes. Further clinical trials are required on eyes with dense cataract and poor visual acuity biometry using IOL master and A scan acoustic biometry.

1. Introduction:

The refractive outcome following cataract surgery and IOL implantation is dependent on a number of factors. They include axial length measurement, keratometry, anterior chamber depth, IOL power formulae, and the quality of the IOL. Of these factors, inaccurate axial length measurements were shown to be the major deterrent to the predictability of the refractive outcome. Studies have shown that an error of 100 µm in axial length measurement could lead to 0.28 D of postoperative refractive error. **[1]**

In phakic eyes, the use of silicone oil endotamponade causes inevitable opacification of the lens. Silicone oil tamponade complicates the ultrasonographic measurement of the axial eye length needed for intraocular lens calculation: the velocity of ultrasound and the refraction of light change, and normally the vitreous cavity is incompletely filled with silicone oil. These problems require experience and skill to be dealt with, however axial length measurement with PCI does not require the same skill and experience in silicone filled eyes. **[2]**

Reports on the use of PCI to measure the axial length in silicone filled eyes are scarce. **Nepp et al. [2]** reported that the measurements using PCI in silicone filled eyes are reliable and are of acceptable accuracy, and this was supported by **Roessler et al. [3]** However, **Wang et al. [4]** report that the axial length values obtained with the IOL Master after removal of silicone oil were lower than the values obtained preoperatively. It is also worth noting that axial length measurements taken with the IOLm were slightly affected by the cataract density but to a lesser extent than ultrasound biometry. **[5]**

2. Patients and Methods:

Study design:

A. Type of study: A prospective observational study

Sample size: 30 eyes were scheduled for phacoemulsification and silicon oil removal.

B. Site of study: Ophthalmology department of Beni-Suef University Hospital. Patients came seeking biometry using IOL master & A scan, 30 eyes were chosen

C. Date and period of the Study:

This study were conducted on January 2023.

D. Ethical considerations:

Patients were enrolled consecutively after the approval of the Ethical Committee of the Beni-Suef University. A written consent was signed by all participants after discussing the procedure, alternative treatment Plans, follow up schedules and possible benefits and risks.

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E. Inclusion criteria:

1. Patients with cataract and silicon filled eyes undergoing phacoemulsification and silicon oil removal
2. Age group 20-80 years oold
3. Sex: Male or female

F. Exclusion criteria:

1. Eventful cataract surgery
2. patients with significant corneal opacity
3. Patients with keratoconus
4. Age group <20 years old

Methodology:

All included patients were subjected to the following:

Preoperative:

- Best corrected visual acuity.
- A noncycloplegic refraction.
- Slit lamp examination.
- Keratometry measurement.
- Axial length measurement
- Fundus examination.
- IOL master 700 was used as an optical biometry & Accutome A scan plus was used as an acoustic biometry

Surgery:

After informed consent, all patients underwent phacoemulsification through a two-step 2.4 mm superior self-sealing clear corneal incision, employing a stop and chop technique. A foldable IOL was implanted in the capsular bag with the injector.

IOL power used aiming for myopia ranging from -0.50D to -1.00D.

Postoperative examination:

One month following the operation *spherical equivalent (SE)* using autorefraction (AutoRef-Keratometer RM8800, topcon) and subjective manifest refraction was performed by the same examiner and best corrected visual acuity (BCVA) was tested using a Snellen chart.

Data analysis:

Data was coded and entered using the statistical package SPSS version 21. Data was summarized using mean ± standard deviation, minimum and maximum in quantitative data and using frequency (count) and relative frequency (percentage) for categorical data. Numerical error (NE) was calculated as the difference between measured error and the predicted error and absolute error was calculated as the absolute difference between measured error and the predicted error for each method. Comparisons between variables measured by IOL master and A-scan were done using paired T test in normally distributed data while non-parametrical Wilcoxon test was used for non-normally distributed data. P-values less than 0.05 were considered as statistically significant.

3. Results:

Table (1): Comparison between the studied groups regarding demographic data

	IOL master group	A scan group	χ^2	p
	N=15 (%)	**N=15 (%)**		
Gender: Female Male	9 (60%) 6 (40%)	12 (80%) 3 (20%)	Fisher	0.427
	Mean ± SD	**Mean ± SD**	**t**	**p**
Age (year)	55.27 ± 8.66	60.0 ± 6.57	-1.686	0.103

χ^2Chi square test t independent sample t test

There is statistically non-significant difference between the studied groups regarding age or gender.

Table (2): Comparison between the two devices IOL master and A scan in measurement of axial length

	IOL master group	A scan group	t	p
	Mean ± SD	**Mean ± SD**		
Axial length	24.64 ± 2.11	24.43 ± 1.99	3.141	0.004*
Mean difference	-0.209			
ICC (95% CI)	0.992(0.983 – 0.996)			
Cronbach alpha	0.992			

ICC test-retest interclass correlation coefficient CI Confidence interval >0.9 is excellent reliability Cronbach alpha≥0.9 is excellent agreement t independent sample t test

There is statistically significant difference between the studied groups regarding axial length by IOL master or A scan when evaluating agreement between IOL master and A scan for calculating IOL in measuring axial length, ICC ranged from 0.983 to 0.996, which reflected excellent reliability. Cronbach alpha was 0.992 demonstrated an excellent agreement.

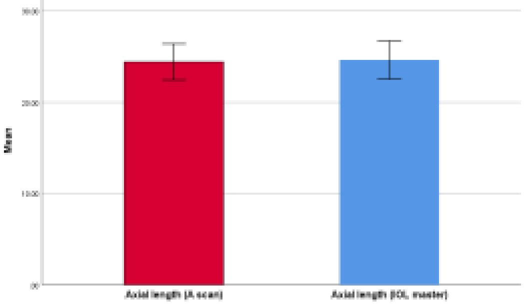

Figure (1): Simple bar chart showing axial length by A scan and IOL master.

Table (3): Comparison between the studied groups regarding predicted and actual refraction as calculated using IOL master

	IOL master group
	Median (IQR)
Predicted refraction	-0.4(-0.59, -0.38)
Actual refraction	-0.75(-1.25, -0.5)
P (Wx)	0.191
Difference	0.37(-1, 0.1)

Wx Wilcoxon signed rank test

On assessing predicted and actual implanted IOL, there was statistically non-significant difference.

Table (4): Comparison between the studied groups regarding predicted and actual refraction as calculated using A scan

	A scan group
	Median (IQR)
Predicted (A scan)	-0.61(-0.82, -0.46)
Postoperative refraction	-0.75(-1.25, -0.25)
P (Wx)	0.955
Difference	-0.29(-0.64, 0.65)

Wx Wilcoxon signed rank test

On assessing predicted refraction and actual postoperative refraction, there was statistically non-significant difference.

Table (5): Comparison between the studied groups regarding predicted and actual refraction as calculated

	IOL master group	A scan group	Z	p
	Median (IQR)	Median (IQR)		
Actual refraction	-0.75(-1.25, -0.5)	-0.75(-1.25, -0.25)	0.691	0.713

Z Man Whitney test

On assessing actual refraction among studied groups, there was statistically non-significant difference.

4. Discussion:

Silicon oil is used as a tamponading agent, worldwide in retinal detachment surgeries. It is specifically used to displace retina towards eye wall (through surface tension) and fill retinal breaks (as a result of lower specific gravity). Silicon oil is associated with prevention of proliferative vitreoretinopathy (PVR). **[6]**

Cataract formation after vitreoretinal surgeries is common. Almost up to 80 percent eyes develop cataract in maximally 24 months of vitrectomy.

Several factors are involved in cataract formation including surgical stress, direct trauma to posterior capsule during surgery, posterior capsular ischemia, Light toxicity, direct oxidative damage to lens proteins, vitreous substitutes as silicon oil causes cataract by inducing epithelial metaplasia due to inhibition of lens metabolism or by direct contact causing mechanical damage. **[7]**

The development of a cataract is common in silicone-oil filled phakic eyes often necessitating cataract removal, intraocular lens implantation and removal of oil in one surgical procedure. The success of this procedure depends on an accurate IOL power calculation to minimize postoperative refractive errors. Different techniques have been considered to address the problem of ultrasound biometry in silicone oil filled-eyes, each with its own limitations. **[8]**

Intra-ocular lens (IOL) power calculation is very challenging in silicon filled eye for phacoemulsification. Axial length is a definitive variable required in all power calculation formulas measured by acoustic biometry or optical biometry (preoperatively). Axial length measurement in optical biometry is based on non-contact partial coherence laser interferometry (signals of retinal pigment epithelium) principle while in acoustic biometry is based on A scan ultrasound method (signals from internal membrane). Moreover, A scan biometry is usually done with two principle techniques; applanation and immersion technique. **[9]**

The measured AL using applanation A-scan ultrasound will be inaccurately shorter with corneal indentation in highly myopic eyes due to globe indentation with incorrect AL measurement and an undesired postoperative refractive outcome. **[10]**

More than 10 years ago, the IOL Master optical biometer was introduced into clinical practice. Over time, optical biometry has replaced ultrasonography as the standard technique for AL measurements of the eye. Optical biometry utilizes a laser for signal transmission. Interference phenomenon between the reflected signal and the reference signal is utilized to determine distances between interfaces. Only data with a signal-to-noise value higher than 2.1 were recorded and were ideal measurements (for the IOL Master). Previous comparisons of applanation ultrasound and optical biometry have reported equal or better results with optical biometry. Being noncontact, avoiding globe compression, the measurement of AL with partial coherence interferometry (IOL Master) has been shown to produce significantly more precise IOL power calculation and refractive outcome in cataract surgery. **[11]**

Applanation ultrasound is still considered a common method to measure AL worldwide, especially in developing countries, due to familiarity with the technique and its low cost compared with IOL Master. **[12]**

The aim of this work is to compare intraocular lens (IOL) power calculations for cataract surgery in silicon filled eyes by evaluating postoperative refraction using A-scan biometry versus PCI-based optical biometry.

In this study we found that there is statistically non-significant difference between the studied groups regarding age or gender.

In the **Mary [13]** study, patients undergoing preoperative biometry were randomly assigned to undergo either A scan ultrasonography (50 eyes) or PCI optical biometry (50 eyes). There were no significant differences between these groups in the mean age (60.82±10.5 years in the IOL master group, 60.64±11.2 years in the A scan ultrasonography group), and also no significant differences in age distribution and gender distribution; that is, the patients in the groups were age and gender (sex)- matched.

In this study we demonstrated that there is statistically significant difference between the studied groups regarding axial length by IOL master or A scan when evaluating agreement between IOL master and A scan for calculating IOL in measuring axial length, ICC ranged from 0.983 to 0.996, which reflected excellent reliability. Cronbach alpha was 0.992 demonstrated an excellent agreement.

Rajurkar et al. [11] found that the mean ± SD of change in AL (mm) in A-scan was 0.31 ± 0.39, which was significantly higher compared to IOL Master (−0.01 ± 0.19) (P < 0.0001).

Similar findings were reported by **Ueda et al. [1]** while comparing the mean AL measured with IOL Master and A-scan pre- and post-SiO removal. They noted there was no statistically significant difference (P = 0.463) in the mean AL measured with IOL Master pre- and postoperatively, while the pre- and postoperative AL measured by conventional acoustic A-scan showed a statistically significant difference (P = 0.004).

Kunavisarut et al. [14] also obtained similar results while comparing the AL measurements obtained using A-scan immersion biometry and IOL Master before and after SiO removal. They observed the preoperative mean AL to be 23.91 ± 0.24 mm (range 21.33–28.61 mm) and 23.71 ± 0.59 mm (range 19.27–36.18 mm) by IOL Master and A-scan immersion, respectively. The postoperative mean AL by IOL Master was 23.90 ± 0.23 mm (range 21.58–27.94 mm), which showed a statistically significant difference from the preoperative mean AL by A-scan immersion (P = 0.005) and no significant difference from the preoperative AL by IOL Master.

Kunavisarut et al. [14] found that the preoperative AXL measured by A-scan immersion (range 19.27–36.18 mm) had a wider range than that measured by IOL master (range 21.33–28.61 mm), and also a higher variable when compared with the postoperative AXL (range 21.58–27.94 mm). In addition, the postoperative and target refraction range differed between −14.62 and 16.41 D in the A-scan immersion group and −2.74 and 2.33 D in the IOL master group. These findings indicated that A-scan immersion biometry had a higher deviation. Factors of high deviation included an eye with AXL >25 mm and aphakia status.

Elsaadani et al. [15] found that Group 1 (A-scan ultrasound biometry group) Included 50 eyes subjected to biometry with A-Scan ultrasound biometry. There were 22 eyes of 22males (44%), and 28 eyes of 28 females (56%). And the mean age was 58.4 ± 10.13years. While Group 2 (Optical biometry (IOL Master group)) Included 50 eyes subjected to biometry with IOL Master Optical biometry. The mean axial length of the patient in Group I was (23.95 ± 0.89 mm) with minimum axial length 23.02 mm and maximum axial length 24.84mm, while, in group, II was

(23.17 ± 0.64mm) with minimum axial length 22.53 mm and maximum axial length 23.81 mm. In this study we found that there is statistically non-significant difference between the studied groups regarding implanted IOL.

Farahat et al. [16] found that the IOL power ranged from +14.5 to −7.5 D and from +13.0 to −4 D in the IOL Master and the ultrasound group, respectively.

In this study we illustrated that there is statistically non-significant difference between the studied groups regarding postoperative SE

Mary [13] found that the mean post-operative spherical equivalent was 0.57±0.34 D in the PCI optical biometer (IOLMaster) group and 0.63±0.39 D in the A scan ultrasonography group; this difference was not statistically significant.

In a similar study done by **Rajan et al. [1],** the post-operative mean absolute error (MAE) was 0.6±0.4 D in patients who underwent ultrasound biometry, which was not significantly different from the value obtained (0.52±0.35 D) in the IOLMaster group.

Farahat et al. [16] found that the postoperative SE was less than ±1 D in 68% of patients in the IOL Master group and 44% in the ultrasound group. Using the data given by the IOL Master to calculate the IOL, we obtained good refractive outcome

In this study we found that on assessing predicted and actual implanted IOL in both groups, there was statistically non-significant difference

In a postoperative study of 140 consecutive eyes undergoing cataract surgery, **Kutschan and Wiegand [17]** found that both contact ultrasound biometry and the IOLMaster were similar in their predictive capabilities, and concluded that the IOLMaster was easier to use.

This study cleared that on assessing predicted SE and actual postoperative SE in both groups, there was statistically non-significant difference

Gantenbein et al. [18] set up high precision and reproducibility with both methods postoperatively compared to the preoperative aim (P<0.001). There was no statistical difference in the mean absolute error between the two groups.

El-Baha and Hemeida [19] found that comparing the predictability of intraoperative Ascan biometry and IOL Master biometry, the two techniques showed small predictive postoperative refractive errors without a statistically significant difference in the predictive errors of the two techniques (intraoperative A-scan biometry: 0.65 0.46 D, IOL Master biometry 0.59 0.38 D).

Limitations

Small sample size and the fact that the study was conducted in one location limit the study's generalizability. Further multi-center study with larger sample size is essential to establish our results.

5. Conclusion:

IOL master is more accurate and reliable method of IOL power calculation resulting in better visual outcomes as compared to A scan acoustic biometry in silicon filled eyes. Further clinical trials are required on eyes with dense cataract and poor visual acuity biometry using IOL master and A scan acoustic biometry.

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