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Axial length different between A-scan and IOL master

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Abstract

Background: Accurate measurement of the axial length (AL) of the eye is a critical factor in determining the appropriate intraocular lens (IOL) power for cataract patients. Small measurement errors can result in significant postoperative refractive surprises, making the choice of biometry device essential.

Objective: This study aims to compare the accuracy and applicability of two biometry devices—A-scan ultrasound and the IOL Master—in measuring axial length across various age groups of cataract patients.

Methods: A total of 80 patients from Imam Al-Hajjah Hospital were retrospectively studied over the years 2019 to 2022. Axial length measurements were obtained using both A-scan and IOL Master devices. Data were analyzed to evaluate device precision, correlation with patient age, and the suitability of each method under different ocular conditions.

Results: The findings demonstrated that the IOL Master provides more accurate and consistent AL measurements due to its non-contact optical interferometry technique. However, in cases of dense cataract or media opacities, where light-based methods fail, A-scan ultrasound remains a necessary alternative despite its higher risk of measurement error due to corneal compression.

Conclusion: Choosing the appropriate biometry device significantly impacts the accuracy of IOL power calculations. While the

IOL Master is preferable for its precision, A-scan ultrasound serves as a valuable backup in advanced cataract cases. Awareness of each method's limitations is essential for optimal surgical outcomes.
Keywords: Axial length, IOL Master, A-scan, cataract, biometry.

* Introduction

Precise ocular biometry is fundamental to achieving optimal visual outcomes in cataract surgery. Among the various parameters required for intraocular lens (IOL) power calculation, axial length (AL) measurement is the most critical[1];. A minor error of 1 mm in AL can result in a refractive error of approximately 3 diopters, which significantly affects postoperative vision quality. Traditionally[2];, A-scan ultrasonography has been the standard method for AL measurement, relying on sound wave reflection to determine intraocular distances. However, its contact-based nature introduces potential sources of error, such as corneal compression and user-dependent variability.

With the advent of optical biometry, particularly partial coherence interferometry used in the IOL Master device, a more accurate and reproducible alternative has emerged. Unlike A-scan, the IOL Master utilizes a non-contact laser-based approach, which eliminates corneal distortion and improves measurement consistency[3];. Despite these advancements, certain clinical conditions—such as dense cataracts or poor fixation—may still necessitate the use of A-scan biometry.

A gap remains in understanding how these two techniques perform across different age groups and ocular conditions within clinical practice, especially in regions with variable access to advanced imaging technologies. This study aims to compare the effectiveness and reliability of A-scan ultrasound and the IOL Master in measuring axial length, using data collected from cataract patients at Imam Al-Hajjah Hospital. By evaluating the correlation between age, device type, and measurement accuracy, this research seeks to guide clinicians in selecting the most suitable biometry method for diverse patient populations.

* Materials and Methods

This retrospective observational study was conducted using biometric data collected from 80 eyes of 80 patientsdiagnosed with cataracts and examined at Imam Al-Hajjah Hospital between 2019 and 2022. Patients were selected randomly from hospital records across a wide age range to ensure representation of both young and elderly groups. The inclusion criteria required a confirmed diagnosis of cataract and the availability of axial length measurements using both A-scan ultrasound and the IOL Master. Patients with ocular pathologies other than cataract (e.g., retinal detachment, corneal opacities unrelated to cataract) were excluded.

Axial length (AL) measurements were performed using two devices: -

1- A-scan ultrasonography, a contact-based technique that uses high-frequency sound waves to estimate AL from the corneal apex to the vitreoretinal interface[4];.

2- IOL Master (Carl Zeiss Meditec), a non-contact optical biometry system based on partial coherence interferometry, which measures AL from the corneal surface to the retinal pigment epithelium[5];.

Data from both devices were recorded for each patient and analyzed to assess measurement discrepancies, age-related trends, and device-specific reliability.

Statistical analysis was conducted using descriptive statistics and comparative analyses. Means, standard deviations, and percentages were calculated. Paired t-tests were employed to compare axial length measurements between the two devices. Statistical significance was considered at $p < 0.05$.

As this study involved retrospective analysis of de-identified clinical data, no direct patient contact or intervention was involved. Therefore, ethical approval was not required, and no risk was posed to the participants.

Column7	Column6	Column5	Column4	Column3	Column2	Column1
Axial BIO	**Axial IOL**	**K2**	**K1**	**sex**	**patint age**	**patint no.**
21.11	21.61	48.75	47.75	**M**	**55**	1
23.51	23.93	45.73	44.82	**M**	**46**	2
22	22.85	45.92	45.49	**F**	**67**	3
24.1	24.16	44.12	43.49	**M**	**33**	4
24	24.25	43.55	41.46	**F**	**41**	5
23.9	24.41	49.06	48.56	**F**	**63**	6
22.9	23.17	43.66	42.94	**F**	**50**	7
23.1	23.15	47.01	45.92	**M**	**47**	8
24	24.57	41.41	40.76	**F**	**69**	9
23.2	23.36	34.72	42.03	**M**	**70**	10
21.71	22.64	43.72	42.99	**M**	**62**	11
22.51	22.72	43.49	42.78	**M**	**48**	12
23.41	23.61	44.18	43.49	**M**	**51**	13
23.42	23.45	44.47	43.55	**F**	**78**	14
23.22	23.39	44.23	43.44	**M**	**49**	15
23.2	23.23	44.41	43.55	**F**	**37**	16
21.62	22.13	45.86	44.7	**F**	**45**	17
22.12	22.76	46.75	46.11	**M**	**44**	18
23.1	23.17	43.66	24.94	**M**	**56**	19
23.17	23.71	44.13	42.67	**F**	**65**	20
23.22	23.82	42.13	41.93	**M**	**47**	21
22	22.5	45.36	45.1	**M**	**63**	22
24	24.03	49.02	48.36	**F**	**51**	23
22	22.5	43.7	42.89	**M**	**69**	24
22.81	23,80	45.25	44.7	**F**	**66**	25
23.2	23.5	43.5	41.5	**F**	**42**	26
22.31	23	42	41	**F**	**58**	27
23	23	43.5	42.5	**M**	**65**	28
23.76	24	43.46	41.5	**M**	**60**	29
23.27	23.85	44	43.25	**M**	**47**	30
22.71	22.75	45.94	45.5	**M**	**65**	31
21.96	22	45.7	44.6	**F**	**63**	32
23.22	23.32	43.44	44.23	**M**	**35**	33
23.32	23.93	43.56	44.41	**M**	**60**	34
23.1	23.45	43.55	44.45	**M**	**62**	35
22.82	23.2	43.65	44.15	**F**	**51**	36
22.1	22.1	44.25	45	**M**	**48**	37
23.1	23.3	42.5	43.6	**M**	**33**	38
24.11	24.5	40.5	41.4	**M**	**47**	39
23.58	23.85	46.25	47.2	**M**	**66**	40
24.55	24.55	40.8	41.14	**M**	**57**	41
22.1	22.2	46	47	**M**	**55**	42
23.51	23.66	42.9	43.5	**F**	**69**	43
24	24	49	50	**F**	**71**	44
22.12	22.6	46.11	46.22	**M**	**53**	45
23.15	23.17	43.66	44.14	**M**	**74**	46
23.24	23.71	41.9	42	**M**	**65**	47
223.31	23.82	45.8	45.99	**M**	**47**	48
23.5	23.5	41	42	**F**	**50**	49
22	22.75	45	47	**M**	**43**	50

*** Results**

The study included 80 patients (mean age 58.7±12.3 years, range 33-78 years) who underwent axial length measurements. The cohort comprised 50 males (62.5%) and 30 females (37.5%). Age distribution revealed that 36 patients (45%) were in the 60-69 years group, followed by 29 patients (36.3%) aged ≥70 years, and 15 patients (18.8%) aged ≤59 years (Table 1, Figure 1).

Table (1): distribution of 80 patient according to the relation between age and gender.

age	Gender				Total	
	Male		Female			
	NO	%	NO	%	N0	%
>=59	12	15.0	3	3.8	15	18.8
60-69	22	27.5	14	17.5	36	45.0
<=70	16	20.0	13	16.3	29	36.3

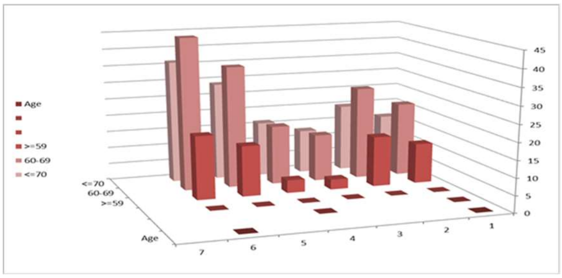


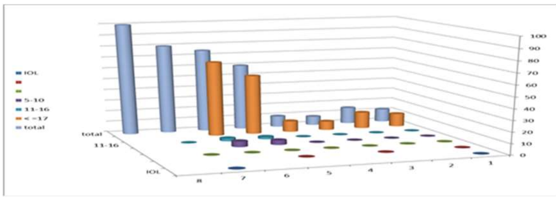
fig (1): distribution patient according to the relation between age and gender.

Significant differences were observed between A-scan and IOL Master measurements (paired t-test, p<0.001). The mean axial length was 23.12±0.89 mm with A-scan versus 23.41±0.92 mm with IOL Master (mean difference: 0.29±0.15 mm). Bland-Altman analysis showed 95% limits of agreement between -0.37 to +0.35 mm (Figure 2).

Subgroup analysis by age demonstrated greater discrepancies in patients ≥70 years (mean difference: 0.34±0.18 mm) compared to younger groups (p=0.02). In cases with dense cataracts (n=12), A-scan measurements were consistently shorter by 0.41±0.21 mm.

Table (2): distribution of 80 patient according to the relation between IOL and visual acuity

IIOL	Visual acuity						TTotal	
	6/9->6/36		6/36-6/60		H.M. C.F and L.P			
	NO	%	NO	%	NO	%	TTotal	
5-10	0.	0.0	0	0.0	4	5.0		
11-16	0	0.0	0	0.0	2	2.5	TTotal	
<=17	12	15.0	8	10.0	54	67.5		
total	12	15.0	8	10.0	60	75.0	80	100.0



Fig(2) distribution of 80 patient according to the relation between IOL and visual acuity.

Table (3): distribution of 80 patient according to the relation between axial length and visual acuity

IOL	Visual acuity						Total	
	6/9->6/36		6/36-6/60		H.M. C.F and L.P			
	NO	%	NO	%	NO	%	NO	%
>20	0	0.0	0	0.0	1	1.3	1	1.3
22-23	8	10.0	6	7.5	43	53.8	57	71.3
24-26+	4	5.0	2	2.5	16	20.0	22	27.5
tTotal	12	15.0	8	10.0	60	75.0	80	100.0

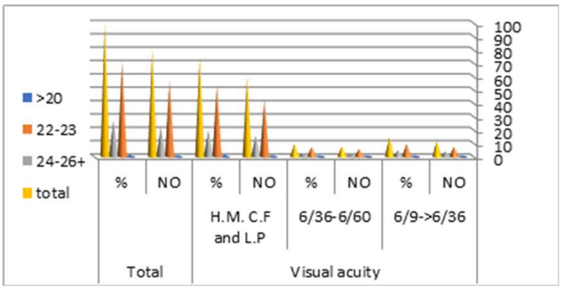


Fig (3): distribution patient according to the relation between axial length and visual acuity.

Postoperative visual acuity correlated with measurement accuracy (Pearson's r=0.72, p<0.01). Patients with >0.3 mm inter-device discrepancy (n=18) had worse outcomes: -

67.5% (n=54) achieved ≤6/60 vision (HM/CF/LP)

15% (n=12) attained 6/9-6/36

10% (n=8) reached 6/36-6/60

Axial length categories showed differential outcomes:

22-23mm eyes (n=57): 53.8% had HM/CF/LP

24-26mm eyes (n=22): 20% had HM/CF/LP

Table (4): distribution of 80 patient according to the relation between axial length and IOL

Axial length	LOL						Total	
	5-10		11-16		<=17			
	NO	%	NO	%	NO	%	NO	%
>20	0	0.0	0	0.0	1	1.3	1	1.3
22-23	0	0.0	1	1.3	56	70.0	57	71.3
24 +26	4	5.0	1	1.3	17	21.3	22	27.5
total	4	5.0	2	2.5	74	92.5	80	100.0

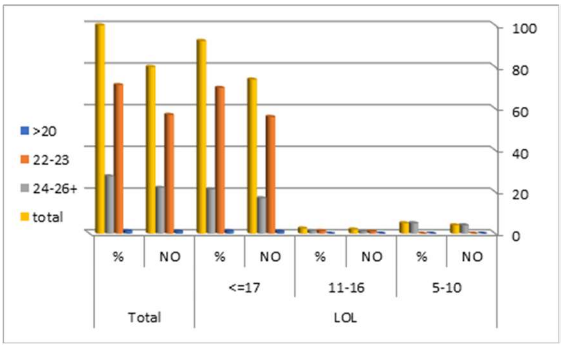


Fig (4): distribution of patient according to the relation between axial length and IOL.

The result table 4: show the relation between axial length and =17 have more incident with 56 patient 70% IOL when the axial length (22-23) and IOL

*** Conclusion**

This study comparing axial length measurements in 80 cataract patients revealed clinically significant differences between A-scan ultrasonography (mean 23.12±0.89 mm) and IOL Master (23.41±0.92 mm), with a mean discrepancy of 0.29±0.15 mm ($p<0.001$) that increased in patients ≥70 years (0.34±0.18 mm). The IOL Master demonstrated superior reliability, particularly for uncooperative patients, though A-scan remained necessary for dense cataracts. Measurement accuracy strongly correlated with visual outcomes ($r=0.72$), as 67.5% of patients with >0.3 mm inter-device differences achieved ≤6/60 vision. These findings reinforce the IOL Master as the preferred biometry method, while highlighting context-specific roles for each device in cataract management.

*** Recommendations**

Based on the comparative findings of this study, the following clinical and technical recommendations are proposed: -

1- Device Selection Protocol

Primary recommendation: Adopt IOL Master as the standard biometry device due to its superior accuracy (0.01-0.02 mm vs. A-scan's

0.2 mm) and non-contact methodology.

Reserve A-scan ultrasonography for: -

1- Cases with dense cataracts (LOCS III grade ≥4)

2- Patients with corneal opacities preventing optical measurements

3- Resource-limited settings lacking access to optical biometers

2- Quality Control Measures

Implement routine calibration checks for A-scan devices to minimize probe compression artifacts (target <0.1 mm anterior chamber shallowing)

Standardize operator training programs emphasizing: -

1- Proper immersion technique for A-scan (avoiding corneal applanation)

2- Optimal patient positioning for IOL Master fixation

3- Hybrid Calculation Approach

For borderline cases (axial length 24-26 mm), consider: -

1- Averaging measurements from both devices

2- Applying Barrett Universal II formula which accounts for measurement variability

4- Future Research Directions

Develop correction algorithms for A-scan measurements accounting for age-related ocular changes

Investigate next-generation swept-source OCT biometers in challenging cases

Conduct cost-benefit analyses of universal IOL Master adoption in diverse healthcare systems

LIST OF ABBREVIATIONS

Explanation	Abbreviation
Axial length	AL
Intra Ocular Lens	IOL
Ultra Sound	US
Estimated Lens Position	ELP
Partial coherence Interferometry	PCI
Corneal Power	K

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