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Optical (Partial Optical Coherence Interferometry) (AL-Scan) versus Ultrasound Biometry (A-Scan) for IOL Power Calculation: A Comparative Study

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Abstract

Context: The refractive power of the human eye depends on the power of the cornea and the lens, the position of the lens, and the length of the eye. Accurate assessment of these variables is essential in achieving optimal postoperative refractive results. *Aims:* To compare the accuracy of IOL power calculation by measuring the axial length with Optical (Partial Optical Coherence Interferometry AL-Scan) biometry and Ultrasound biometry.

Settings and Design: It was a prospective observational study done at Medivision eye and Health Care centre.

Methods and Material: The study group was 200 patients, who underwent Phaco-emulsification. The SRK-T formula was used to calculate the IOL power in all patients. Auto-keratometry performed with the optical scan was used in all patients.

Statistical Analysis: Mean (SD) and frequency (percentage) was used to describe summary data. Paired T test was performed to explore statistically significant difference between two measurements. Chi-square was used to assess the difference between categorical variables.

Results: Out of 200 patients 83 (41.5%) were female and 117 (58.5%) were male. Mean Age of the study population was 62.30±7.66 years and the range 33 to 81. The mean difference between axial lengths measured by the 2 modalities was 0.1274±0.1733 mm with AL Scan measuring higher than US Biometry (Paired T- Test $p < 0.05$). The residual error was Zero in 75 (37.5%) eyes in the AL-scan group and 59 (29.5%) eyes in the A-scan group. When analyzed at 95% confidence for the difference at zero error in pre-operative prediction versus post-operative acceptance of IOL power, the predictions did not differ between both the modalities.

Conclusion: The AL-scan is on average a closer predictor than A-scan of the final spherical equivalent. AL-scan may offer a slight advantage because of the easier and quicker operation compared with the A-scan.

Keywords: Axial; A-Scan; Eye; Phacoemulsification.

Introduction

The refractive power of the human eye depends on the power of the cornea and the lens, the position of the lens, and the length of the eye. Accurate assessment of these variables is essential in achieving optimal postoperative refractive results. If these biometric measurements and calculations are inaccurate, the patients may be left with a significant refractive error. Studies conducted by Olsen [1] showed that imprecision in measurements of anterior chamber depth (ACD), axial length and corneal power contribute to 42%, 36% and 22%, respectively, of the error in predicted refraction after implantation of an intraocular lens (IOL). Currently, the axial length can be obtained by using either A Scan Ultra Sound or the partial coherence laser interferometer. In A-scan ultrasound biometry, a crystal oscillates to generate a high-frequency sound wave that penetrates into the eye. When the sound wave

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encounters a media interface, part of the sound wave is reflected back toward the probe. These echoes allow us to calculate the distance between the probe and various structures in the eye.

A non-contact partial coherence laser interferometer, as an alternative technique to measure the axial length of the eye was used. It measures the delay and intensity of infrared light reflected back from media interfaces in order to determine the distance from the cornea to the retinal pigment epithelium [2].

Accurate Biometry is needed to obtain satisfactory postoperative results, more than ever as a result of heightened patient expectations. The IOL master has been in use for several years and measures AL (axial length), ACD (anterior chamber depth) and corneal curvature with high precision and good resolution [2]. The IOL master is a better predictor of postoperative refraction than ultrasound biometry, particularly within close ranges [5]. The use of optical biometry offered a better predictive value than the use of applanation axial biometry measurement [6]. The axial length measurements taken with IOL master were slightly affected by the cataract density but to a lesser extent than ultrasound biometry [7]. However; several other studies [8-13] demonstrated that optical biometry represents a significant simplification in the course of investigation prior to cataract surgery.

Hence present study was carried out to compare the accuracy of IOL power calculation by measuring the axial length with Optical (Partial Optical Coherence Interferometry AL-Scan) biometry and Ultrasound biometry.

Materials and Methods

Study Area

Medi-vision Eye & Health Care Center, Hyderabad

Study Design

Patients with Cataractous lens undergoing Phacoemulsification with foldable IOL implantation

Study Participants

Prospective observational study

Sample Size Calculation

To detect the differences of refractive errors of 0.25 D of spherical equivalent (power 90%; α-0.05) between patients with Partial coherence interferometry (AL-scan) calculated IOL power and ultrasound biometry (A-scan) calculated IOL power and assuming 10% loss to follow-up a minimum of 174 sample size was required.

Inclusion Criteria

Patients who are undergoing cataract surgery.

Exclusion Criteria

- Corneal disease
- Traumatic cataract
- Previous intraocular surgery
- Pre-existing glaucoma
- Patients with poor visual prognosis (ex: amblyopia, macular scar)
- Uncooperative patients

Methodology

Patients selected for surgery for them a complete ophthalmic examination including refraction, slit lamp examination; four mirror Gonioscopy to look for any angle abnormalities, Goldman applanation tonometry and Fundus examination through dilated pupil by direct and indirect ophthalmoscopy was done. B-scan was done if fundus examination was not possible as in dense cataract cases.

AL-scan was first performed before any applanation method and ultrasound biometry (ALCON) performed for IOL calculation. A single experienced optometrist had done the ultra sound (A-scan) and Partial Coherence Interferometry (AL-scan) measurements in all cases. The SRK-T formula was used to calculate the IOL power in all patients. The reliability of measurements was assessed by ideal graph/SNR in IOL biometry and retinal spikes in acoustic biometry. To eliminate the confounding variables introduced by keratometer performed with different techniques on treatment group, auto-keratometry performed with the optical scan was used in all patients.

The A constant was individualized for the IOL chosen by the patient. Cataract surgery by Phacoemulsification (2.8 mm temporal clear corneal tunnel) method was done and a foldable lens was implanted within the capsular bag under topical anaesthesia.

Postoperative assessment was performed at 1st post-operative day, 1st week, 2nd week, and 1 month and 6 weeks. The latest available refraction was used as final refraction and was converted into spherical equivalent and compared with the pre-operative predictions made by the Optical Scan and Ultrasound Biometry. All postoperative assessments were made by the same examiner. Informed consent was taken from all the study subjects. Ethical committee approval taken from the institute's ethical board.

Statistical Analysis

Mean (SD) and frequency (percentage) was used to describe summary data. Paired T test was performed to explore statistically significant difference between two measurements (Optical Scan and Ultra sound biometry). Chi-square was used to assess the difference between categorical variables. Differences considered statistically significant when the P value is <0.05.

Results

Table 1 shows mean Age of the study population was 62.30±7.66 years and the range was 33 to 81. Majority 109 (54.5%) of patients were in the age group 61-70 years.

Table 2 shows that patient population included in the study was almost equally distributed with 41.5% (n=83) female patients and 58.5% (n=117) male patients.

Table 3 shows that Mean Axial length measurement by AL-Scan (optical scan) was 23.21 mm with standard deviation of 1.00 mm

Table 4 shows that the mean axial length measurement by A-Scan (ultra sound scan) was 23.11 mm with standard deviation of 1.00 mm.

Table 5 shows that the residual error was Zero in 75 (37.5%) eyes in the AL-scan group and 59 (29.5%) eyes in the A-scan group. The residual error was more than 0.50 D in 24 (12%) eyes and 0.50 D or less in 101 (50.5%) eyes in the AL-scan group. In the A-scan group the residual error was more than 0.50 D in 29 (14.5%) eyes and 0.50 D or less in 112 (56%) eyes. It is also observed that the predictions made by A-Scan tend to be more frequent on lower (negative) side compared to that of AL-Scan though both look to be equal in most of the cases

Table 6 shows that the mean difference between axial length measured by the 2 modalities was 0.1274 mm with a standard deviation of 0.1733 mm (95% CI 0.104 – 0.152) with AL Scan measuring higher than US Biometry.

Table 7 shows that the mean difference between axial length measured by the 2 modalities was 0.0142 mm with a standard deviation of 0.3646 mm (95% CI 0.0367 – 0.065).

Table 8 shows that the prediction precision of IOL Power by both the modalities was compared with that of accepted power of IOL after adjusting for the residual error in the following tables in paired T-test.

The mean (SD) difference between the predicted refraction and final spherical equivalent was +0.0142 (SD 0.3646) D for the AL-Scan and +0.1242 (SD 0.4010) for the A-Scan. This finding demonstrates that, on average, the AL-Scan was a closer predictor ($p=0.584$) than the A-Scan of the final spherical equivalent ($p<0.05$).

Table 1: Age wise distribution of sample

Age (years)	Number	Percentage
31-40	03	1.5
41-50	14	07
51-60	56	28
61-70	109	54.5
71-80	17	7.2
> 80	01	0.5
Total	200	100

Table 2: Gender wise distribution of sample

Gender	Number	Percentage
Male	117	58.5
Female	083	41.5
Total	200	100

Table 3: Pre-Operative Axial Length Measurements by AL Scan

Range of axial length	AL scan Number	AL scan Percentage
20-20.99	2	1
21-21.99	20	10
22-22.99	64	32
23-23.99	77	38.5
24-24.99	32	16
25-25.99	03	1.5
26-26.99	01	0.5
27-27.99	01	0.5
Total	200	100

Table 4: Pre-Operative Axial Length Measurements by A-Scan

Range of axial length	A scan Number	A scan Percentage
20-20.99	2	1
21-21.99	24	12
22-22.99	70	35
23-23.99	75	37.5
24-24.99	25	12.5
25-25.99	02	01
26-26.99	01	0.5
27-27.99	01	0.5
Total	200	100

Table 5: Difference between predicted refraction and the final spherical equivalent with different scans

Range of residual power in Diopters	AL scan Number	Percentage	A scan Number	Percentage
-1.00	0	0	1	0.5
-0.75 to -1.00	4	2	9	4.5
-0.50 to -0.75	13	6.5	14	07
-0.25 to -0.50	16	8	30	15
0 to -0.25	27	13.5	42	21
0	75	37.5	59	29.5
0 to 0.25	37	18.5	19	9.5
0.25 to 0.50	21	12.5	21	12.5
0.50 to 0.75	05	2.5	03	1.5
0.75 to 1.00	02	01	02	01
1.00	0	0	0	0
Total	200	100	200	100

Table 6: Comparison of axial lengths measured by AL-Scan and Ultrasound scan

	Paired differences					T value	df	Significance (2 tailed)
	Mean	Standard deviation	Standard error of mean	95% C. I. Lower	95% C. I. Upper			
AL scan axial length USB AxLgth	0.1274	0.1733	0.0123	0.1032	0.1515	10.394	199	0.0001

Table 7: Comparison of predicted refraction by AL-Scan versus Final spherical equivalent

	Paired differences					T value	df	Significance (2 tailed)
	Mean	Standard deviation	Standard error of mean	95% C. I. Lower	95% C. I. Upper			
Final Spherical Equivalent – Residual Power by AL-Scan	0.0142	0.3646	0.0258	0.0367	0.065	0.549	199	0.584

Table 8: Comparison of predicted refraction by A-Scan versus Final spherical equivalent

	Paired Differences							
	Mean	Standard deviation	Standard error of mean	95% C. I. Lower	95% C. I. Upper	T value	df	Significance (2 tailed)
Final Spherical Equivalent – Residual Power by A-Scan	0.1242	0.4010	0.0284	0.0682	0.1801	4.378	199	0.0001

Table 9: Comparison of prediction precision of residual error with Al-Scan and A-Scan (spherical equivalent) at zero error

Error	AL scan	A scan	Chi square	P value
Zero error	75	59	2.8729	0.09
Any error	125	141		

Table 9 shows that at 95% confidence for the difference at zero error in pre-operative prediction versus post-operative acceptance of IOL power, the predictions did not differ between both the modalities (The Chi-square statistic is 2.8729. The P value is 0.09). When observed for the final outcomes of both the modalities it was seen that the overlapping residual error of +0.50 was seen in 83% of eyes.

Discussion

The present study included 200 eyes of 200 patients who underwent cataract surgery. Out of 200 patients 83 (41.5%) were female and 117 (58.5%) were male. In another study 65% were female's ad 35% were males [8].

In the present study the mean age of the study population was 62.30±7.66 years and the range 33 to 81. In another study, the mean age of patients was 69.8±13.1 years (range, 11 – 85 years) in the PCI Group and 70.0±9.3 (range, 45 - 86 years) in the US Group (P = 0.7165) [8].

In the present study the mean axial length measurement by AL-Scan (optical scan) was 23.21±1.00 mm while the mean axial length measurement by A-Scan (ultra sound scan) was 23.11±1.00 mm. In another study the mean AL measured by the PCI was 23.22±1.00 mm (range, 21.01 - 25.45 mm) and that measured by US was 23.22±1.06 mm (range, 20.05 - 25.78 mm) (P = 0.9110); years (range, 11 – 85 years) in the PCI Group and 70.0±9.3 (range, 45 - 86 years) in the US Group (P = 0.7165) [8].

In the present study the mean difference between axial lengths measured by the 2 modalities was 0.1274±0.1733 mm with AL Scan and the difference was statistically significant. In the study conducted by Anand B Bhatt et al [5] the mean axial lengths measured by IOL master and ultrasound biometry were 23.97 and 23.92 mm, respectively. The mean difference between the axial lengths measured by the two modalities was 0.042. In the study conducted by Beatiz Machado Fontes et al [8] the mean axial length measured by PCI was 23.22±1.0 mm and that measured by US was 23.22±1.06 mm.

In the study conducted by Findl O et al [14] the optical axial length obtained by the IOL Master was significantly longer (p < 0.001, Student's t test) than the axial length by applanation ultrasound, 23.36 (SD 0.85) mm vs. 22.89 (0.83) mm. Possibly the most important reason for this difference is the pressure exerted on the eye by the ultrasound probe, which results in corneal indentation and shortening of the AL. In addition, the ultrasound is reflected mainly at the internal limiting membrane whereas the light of the IOL Master at the retinal pigment epithelium, thus resulting in a difference that corresponds to the retinal thickness of the fovea, which is about 130 micron [14].

In the present study the mean (SD) difference between the predicted refraction and final spherical equivalent was +0.0142 (SD 0.3646) D for the AL-Scan and +0.1242 (SD 0.4010) for the A-Scan. This finding demonstrates that, on average, the AL-Scan was a closer predictor (p = 0.584) than the A-Scan of the final spherical equivalent (p < 0.05). The present study findings were similar another study were the mean (SD) of the difference between predicted refraction and final spherical equivalent was -0.43 (0.84) diopters (D) for the IOL m and -0.60 (0.87) D for ultrasound biometry, indicating that on average the IOL m was a closer predictor than ultrasound biometry of the final spherical equivalent ($P < .001$) [5].

The residual error was Zero in 75 (37.5%) eyes in the AL-scan group and 59 (29.5%) eyes in the A-scan group. The residual error was more than 0.50 D in 24(12%) eyes and 0.50 D or less in 101 (50.5%) eyes in the AL-scan group. In the A-scan group the residual error was more than 0.50 D in 29 (14.5%) eyes and 0.50 D or less in 112 (56%) eye.

It is also observed that the predictions made by A-Scan tend to be more frequent on lower (negative) side compared to that of AL-Scan though both look to be equal in most of the cases

On comparing the prediction precision of IOL Power by both the modalities with that of accepted power of IOL after adjusting for the residual error the mean (SD) difference between the predicted refraction and final spherical equivalent was +0.0142 (SD 0.3646) D for the AL-Scan and +0.1242 (SD 0.4010) for the A-Scan. This finding demonstrates that, on average, the AL-Scan was a closer predictor ($p = 0.584$) than the A-Scan of the final spherical equivalent ($p < 0.05$). With use of the SRK-T formula to obtain predictions for postoperative refraction, the AL-scan was 0.11 D more accurate than A-scan biometry in predicting the final spherical equivalent.

In our study it was observed that AL-scan is on average a closer predictor than A-scan of the final spherical equivalent but when analyzed at 95% confidence interval at zero error there was no statistically significant error between the two modalities. In another studies it was found that s high precision and reproducibility was obtained with both methods [8,15,16,17].

When observed for the final outcomes of both the modalities it was seen that the overlapping residual error of +0.50 was seen in 83% of eyes.

Conclusion

AL-scan offer a slight advantage because of the easier and quicker operation compared with the A-scan. For the surgeon who wants to continue using A-scan biometry there is no significant disadvantage. The advantage of A-scan biometry is that very dense ocular media prevent obtaining axial length measurements by AL-Scan while still A-Scan could give axial length measurements. However, these cases were excluded from our study due to lack of AL-Scan measurements.

Key Messages

For the surgeon who wants to continue using A-scan biometry there is no significant disadvantage.

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