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COMPARISON OF IOL MASTER AND ULTRASOUND A-SCAN BIOMETRY IN POST-OPERATIVE REFRACTIVE OUTCOME AFTER CATARACT SURGERY

Dr. Bushra Ashraf[*1], Dr. Najam Iqbal Ahmad[2], Dr. Humera Zafar Ali Khan[3], Dr. Sana Akhtar[4], Dr. Muhammad Itban Jamil[5], Dr. Khurram Chauhan[6]

[*1]*MBBS, Post Graduate Trainee (FCPS Ophthalmology), Department of Ophthalmology at Sir Ganga Ram Hospital, Lahore.*
[2] *MBBS, FCPS, MRCS, CHPE, Associate Professor, Department of Ophthalmology, Sir Ganga Ram Hospital, Lahore.*
[3] *MBBS, FCPS and MCPS (HPE), Professor /Head of Department (HOD) of Ophthalmology, Sir Ganga Ram Hospital, Lahore.*
[4] *MBBS, FCPS Trainee, Department of Ophthalmology, Sir Ganga Ram Hospital, Lahore.*
[5] *MBBS, FRCOPHTH, Postgraduate Resident (PGR), Department of Ophthalmology, Sir Ganga Ram Hospital, Lahore.*
[6]*MBBS, FCPS (Ophthalmology), and FCPS (VRO) qualifications, Senior Registrar, Department of Ophthalmology, Sir Ganga Ram Hospital, Lahore.*

[*1]ashrafbushra0@gmail.com

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Corresponding Author: *
Dr. Bushra Ashraf

Abstract

Objective: *To compare the efficacy of IOL Master optical biometry and ultrasound a-scan biometry in achieving post-operative refractive outcome after cataract surgery.*

Study Design: *Quasi Experimental Study*

Place and Duration of Study: *Department of Ophthalmology at Sir Ganga Ram Hospital, Lahore, over a period of three months w.e.f. 21-10-2025 to 21-01-2026.*

Methodology: *After ethical review approval, patients were screened by taking ocular history and performing a clinical examination and allocated two groups on non-random basis. Preoperative assessment included BCVA and UCVA with a Snellen chart, slit-lamp and fundus examination, and autorefraction for astigmatism and refractive error. Group A underwent IOL Master 700 biometry, while Group B had keratometry with HUVITZ MRK-3100 and ultrasound A-scan. Patients received anesthesia with 0.5% proparacaine eye drops, underwent phacoemulsification, and were followed on day 1, week 1, month 1, and month 3 for visual outcomes and complications.*

Results: *Sixty patients were equally divided into IOL Master and ultrasound A-scan groups. Baseline characterizes were comparable between the groups i.e. UCVA ($p=0.973$), BCVA ($p=0.791$), and refractive error ($p=0.647$). IOL Master group was much more successful in postoperative UCVA and BCVA ($p<0.05$). One month later, the results regarding refraction were also better ($p<0.05$).*

Conclusion: *This study demonstrates that IOL Master optical biometry provides more precise IOL power calculations and superior postoperative visual and*

refractive outcomes compared to ultrasound A-scan, while baseline ocular parameters were comparable. Optical biometry is therefore recommended for routine cataract surgery to optimize uncorrected and best-corrected visual acuity and refractive accuracy.

INTRODUCTION

Visual impairment is considered as one of the significant health complexes worldwide and cataract is one of the most common causes of reversible blindness.[1] Over 26 million cataract surgeries are done each year.[2] Procedure volume is rising with a compound annual rate of 3.1 due to the demographic changes and availability of more medical services, with the type and location of IOL, incision size, and proper preoperative biometry being the most crucial factors influencing the success of phacoemulsification in offering optimality of visual results.[3,4]

Biometry is performed by measuring the axial eye length (AEL) and keratometry (K) of the eyes and using special formulas to estimate the optimal IOL power.[5] IOL calculations have traditionally involved the use of the applanation ultrasound (US) biometry as the means of measuring the postoperative refractive outcomes. It works by ultrasound waves through a probe resting on the cornea, usually at 10 MHz and evaluating their reflection by the ocular tissues.[6] The contact technique, however, may flatten cornea and cause a lot of shortening of the axial length thus creating a lot of postoperative refractive error as the error of 1 mm could create a refractive error of 3.00-3.50 diopters. The non-contact based, highly reproducible, and observer-independent optical biometry, which is founded on partial coherence interferometry (PCI), is now the method of choice.[5,6]

The clinical differences between ultrasound and optical biometry are considerable. Optical biometry achieves higher resolution due to the shorter wavelength of laser light, allowing axial length measurements with approximately 0.012 mm accuracy, compared to 0.10–0.12 mm with ultrasound.[7] Additionally, the two techniques measure AEL along different axes: ultrasound measures from the corneal vertex to the internal limiting membrane of the fovea, whereas optical biometry measures from the cornea's second principal plane to the photoreceptor layer. These differences affect IOL power predictions and postoperative spherical equivalents.[8,9] To enhance surgical precision, multiple generations of IOL calculation formulas have been developed, including theoretical and regression-based formulas. The SRK/T formula, a third- and fourth-generation theoretical formula, calculates anterior chamber depth while integrating retinal thickness and corneal refractive index, ensuring more accurate lens selection and improved visual outcomes.[10,11]

Optical biometry has been shown to provide higher precision and better refractive accuracy, as reported by Surapaneni et al., though A-scan ultrasonography remains essential in resource-limited settings.[12] Conversely, Mazhry et al. found no significant difference between optical and ultrasonic methods, suggesting that both techniques can achieve comparable results in certain contexts.[13] Therefore, this study was planned to compare these techniques, considering that optical biometry has demonstrated higher precision and superior refractive accuracy, with the benefit of guiding optimal IOL selection, improving postoperative visual outcomes, and reducing refractive errors in diverse clinical settings.

METHODOLOGY

The sample size was calculated based on the mean difference in postoperative refractive error reported in previous studies, accounting for a 20% dropout rate. Using a significance level of 95% ($Z1\text{-}\alpha/2$), expected mean changes in refractive error for the optical biometry group ($\mu1 = 0.14$, $\delta1 = 0.695$) and ultrasound A-scan group ($\mu2 = 0.6$, $\delta2 = 0.622$), and study power of 80% ($Z1\text{-}\beta$), the calculated sample size per group was 30.[13]

Patients were unaware about type of intervention. Treatment allocation was non-random, dividing patients into two groups: Group A (IOL Master Optical Biometry) and Group B (Ultrasound A-scan Biometry).

Inclusion criteria included patients aged above 40 years of any gender, diagnosed with cataract, and scheduled for phacoemulsification with IOL implantation. Patients with previous ocular surgery, ocular trauma, glaucoma, corneal disease. Informed consent was obtained from all participants, and a predesigned proforma was used for systematic data collection.

Biometry included measurement of axial eye length (AEL) and keratometry (K) readings, analyzed with standard formulas to determine the optimal IOL power. Keratometry was performed to measure the anterior corneal curvature accurately. Group A underwent biometry using the IOL Master 700, a non-contact optical technique, while Group B was assessed with the HUVITZ MRK-3100 Auto-Ref/Keratometer for keratometry and ultrasound A-scan for axial length measurement. All assessments were performed by trained optometrists or resident medical officers under the supervision of a consultant ophthalmologist.

Preoperative assessment included ocular history, clinical examination, and evaluation of UCVA and BCVA using a Snellen chart and converting to logMAR values for analysis, slit-lamp examination for coexisting ocular pathologies, fundus examination, and autorefraction to determine preoperative refractive error and astigmatism. Phacoemulsification was performed under peribulbar anesthesia using 50% Lignocaine 2% and 50% Bupivacaine 0.5%, following pupil dilation with Tropicamide 1% and antisepsis with 5% povidone-iodine. All standard phacoemulsification steps were followed, and patients were followed postoperatively on day 1, week 1, month 1, and month 3. The complications that were assessed during the evaluation of the postoperative period were wound leakage, corneal edema, depth of the anterior chamber, morphology of the pupil, and location of the IOL. At one week, one month and three months, autorefraction and subjective refraction were obtained to derive visual and refractive results.

The analysis of data was done using SPSS software version 26. The variables of continuous type, including age and refractive error, had been provided as the mean ± SD, whereas the variables, including gender and the frequency of complications, were of the categorical type presented in percentages and frequencies. Paired t-tests were used to compare the preoperative and postoperative refractive errors of each group, and independent t -tests were compared between groups. The p-value below 0.05 was taken to be statistically significant and showed the presence of significant differences between the two biometry methods in the visual outcomes and refractive precision.

RESULTS

The study included a total of 60 patients, equally divided into Group A (IOL Master) and Group B (Ultrasound A-scan), each with 30 participants. The mean age of the overall sample was 56.62±6.76 years, with Group A at 56.87±7.05 years and Group B at 56.37±6.56 years, showing no significant difference between groups (p=0.777). Age distribution was similar, with 36.7% of patients aged 41–55 years and 63.3% above 55 years (p=0.592). The sample comprised 58.3% males and 41.7% females, with no statistically significant gender difference between the groups (p=0.432).

Mean preoperative UCVA was 0.96±0.13 in Group A and no significant difference was detected with Group B (p=0.973), and this means that there is similarity in baseline visual status. Group A showed improvement of UCVA progressively as postoperatives, where the mean value at week 1 was 0.38±0.10, at one month, 0.07±0.07, and at three months, respectively. These values were much more impressive than Group B at all of the follow-up periods ($p<0.05$), and these values indicated better uncorrected vision outcomes in the case of IOL Master optical biometry. Data is given in Table I. Paired sample analysis showed that UCVA has improved significantly in both groups at all the postoperative intervals relative to the baseline.

Group A had a mean preoperative BCVA of 0.68 ±0.12 that was similar to Group B (p=0.791), showing equal baseline best-corrected visual status. Group A improved progressively in the postoperative period with mean BCVA; 0.30 ± 0.06 at week 1, 0.13 ± 0.05 at one month and 0.04 ± 0.05 at three months. These values were

much superior to Group B at any follow-up time ($p<0.05$), indicating better visual results using IOL Master optical biometry. Data is given in Table II. BCVA was significantly improved at all postoperative time points relative to baseline in both groups, and so represents progressive visual recovery after cataract surgery. Data is given in Table II.

The mean preoperative refractive error in Group A was −2.58±0.36 D, comparable to Group B ($p=0.647$), indicating similar baseline refractive status. Postoperatively, Group A showed progressive reduction in refractive error, with mean values of −0.30±0.15 D at week 1, −0.20±0.11 D at one month, and −0.11±0.08 D at three months. Refractive outcomes in Group A were significantly better than Group B from one month onwards ($p<0.05$), reflecting higher accuracy in IOL power calculation with optical biometry. Data is given in Table III. In both groups, refractive error improved significantly at all postoperative intervals compared to baseline, as demonstrated by paired sample analysis, indicating effective correction of refractive status following cataract surgery.

Table I: Comparison of logMAR UCVA at Various Intervals between the Groups

Time Interval	Group	N	Mean	Std. Dev.	p-value
Pre-OP	Group A	30	0.96	0.13	0.973 *
	Group B	30	0.97	0.17	
Post-Op Week1	Group A	30	0.38	0.10	0.013*
	Group B	29	0.45	0.11	
Post-Op Month1	Group A	28	0.15	0.06	0.000*
	Group B	28	0.23	0.08	
Post-Op Month3	Group A	26	0.07	0.07	0.000*
	Group B	28	0.16	0.08	

Independent sample t test, taking p-value≤0.05 as significant.

Table II.0: Comparison of logMAR BCVA at Various Intervals between the Groups

Time Interval	Group	N	Mean	Std. Dev.	p-value
Pre-OP	Group A	30	0.68	0.12	0.791
	Group B	30	0.69	0.12	
Post-Op Week1	Group A	30	0.30	0.06	0.001
	Group B	29	0.36	0.08	
Post-Op Month1	Group A	28	0.13	0.05	0.000
	Group B	28	0.19	0.06	
Post-Op Month3	Group A	26	0.04	0.05	0.030
	Group B	28	0.10	0.15	

Independent sample t test, taking p-value≤0.05 as significant.

Table III.0: Comparison of Refractive Error (Diopter) at Various Intervals between the Groups

Time Interval	Group	N	Mean	Std. Dev.	p-value
Pre-OP	Group A	30	-2.58	.36	0.647
	Group B	30	-2.53	.39	

Post-Op Week1	Group A	30	-.30	.15	0.052
	Group B	29	-.39	.19	
Post-Op Month1	Group A	28	-.20	.11	0.003
	Group B	28	-.33	.19	
Post-Op Month3	Group A	26	-.11	.08	0.000
	Group B	28	-.25	.16	

Independent sample t test, taking p-value≤0.05 as significant.

DISCUSSION

Cataract is one of the major causes of reversible blindness in the globe, and the traditional procedure of measuring intraocular lens (IOL) power involves the use of ultrasound A-scan biometry which measures axial length but is operator-dependent and subject to minor measurement errors.[14,15] Over the past years, IOL Master optical biometry has become a no-contact, highly accurate alternative, with a better reproducibility and accuracy, though comparative data on long-term postoperative refractive results between the two methods are sparse and scarce.[12,13]

While comparing the findings of this study with existing literature, it is evident that optical biometry with IOL Master consistently demonstrates superior accuracy and refractive predictability compared to ultrasound A-scan biometry. Patients who underwent optical biometry achieved significantly better uncorrected and best-corrected visual acuity at all postoperative intervals, along with lower refractive error, compared to those measured using ultrasound A-scan. These results are consistent with prior research, reinforcing the clinical advantages of optical biometry in modern cataract surgery.[12,16,17]

In India, Surapaneni et al. found that optical biometry is more accurate and offers greater precision in the refractive results, but A-scan ultrasonography is still useful in resource-constricted settings. Their findings emphasize the need for careful selection of biometry techniques tailored to patient characteristics and institutional resources.[12] Kolega et al. compared 20 eyes measured with IOL Master to 20 eyes assessed with applanation ultrasound and observed slightly better postoperative visual acuity (0.9 ± 0.1 versus 0.85 ± 0.15) and lower mean absolute refractive error (0.50 ± 0.50 D versus 0.75 ± 0.50 D) in the optical biometry group, supporting the enhanced accuracy of IOL Master in routine cataract cases.[16]

Anwar et al. similarly demonstrated that patients measured with IOL Master achieved significantly improved LogMAR visual acuity and lower postoperative refractive error compared to A-scan, with differences in postoperative axial length also reaching statistical significance. These findings corroborate the superior reliability of optical biometry for IOL power calculation, even in more complex scenarios such as silicon-filled eyes.[17] Conversely, Mazhry et al. reported no significant difference between optical and ultrasonic biometry in mean absolute error or target refraction, indicating that, in certain contexts, both methods may yield comparable outcomes.[13] Similarlry, Sabih et al. demonstrated that both optical and ultrasound biometry yield comparable postoperative spherical equivalent results.[14]

Gopi et al. in a study of 211 eyes across a wide range of axial lengths, found strong agreement between IOL Master and ultrasound A-scan for both axial length and anterior chamber depth measurements. Despite slightly higher axial length values with optical biometry, the correlation between the two techniques was good across extremely long, medium, and short eyes.[19] Gupta et al. further confirmed that IOL Master 700 produced better postoperative refractive outcomes, with 89.8% of eyes achieving ±0.75 D compared to 66.9% in the ultrasound group, demonstrating both statistical and clinical superiority.[20] Badr et al. also highlighted significantly lower predicted IOL power errors with IOL Master compared to A-scan, reinforcing

the precision of optical biometry in achieving optimal refractive outcomes.[21]

Together, these studies, combined with the existing data, point to the uniform benefits of optical biometry in the enhancement of visual acuity and refractive accuracy. However, ultrasound A-scan still has its niche in certain cases such as dense cataracts, poor fixation or in the environment where optical equipment cannot be obtained easily. The results promote the use of patient-oriented mode in choosing biometry methods, given the ocular features, the rate of cataracts, and resources at hand.

The strengths of the study are a clear sample whose baseline demographics are similar and the measure of various postoperative outcomes, including UCVA, BCVA, and refractive error, which is thorough in evaluating biometry techniques. Weaknesses include that distinct groups of patients are used in each approach, which can result in inter-patient differences. Further research must take into consideration a paired-type study; in this case, the same patients will receive an IOL Master and A-scan to be directly compared to exclude other confounding factors and produce stronger evidence that can be used to make the clinical decision.

CONCLUSION

Patients evaluated with IOL Master optical biometry showed superior postoperative UCVA, BCVA, and lower refractive error compared to Ultrasound A-scan biometry. Both groups improved significantly from baseline, but optical biometry provided more precise IOL power calculation, leading to better visual accuracy and optimal refractive outcomes after cataract surgery.

PATIENTS' CONSENT: Informed consent was taken before the initiation of the study from all the participants.

COMPETING INTEREST: The authors declared no conflict of interest.

Authors Contribution

Author 1

Substantial contributions to study design, acquisition of data
Analysis & Interpretation of Data, Manuscript writing
Has given final approval of the version to be published
Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

Author 2,3,4

Substantial contributions to concept, study design
Data Analysis, Manuscript writing, Critical Review
Has given final approval of the version to be published
Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

Author 5,6

Substantial contributions to concept, Data Analysis,
Manuscript writing, Critical Review
Has given final approval of the version to be published
Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

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