



2023

Section: Ophthalmology

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### How to Cite This Article

Ahmed, Abd El Moez Haddad; Ghany, Abd El Ghany Ibrahim Abd El; and Mostafa, Hesham Abd El Gawad (2023) "Comparison between Conventional Ultrasound biometry and Optical biometry in preoperative Intraocular Lens Power Calculation in cataractous emmetropic patients," *Al-Azhar International Medical Journal*: Vol. 4: Iss. 10, Article 24.

DOI: <https://doi.org/10.58675/2682-339X.1966>

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# Comparison Between Conventional Ultrasound Biometry and Optical Biometry in Preoperative Intraocular Lens Power Calculation in Cataractous Emmetropic Patients

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## Abstract

**Background:** The most common type of ophthalmic surgery performed nowadays is cataract removal followed by the insertion of an intraocular lens (IOL).

**Aim:** The purpose of this study was to compare the accuracy of predicting refractive outcomes between conventional ultrasonic and IOL master in emmetropic eyes with varying axial lengths (22–24 mm).

**Subject and methods:** This prospective case study lasted for a total of six months, the period from May 2022 to November 2022 in the ophthalmology department of memorial institute of Ophthalmology Hospital and sayed galal Hospital, Al-Azhar University scheduled for patients underwent biometry by both IOL Master and ultrasound biometry. All patients underwent phacoemulsification surgery. Three months following cataract surgery, the postoperative visual acuity and refractive error tests were conducted.

**Results:** our study found that the average amount of refractive error by A-Scan was  $0.53 \pm \text{SD } 0.35$  (ranging from 0.05 to 1.24). The mean refractive error as measured by IOL Master was  $0.22 \pm \text{SD } 0.19$  (ranging from 0.03 to 0.74), and Regarding postoperative outcomes, Master intraocular lens patients were not differentiated from A scan patients BCVA while the refractive errors were significantly decreased in intraocular lens Master group.

**Conclusion:** The IOL Master is quick and friendly to be used and does not need an eye contact with no risk of disease transmission and most patients are comfortable with its use. This method yields a more precise axial length measurement, which in turn allows for a more precise calculation of the IOL's power and an improved refractive state after surgery.

**Keywords:** Cataractous, Conventional ultrasound biometry, Emmetropic, Intraocular lens power, Optical biometry

## 1. Introduction

The most common type of ophthalmic surgery performed nowadays is cataract removal followed by the insertion of an intraocular lens (IOL). The difficulty of accurately predicting the power of the IOL needed to achieve the target postoperative refraction has not, however, been resolved after years of study.<sup>1</sup>

Biometric studies using pre- and post-operative ultrasonography reveal that AXL measurement

errors account for 54% of postoperative refraction problems, corneal power measurement errors account for 8%, and incorrect evaluation of postoperative (ACD) anterior chamber depth accounts for 38%.<sup>2</sup>

The distance from the central cornea to the retinal pigment epithelium may be calculated with the use of partial coherence interferometry, which is what IOL Master employs.<sup>3</sup>

The lens implant power for cataract surgery may be determined quickly and painlessly with IOL

Accepted 27 April 2023.  
Available online 20 November 2023

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<https://doi.org/10.58675/2682-339X.1966>

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Master's Partial Coherence Interferometry (PCI). Compared to ultrasound biometry, it has been said to have a higher potential for accuracy.<sup>4</sup>

The IOL Master will fail to work if there is too much axial opacity. A mature or darkly brunescient lens, a thick posterior subcapsular (PSC) plaque, vitreous hemorrhage, or a central corneal scar can all prevent precise measurements from being taken.<sup>5</sup> The purpose of this study was to evaluate the refractive result prediction of conventional ultrasound versus IOL master in emmetropic eyes with axial length (22–24 mm).

## 2. Patients and methods

This case study lasted for 6 months, the period from May 2022 to November 2022 in ophthalmology department of memorial institute of ophthalmology Hospital and sayed galal Hospital, Al-Azhar University scheduled for patients underwent biometry by both IOL Master and ultrasound biometry. All patients underwent phacoemulsification surgery. Postoperative routine examination (slit lamp, fundus and IOP). The postoperative visual acuity and refractive error was carried out 3 months after cataract surgery.

**Ethical Approval:** Institutional review board permission was obtained before research initiation. All consecutive patients in memorial institute of ophthalmology Hospital and sayed galal Hospital, Al-Azhar University who underwent for phacoemulsification surgery between May 2022 to November 2022 for symptomatic eye cataract. All participants were informed of the study's methods and given the option

to drop out or discontinue participation at any time, with no explanation required.

### 2.1. Patients criteria

**Inclusion criteria:** Emmetropic Patients with cataract and both males and females were included.

**Exclusion criteria:** Opacities in the cornea, history of eye surgery, history of penetrating ocular trauma, patients with retinal detachment or optic nerve atrophy and patients with Severe dryness Fig. 1.

## 3. Methods

All included patients were subjected to the following: Gathering background info, such as names, ages, and sex identities. An evaluation of preexisting ocular and general health conditions.

**Ophthalmic examination: had included:** Tests of both uncorrected and corrected vision, slit-lamp examination, fundus examination using a volk 90 lens, and intraocular pressure measurement using a keeler applanation tonometer.

**Surgery Procedure:** After patient agreement, phacoemulsification was performed using a stop-and-chop approach through a 2.8 mm temporal self-sealing clear corneal incision. A foldable intraocular lens (IOL) was implanted into the capsular bag using the Unfolder, and its power was established by the least predicted refractive error obtained from the optical biometry findings and the scan results, which were then compared to the values obtained prior to surgery.

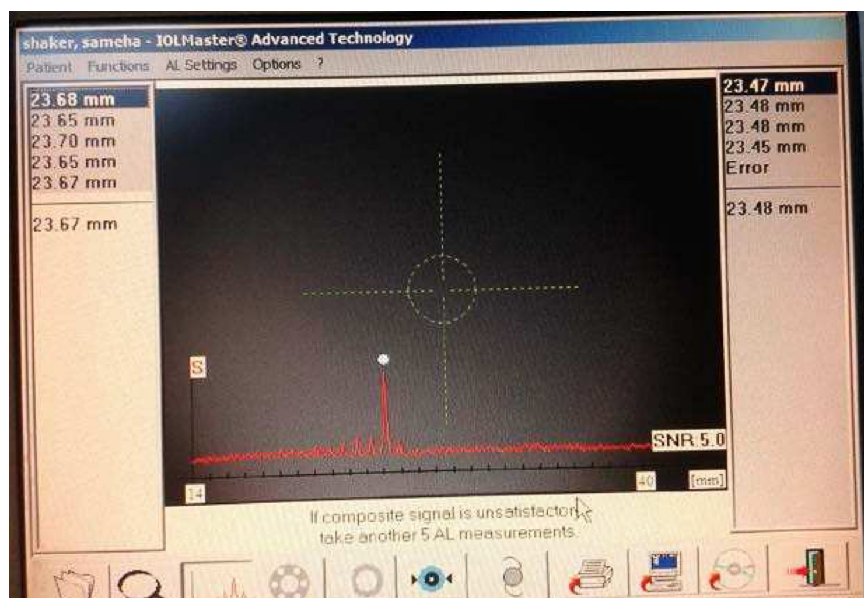


Fig. 1. Example for axial length measurement using IOL Master AXL measuring 23.67 mm.

Table 1. Demographic characteristics of the studied groups.

	No. = 40
Age	
Mean $\pm$ SD	54.45 $\pm$ 6.82
Range	42–72
Sex	
Female	26 (65.0%)
Male	14 (35.0%)
Type of cataract	
PSC	13 (32.5%)
Ant.cortical	5 (12.5%)
NC III	12 (30.0%)
NC IV	10 (25.0%)

**Postoperative Examination:** At the last follow-up appointment, which was about three months after the surgery, the same examiner measured the patient's spherical equivalent (SE) with an Autorefraction (AutoRef-Keratometer TOPCON 800) and the patient's subjective manifest refraction. They checked the patient's intraocular pressure, examined

the fundus, and determined the patient's best-corrected visual acuity (BCVA) using a Snellen chart.

### 3.1. Statistical analysis

IBM's statistical analysis program, SPSS, version 20.0, was used to process the data. The qualitative information was defined using IBM's (Armonk, NY: IBM Corp) descriptions. The Shapiro-Wilk test was used to make certain that the data were distributed properly. Maximum and minimum values, as well as averages, standard deviations, medians, and inter-quartile ranges, were used to characterize the quantitative data (IQR). At the 5% level of significance, the findings were considered to be significant.

## 4. Results

Tables 1–5, Figs. 2 and 3.

Table 2. Comparison between intraocular lens Master group and A scan group as regards Keratometry readings.

	A-scan group No. = 20	IOL-master group No. = 20	Test value	P value	Sig.
K1 readings					
Mean $\pm$ SD	44.68 $\pm$ 1.00	44.08 $\pm$ 1.73	1.325	0.193	NS
Range	42.25–46.5	41.25–46.5			
K2 readings					
Mean $\pm$ SD	45.93 $\pm$ 1.00	45.34 $\pm$ 1.69	1.338	0.189	NS
Range	43.75–47.27	41.75–47.25			

P-value more than 0.05: Nonsignificant (NS); P value < 0.05: Significant (S); P value less than 0.01: very significant (HS).

Table 3. Comparison between intraocular lens Master group and A scan group as regards Preoperative BCVA, IOL power and predicted Error.

	A-scan group No. = 20	IOL-master group No. = 20	Test value	P value	Sig.
Pre-operative BCVA					
Mean $\pm$ SD	−0.82 $\pm$ 0.54	0.84 $\pm$ 0.55	−0.219 <sup>b</sup>	0.887	NS
Range	0–1.3	0–1.3			
IQL Power					
Mean $\pm$ SD	20.35 $\pm$ 1.73	21.13 $\pm$ 2.86	−1.038 <sup>a</sup>	0.306	NS
Range	18–24	16–25			
Predicted Error					
Mean $\pm$ SD	−0.29 $\pm$ 0.15	−0.38 $\pm$ 0.21	−1.538 <sup>b</sup>	0.113	NS
Range	−0.64 to −0.05	−0.72 to −0.05			

P-value >0.05: Non significant (NS); P-value less than 0.05: Significant (S); P value < 0.01: very much significant (HS).

<sup>a</sup> Independent *t*-test.

<sup>b</sup> Mann Whitney test.

Table 4. Comparison between intraocular lens Master group and A scan group as regards Axial length.

Axial Length	A-scan group No. = 20	IOL-master group No. = 20	Test value <sup>a</sup>	P value	Sig.
Mean $\pm$ SD	22.93 $\pm$ 0.50	22.98 $\pm$ 0.53	−0.312	0.757	NS
Range	22.22–24	22.2–23.9			

P-value >0.05: Non significant (NS); P-value less than 0.05: Significant (S); P value less than 0.01: highly significant (HS).

<sup>a</sup> Independent *t*-test.

Table 5. Comparison between intraocular lens Master group and A scan group as regards postoperative refraction and BCVA.

Post-operative	A-scan group No. = 20	IOL-master group No. = 20	Test value <sup>a</sup>	P value	Sig.
Refraction					
Mean ± SD	-0.81 ± 0.44	-0.64 ± 0.26	-1.193	0.233	NS
Range	-1.75 to -0.25	-1 to -0.25			
BCVA					
Mean ± SD	0.02 ± 0.05	0.00 ± 0.00	-1.433	0.152	NS
Range	0-0.176	0-0			

P-value more than 0.05: Non significant (NS); P-value less than 0.05: Significant (S); P-value < 0.01: very significant (HS).

<sup>a</sup> Mann Whitney test.

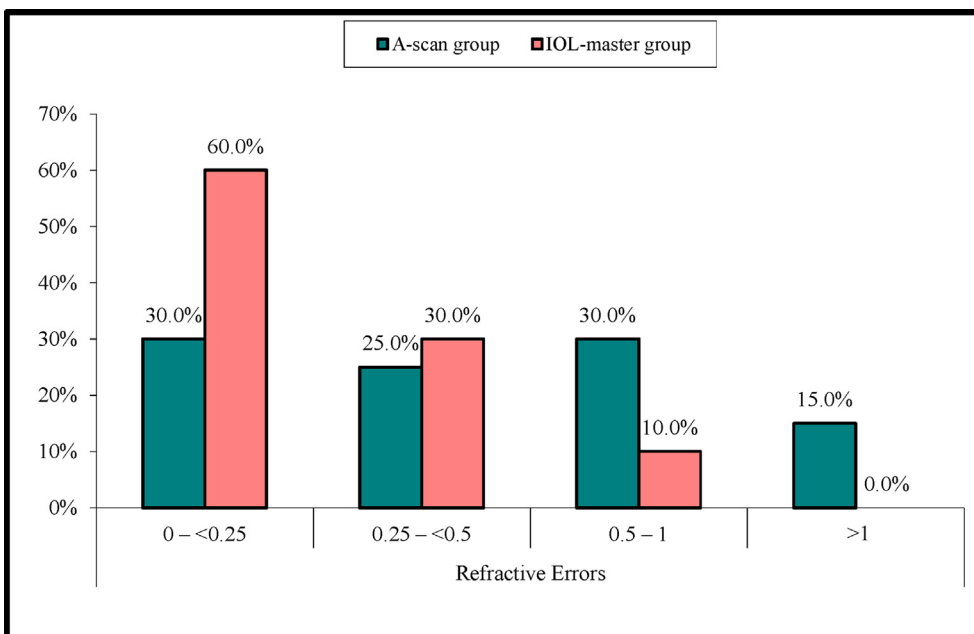


Fig. 2. Comparison between intraocular lens Master group and A scan group as regards different categories of refractive errors (absolute error).

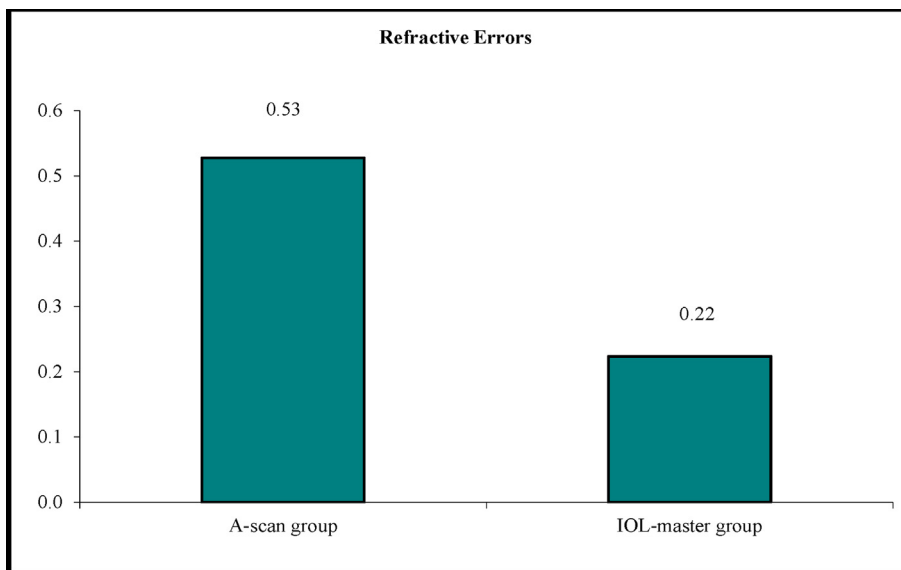


Fig. 3. Comparison between intraocular lens Master group and A scan group as refractive error (MAE) in diopters.

## 5. Discussion

Many biometric characteristics, including axial length (AXL), keratometry (K), and anterior chamber depth (ACD), are used to establish the appropriate power of an intraocular lens (corneal epithelium to lens). The most crucial aspect in determining the power of the intraocular lens (IOL) is the preoperative assessment of axial length (AXL).

An exact IOL power formula and precise preoperative measurements are required for best results during cataract surgery.<sup>6</sup>

Tertiary care hospital was the setting for this prospective investigation at Giza Memorial Institute of Ophthalmic Research and Sayed Galal hospital from May 2022 till November 2022 and implemented on a total of 40 emmetropic eyes of patients who diagnosed with cataract.

In the end, the analysis was based on the information from 40 emmetropic eyes of cataract patients.

In our study Preoperative BCVA was  $0.82 \pm 0.54$  in A scan group and  $0.84 \pm 0.55$  in IOL Master group the two approaches had an average difference of 0.219.

The mean IOL power calculated by IOL Master was  $+21.13D \pm 2.86$  (ranging from +16D to +25 D). IOL power measured by A-Scan was  $+20.35 \pm 1.73D$  (ranging from +18.00 to +24.00 D). For the two approaches, there was a mean difference of  $-1.038$ .

The predicted error as measured by IOL Master was  $-0.38 \pm 0.22$  (ranging from  $-0.72$  to  $-0.05$ ). The predicted error as measured by A-Scan was  $-0.29 \pm 0.15$  (ranging from  $-0.64$  to  $-0.05$ ). For the two approaches, there was a mean difference of  $-1.583$ .

Preoperative best-corrected visual acuity (BCVA) ( $P$  value = 0.827), IOL power ( $P$  value = 0.306), and projected error ( $P$  value = 0.113) were not significantly different between the A-scan group and the IOL-master group.

These results corroborate those of prior research. Prospective research was performed by Gad *et al.*<sup>7</sup> that enrolled 32 eyes of 32 patients (8 men and 24 women) who scheduled for phacoemulsification and IOL implantation after undergoing routine ophthalmological examination the mean  $\pm$  SD IOL power calculated by IOL Master was  $+13.50 \pm 7.80D$ , which was lower than that calculated by A-Scan, which was  $+13.63 \pm 9.05D$ , in emmetropic eyes. This comparison was made to assess the accuracy of preoperative IOL power results evaluated by IOL Master vs AUS biometry regarding postoperative refractive error. The two techniques had a 0.125 mean difference ( $P = 0.930$ ), which was statistically insignificant and the predicted error was  $-0.35 \pm 0.16$  by IOL Master and

was  $-0.40 \pm 0.21$  as measured by A-Scan with no statistically significant among them ( $P = 0.564$ ). For the two approaches, there was a mean difference of 0.0475, which was statistically insignificant.<sup>7</sup>

Additionally, Paul,<sup>8</sup> appointed 234 patients for a prospective study to assess assessment of axial length and calculation of intraocular lens (IOL) power before to cataract surgery, similarity between applanation ultrasonic biometry and optical biometry and its effect on refractive outcomes after surgery. His findings supported ours in that The ultrasound method yielded a mean IOL power prediction  $\pm$ SD of  $20.98 \pm 2.68$  D in the study eyes, while the optical biometry method yielded a mean IOL power prediction  $\pm$ SD of  $20.89 \pm 2.85$  D ( $P = 0.72$ ).

Salouti *et al.*<sup>9</sup>'s prospective study, which included 229 eyes scheduled for phacoemulsification cataract surgery and evaluated by optical and ultrasound-based biometry, corroborates with our findings they compared a working prototype of a new partial coherence interferometry biometer with the IOL Master and conventional A-scan applanation ultrasonography for biometric values measurements (such as axial length, keratometry, anterior chamber depth, IOL power) and revealed that the mean IOL power measurements with IOL Master and ultrasound were  $19.87 \pm 3.91$  and  $19.88 \pm 3.87$  respectively.

As regards the axial length, the mean AXL measured with the IOL Master in our research was  $22.98 \pm 0.53$  mm (range: 22.2–23.9 mm). A-scan revealed a mean AXL of  $22.93 \pm 0.50$  mm (range: 22.22–24 mm). A difference of 0.312 was found on average between the two approaches.

Axial length did not vary significantly between the Master intraocular lens group and the A scan group ( $P = 0.757$ ).

In agreement with our findings, Gad *et al.*,<sup>7</sup> indicated that the difference between the axial lengths determined by the IOL Master and the A-scan was 0.34 mm, which was statistically insignificant ( $P = 0.2112$ ).

Paul,<sup>8</sup> confirmed our findings by showing that no statistically significant variations in the mean axial length measured by optical biometry and ultrasonography in the study eyes ( $P = 0.19$ ), which was  $23.46 \pm 1.01$  mm and  $23.57 \pm 0.99$  mm, respectively. In contrast to our findings, Nakhli,<sup>10</sup> reported statistically significant differences as regards axial length when comparing measurements between IOL Master and ultrasound for emmetropic eyes. Applanation ultrasonography revealed an average AL of  $23.86 \pm 1.85$  mm (range: 19.01–29.27 mm), whereas optical biometry yielded a similar result ( $23.76 \pm 1.87$  mm) (range: 19.29–29.88 mm). The IOL

master's AXL was 0.21 mm longer ( $P = 0.033$ ) than the other.

Because of this, it's possible that the anatomy of the posterior pole of the eye is comparably small, and a slight deviation in position can alter the path taken by an ultrasonic signal emanating from the fovea.<sup>7</sup>

As regards the keratometry, Preoperative K1 and K2 keratometry values not vary significantly ( $P = 0.193$  and  $P = 0.289$ ) between the Master intraocular lens group and the A scan group.

These findings were also supported by another study which showed that the mean Keratometry measurements assessed by ultrasound was  $44.56 \pm 1.84$  D and by IOL master was  $44.61 \pm 1.84$  D with no statistically significance among the studied groups ( $P < 0.05$ ).<sup>9</sup>

Postoperatively, in our study the mean refractive error as measured by A-Scan was  $0.53 \pm$  SD 0.35 (ranging from 0.05 to 1.24). The mean refractive error as measured by IOL Master was  $0.22 \pm$  SD 0.19 (ranging from 0.03 to 0.74). The mean change between the two techniques was  $-2.950$ .

Postoperative BCVA did not change between the Master and A scan groups, however refractive errors were reduced more in the Master group ( $P = 0.003$ ).

Our findings are consistent with those of Gad *et al.*,<sup>7</sup> who found that all 227 eyes improved to 6/18 or better after surgery, with 204 eyes (89.87percent) reaching 6/6 vision with no statistically significant difference between the IOL Master and AS mean absolute errors of 0.19 SD 0.1417 and 0.561 SD 0.623, respectively. There was a statistically significant mean difference of 0.371 ( $P = 0.0385$ ) between the 2 approaches.

In considering the ultrasound and the IOL Master technologies, we will find the difference MAE, a better helpful measure to find the true estimation of the error, being statistically significant to improve from a 0.561 D. error (MAE as measured by A-scan) to only a 0.19D error (MAE as measured by IOL Master). This denotes significant improvement of 66% in absolute postoperative refractive error measured by IOL Master in comparison with that measured by Applanation ultrasound.<sup>7</sup>

There were no patients lost to follow-up, the study was carried out prospectively, and two distinct approaches to estimating IOL power were included and compared. Moreover, the study was performed at two institutions with only two surgical teams and the same anesthetic protocol, which likely increased the validity of our results.

It's important to note the research's caveats, such as its smaller sample size compared to past studies

and the substantial risk of publication bias this poses because it wasn't a multicentric study.

### 5.1. Conclusion

The IOL Master is quick and friendly to be used and does not need an eye contact with no risk of disease transmission and most patients are comfortable with its use. It measures the real axial length, which allows for a more accurate estimation of the IOL's power and a better refractive outcome after surgery.

### Disclosure

The authors have no financial interest to declare in relation to the content of this article.

### Authorship

All authors have a substantial contribution to the article.

### Conflicts of interest

The authors declared that there were NO conflicts of Interest.

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