Original Article

Partial Coherence Laser Interferometry Versus Conventional A-Scan Acoustic Biometry in Intraocular Lens Power Calculation – Comparison of Postoperative Refractive Error

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ABSTRACT

Purpose: To compare the post-operative residual refractive error in patients undergoing cataract surgery using partial coherence laser interferometry (PCLI) versus A-scan Applanation acoustic biometry.

Study Design: Quantitative experimental research.

Place and Duration of Study: Shifa International Hospital (SIH), Islamabad from November 2018 to August 2019.

Methods: Total 254 patients were selected. Group A included patients whose biometry was done using PCLI method and group B included patients who had A-Scan acoustic biometry. Intraocular lens power calculation was done using SRK/T formula. Phacoemulsification surgery with foldable Intraocular lens was performed. Patients were called for follow-up visit the next day and then one month after surgery. Postoperative refractive error was checked after one month. All data were entered and analyzed using SPSS version 21.0. Descriptive statistics were used for qualitative as well as quantitative variables. We applied independent samples t-test to compare the mean postoperative refractive error in both groups. A p-value of less than 0.05 was considered significant.

Results: The mean age of patients was 65 ± 9.37 years. The preoperative mean axial length was 20.35 ± 1.1 mm in the PCLI group and 21.54 ± 1.2 mm in the ultrasound group. Mean Absolute Error (MAE) of postoperative residual refractive error in the PCLI group was 0.12 ± 0.13 mm (P = 0.003). The MAE in the ultrasound group was 0.18 ± 0.12 mm (P = 0.02).

Conclusion: The non-contact optical biometry improves the mean absolute error for postoperative refraction and is a reliable tool for biometry in phakic eyes before surgery.

Key Words: Partial coherence laser interferometry; Ultrasound A scan; Biometry; A-constant; Intraocular lens.

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INTRODUCTION

According to World Health Organization (WHO), cataract is the commonest cause of reversible blindness in the world.[1] Nowadays Phacoemulsification is the standard method of treatment for cataract.[2,3] Generally the opinion is that 85% of cataract surgeries should achieve a good visual outcome (presenting visual acuity [PVA]: 6/18 or better) with fewer than 10% having borderline (< 6/18 – 6/60), and less than 5% having poor (< 6/60) outcomes.[4]

The postoperative refractive outcome mainly depends on the accuracy of calculating power of the

intraocular lens, which depends on several factors including axial length (AL) measurement, anterior chamber depth (ACD), keratometry readings, intraocular implants calculation formulae and material of the intraocular lens.

Out of all these factors, imprecise AL measurements have shown to be the major factor responsible for the surprised refractive outcome. Studies show that an error of 100 micrometers in AL measurement leads to a refractive error of 0.28 D when the mean absolute error (MAE) in the partial coherence laser interferometry group is 0.52 ± 0.32 D and in the ultrasound group, is 0.62 ± 0.4 D.[5] There are currently two methods of biometry available worldwide: ultrasound and optical. Studies have shown that A-scan AL measurements are lower than that of IOL Master, the mean difference being 0.2 ± 0.44 mm.[6]

Ultrasound biometry uses the technique of echo delay time to measure ocular distances. It has a longitudinal resolution of 200 micrometers and a precision of 100–120 micrometers. It involves direct contact of the cornea with the probe using topical anesthetic drops. It is uncomfortable for the patient as well as it has the disadvantage of corneal indentation during measurement.[5] It requires a specially trained person to avoid errors due to excessive compression of the cornea by the ultrasound probe.

On the other hand, the optical biometer works on the principle of partial coherence laser interferometry (PCLI). The IOL Master operates as a modified Michelson interferometer and uses infrared laser light (wavelength 780 nm) for precise AL and anterior curvature of cornea measurements.[7] The eye to be measured and the photodetector are situated at each end of the interferometer. The signal is generated as a result of interference between the light reflected by the tear film over the cornea and that reflected by the retinal pigmentary epithelium and this signal goes to the photodetector. The position of the interferometer mirror is used to precisely measure the interference signal received by the photodetector. This gives us the optical length between the corneal surface and retina. This length is used to obtain intraocular distances by putting in the refractive indices of the respective ocular media (cornea, lens, aqueous humor, and vitreous). This method is reported to have a high resolution of about 12mm and an accuracy of 0.3 – 10mm.[5] Perfect measurements by optical biometer require a signal-to-noise ratio of greater than 2.0.[8] The limitation of this optical biometer is its inability to measure the distances with accuracy in conditions; for example corneal opacities, dense vitreous hemorrhages, mature cataracts, and vitrectomised eye.[9]

The purpose of doing this study was to document the results of comparison of two different techniques in a tertiary care facility of Pakistan. The results of this study will help in predicting the post-operative visual improvement after cataract surgery in patients.

METHODS

Ethical approval was obtained from the Institutional review board and ethics committee SIH, before the initiation of the research work. Synopsis approval from the Research evaluation unit (REU), (College of Physicians and Surgeons Pakistan), was also taken. Data was collected over a period of ten months after the date of approval. A consecutive non-probability sampling technique was used for data collection. The sample size was calculated using WHO sample size calculator.[5] The following parameters were taken. Hypothesis tests for two population means (one-sided test), level of significance as 5%, power of the test as 80%, population standard deviation (0.36), population variance (0.1024), population mean in PCLI group (0.52) and population mean in A-Scan group (0.62). The sample size was 127 in each group.

Patients with age-related cataract of either gender were included. Patients who did not give consent to be part of this study, patients with complicated cataract or any other significant ocular conditions e.g., ocular trauma, squint, amblyopia, diabetic retinopathy, age-related macular degeneration, central serous chorioretinopathy, retinitis pigmentosa, keratoconus, viral keratitis, corneal dystrophies, corneal opacity, or any other corneal or macular disease were excluded from the study. Patients with high myopia, hypermetropia i.e., greater than 5Diopters, and astigmatism of greater than 2 Diopters, patients with a history of any previous ocular surgery in the same eye for example refractive surgery, corneal transplant, or retinal surgery were also excluded.

The patients were recruited by consecutive sampling technique from ophthalmology department of SIH, Islamabad. Total 254 patients were selected. Group A included patients whose biometry was done using PCLI method and group B included patients who had A-Scan acoustic biometry.

We used Zeiss IOL Master 700 as an optical biometer and Quantel compact touch as an A-Scan biometer. Biometry was performed by a single trained ophthalmic technician. Intraocular lens power calculation was done using SRK/T formula. This is the most commonly used formula that is used in both methods of biometry. We aimed for emmetropia for distance vision. After lens power calculation, Phacoemulsification surgery with foldable Intraocular lens (Acrysof IQ-monofocal) was performed. Patients were called for a follow-up visit the next day and then one month after surgery. Postoperative refractive error was checked after one month.

All data were entered and analyzed using SPSS version 21.0. Descriptive statistics were used for qualitative as well as quantitative variables. Qualitative variables were gender, eye, type of refractive error and quantitative variables were age, pre-operative and post-operative visual acuity, best-corrected pre-operative and post-operative visual acuity and refractive error. For qualitative variables, frequency and percentages were determined, and for quantitative variables data mean and standard deviation was ascertained. We applied independent samples t-test to compare the mean postoperative refractive error in both groups. Type of refractive error, gender and the eye were used for stratification and post-stratification independent sample t-test. A p-value of less than 0.05 was considered significant.

RESULTS

Among the 254 patients included in the study, the mean age of participants was 65.54 ± 9.38 years. The minimum and maximum age of patients were 37 and 84 years respectively. There were 138 (54.3%) male and 116 (45.7%) female patients. There were 80 males and 47 females in Group A while 58 males and 69 females in Group B. Distribution of study patients according to the type of refractive error is shown in (Table-1).

Pre- operative Mean best corrected Visual Acuity according to Log MAR scale was 0.5220 ± 0.2289 and Post-operative Mean Best Corrected Visual Acuity was 0.0417 ± 0.089. The mean pre-operative AL in the ultrasound group was 21.54 ± 1.2 mm, the mean error 0.07 ± 0.2 mm and MAE of 0.18 ± 0.12 mm ($P= 0.02$). while the mean preoperative AL in the PCLI group was 20.35 ± 1.1 mm, the mean error -0.06 ± 0.17 mm and MAE of 0.12 ± 0.13 mm ($P = 0.003$). There was

no statistically significant difference in preoperative AL values in both the groups as shown in **Table-2**.

Table 1: *Type of Refractive Error and distribution according to the Groups.*

Type of Refractive Error		Group A	Group B	Total	p-Value
Myopia	Yes	16	12	28	0.422
	No	111	115	226	
Hypermetropia	Yes	40	11	51	0.00001
	No	87	116	203	
Astigmatism	Yes	45	52	97	0.3659
	No	82	75	157	
Nil	Yes	26	52	78	.0004
	No	101	75	176	

Table 2: *Comparison between partial coherence laser interferometry and ultrasound biometry by Application of independent T test.*

	PCLI Mean ± SD	Ultrasound Biometry Mean ± SD	p-Value
Post–operative mean Refractive Error	0.42 ± 0.35 D	0.50 ± 0.4 D	0.003
Post- operative mean Axial Length	20.35 ± 1.1	21.54 ± 1.2	0.02
P Value	**0.003**	**0.02**	-

Mean Refractive Error between Groups alongside effect modifiers is explained in Table-3.

Table 3: *Mean Refractive Error between Groups alongside effect modifier.*

Effect Modifier		Group A	Group B	p-Value
		Mean Refractive Error (Mean ± SD)		
Gender	Male	0.041 ± 0.09	0.038 ± 0.08	0.714
	Female	0.087 ± 0.12	0.015 ± 0.05	
Age Categories	> 50	0	0.0167 ± 0.003	0.13
	< 50	0.06 ± 0.11	0.03 ± 0.005	
Eye Side	Right	0.035 ± 0.08	0.021 ± 0.06	0.01
	Left	0.086 ± 0.12	0.03 ± 0.07	

DISCUSSION

Ocular biometry is fundamental to cataract surgery. PCLI is a non-contact method and offers the ease of obtaining keratometry values, ACD, and AL measurements in a single sitting, which is a significant advantage when compared to ultrasound biometry. It is less time-consuming and has the advantage of improved precision, as compared to ultrasound

biometry, which demands topical anesthesia and is time-consuming. Our study compared the refractive outcome between applanation acoustic biometry and PCLI. It has shown significant improvement in IOL power calculation using PCLI compared with ultrasound (mean difference was 0.08 D). Statistically significant differences ($p < 0.05$) were found in the mean values obtained using both techniques of measurement. PCLI method can achieve reliable AL measurements in phakic eyes, as observed in our study with a mean difference of 1.19 ± 0.1mm. It shows that PCLI leads to statistically significant improvement for postoperative refraction when compared to A-Scan using prospective IOL power calculations in phakic eyes.

From a theoretical point of view, the total error in IOL power calculation may be expected to decrease significantly as a result of the decrease in the variability of AL readings with PCLI. If one assumes the small variation observed between preoperative and postoperative PCLI measurements to reflect the total error originating from the axial length measurements, this source is shown to represent only 30–40% of the total prediction error, compared with 50–60% with ultrasound.[10] Another study showed that the average absolute IOL prediction error (observed minus expected refraction) was 0.65 D with ultrasound and 0.43D with PCLI using the 5-variable ACD prediction method.[11] Furthermore, the noncontact essentially operator-independent method, gave significantly more reliable biometry before cataract surgery, especially in the case of a less experienced operator.[12] Rajan et al. found that the use of optical biometry offered a better predictive value than the use of applanation axial biometry measurements.[5]

On the other hand, Haigis et al., in their study of comparing the outcome of postoperative refraction measurements by two different methods (ultrasound vs. PCLI), concluded that postoperative refraction was predicted accurately by the ultrasound method.[13] The influence of the operator's experience especially on the contact technique was emphasized by Kittahaweesin.[14] He compared the acoustic biometry method with the immersion technique and found that the reproducibility of both techniques was similar when performed by an experienced operator, whereas, the less experienced operator had greater reproducibility with the immersion technique. He suggested that the immersion technique should be considered, particularly for less-experienced operators.[14] Other

studies showed that experienced operators had less difference and lower variability in the difference between applanation acoustic biometry and IOL Master readings for AL and ACD measurements.[15,16]

There are variable conclusions about which technology has a better predictive value. Our study has shown the IOL prediction value accuracy of around 80% as compared to other studies, which have shown an improvement in predictive value up to 27%.[17] Our study showed that the average absolute error inaccurate IOL power prediction was found to decrease from 0.5 D with ultrasound to 0.4 D with PCLI. Both the groups were compared favorably with no significant difference in functional outcome. However, the patients who had PCLI did better in reaching $\pm$ 1 D of the expected post-op refraction (80%) as compared to 87% shown by Rajan et al.[5] They also showed that preoperative mean AL was 23.47 ± 1.1 mm in the PCLI group and 23.43 ± 1.2 mm in the ultrasound group ($P > 0.05$). The MAE in the PCLI group was 0.52 ± 0.32 D. The MAE in the ultrasound group was 0.62 ± 0.4 D. These results are comparable to our study. In our study, the mean pre-operative AL in the PCLI group was 20.35 ± 1.1 mm and in the ultrasound group, was 21.54 ± 1.2 mm. The MAE in PCLI group was 0.42 ± 0.35 D ($P = 0.003$) and ultrasound group was 0.50 ± 0.4 D ($P = 0.02$).

Rajan et al also studied the role of PCLI in pseudophakic AL measurement. It revealed a mean shortening of the eyes postoperatively in the PCLI group.[5] The mean shortening encountered with PCLI was seen to be most likely related to the group refractive index incorporated in the calculation, causing this systematic error. The A-constant needs to be altered to suit PCLI to achieve better accuracy.[18,19] In contradiction to the above study, PCLI was able to achieve reliable AL measurements in pseudophakic eyes as observed in our study. This application becomes clinically relevant in evaluating pseudophakic eyes that might need a secondary piggyback IOL.

PCLI relies on adequate foveal fixation eyes with corneal scarring, dense cataracts, posterior capsule plaque, macular degeneration and eccentric fixation fail to obtain reliable results.[20] Furthermore, in the areas where hard cataracts are common, this optical method cannot work very well. On the other hand, PCLI has an edge over acoustic biometry in measuring the AL of eyes with silicone oil or posterior staphyloma. We also did not calculate the failure rate,

positive predictive value, and negative predictive value so we cannot compare these values with other studies. Another limitation is that we did not compare the experienced operator with the less experienced operator in the case of acoustic biometry. Furthermore, we had to choose the patients who did not have mature cataracts resulting in selection bias. Some patients were lost to follow-up.

A multicenter study with larger sample size is required to make the results more reliable and find out the importance of ACD accuracy in the prediction of postoperative refraction when IOL is implanted in cataract surgery.

CONCLUSION

It is concluded that the non-contact optical biometry using the PCLI principle reduces the MAE of postoperative refraction after cataract surgery and is a more reliable tool in the measurement of intraocular lenses in cataractous eyes before surgery. The highly significant improvement of PCLI over ultrasound found in the present paper might be reinforced in a highly controlled best-case study. These results support the likelihood that IOL implantation after calculation of its value by a non-contact method is one of the most accurate methods. Thus, an optical biometer, in the future can be the most precise tool in measurements of IOL power in patients in which corneal power has been changed due to refractive surgery.

Ethical Approval

The study was approved by the Institutional review board/ Ethical review board (**IRB-952-227-2018).**

Conflict of Interest

Authors declared no conflict of interest.

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Authors' Designation and Contribution

Javeria Muid; *Consultant Ophthalmologist: Concepts, Design, Literature search, Data acquisition, Data analysis, Statistical analysis, Manuscript preparation, Manuscript editing,*

Farooq Afzal; *Professor: Concepts, Manuscript preparation, Manuscript review.*

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