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Original Research Article

Effect of Pupillary Dilation on Ocular Biometric Parameters and Intraocular Lens Power Estimation in a Nigerian Tertiary Hospital

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Abstract: ***Introduction:*** A good postoperative outcome of cataract surgery requires a precise biometric measurement; hence, accurate preoperative measurements of the eye are essential to achieving the desired postoperative refractive result. This study assessed the effect of pupillary dilatation on ocular biometry and intraocular lens (IOL) power calculation in a Nigerian Teaching Hospital. ***Method:*** A prospective study was performed on eighty eyes of 69 patients scheduled for cataract surgery. Anterior chamber depth (ACD), axial length (AL), flat keratometry (K1), steep K (K2), average keratometry reading (average K), Lens thickness (LT), Intraocular lens (IOL) power were measured, before and after pupil dilatation using Apamide plus (Tropicamide 1% Phenylephrine 2.5%. Intraocular lens (IOL) power was calculated using the Sanders-Retzlaff-Kraff/Theoretical (SRK/T) and Haigis formulae integrated in the ultrasound Tomey Biometer AL-100. We compared the ocular parameters before and after pupil dilatation. ***Results:*** There was a statistically significant increase in mean post-dilatation ACD and a decrease in mean post-dilatation LT in all patients, in comparison to mean pre-dilatation measurements ($p. < 0.05$). IOL power calculation using SRK/T and Haigis formula was not affected by pupillary dilatation. However, in all 3 groups of AL, only group 2 (AL) had a statistically significant increase in mean post-dilatation in ACD, in comparison to mean pre-dilatation measurements ($p. < 0.05$). ***Conclusions:*** Pupillary dilatation significantly affected biometry readings like ACD and LT but did not influence keratometry readings, AL and IOL Calculation formulae SRK/T and Haigis.

Keywords: Ocular Biometry, Pupillary Dilatation, Axial Length, Anterior Chamber Depth, Intraocular Lens Calculation.

INTRODUCTION

Among intraocular surgeries, cataract removal is by far the most prevalent, both in Nigeria and globally [1]. Ocular biometry and the calculation of intraocular lens (IOL) power represent standard assessments frequently performed on patients preparing for intraocular procedures, including cataract extraction. A favourable postoperative outcome following cataract surgery necessitates meticulous biometric measurements; thus, precise preoperative assessments of the eye are crucial for attaining the intended refractive result post-surgery.

In order to assess the architecture and morphology of the cataract's anterior region, either in the days leading up to the operation or during it, preoperative pupillary dilatation is often performed [2]. One of the ocular biometric parameters employed in several IOL power formulas, especially in third, fourth, and more recent generation IOL power formulae, is anterior chamber depth (ACD), which naturally increases as a result of dilated pupils [3, 4]. Therefore, it is important to find out if pupillary dilatation affects ocular biometry data and IOL power calculation. This will help evaluate whether the two operations may be done simultaneously without compromising the success of the surgery in

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restoring vision. Additionally, the impact of pupillary dilatation on ocular biometry measurements and/or IOL power calculations has been the subject of several studies conducted around the globe [5-7]. To the best of the researcher's knowledge, no local studies have been done.

Therefore, this study aimed to assess the effect of pupillary dilatation on K1 (flat), K2 (steep K), Average or mean K, AL, ACD, LT and IOL power calculations using the SRK/T and Haigis Formulae with the aid of the Autokeratorefractometer KR8800 and Tomey Biometer AL-100 (A-Scan) among patients being booked for cataract surgery in Ekiti State University Teaching Hospital (EKSUTH).

METHODOLOGY

Study Design

A prospective study was conducted at the Ophthalmology Clinic of EKSUTH, Ado–Ekiti.

Study Population

The research included a cohort of consecutive patients seen at the Ophthalmology Clinic at Ekiti State University Teaching Hospital in Ado Ekiti, Ekiti State, who had a diagnosis of cataract in either eye or both eyes. Patients must be at least 18 years old, have a cataract in either eye, and willingly agree to participate in the research in order to be considered. This study will not include patients who have refused to participate, patients with keratoconus, pellucid marginal degeneration, corneal scars, shallow anterior chamber, history of ocular trauma, current or past ophthalmic treatment, tropicamide or phenylephrine allergies, recent gas permeable contact lens wear (soft or rigid) within the past six months, or the inability to conduct an ocular biometry evaluation.

Sampling size Determination and Techniques

The sample size was estimated using Fischer's formula [8], which gave rise to 69 patients (80 eyes), which was selected using consecutive sampling techniques.

Study Procedure

Physical Examination:

All of the subjects had their eyes checked. The ophthalmologist checked the patient's visual acuity (VA), using a pen light to do slit lamp biomicroscopy and gonioscopy to look for anomalies in the anterior segment and shallow anterior chamber, and make that the patient's lenses are orientated correctly.

Slit-Lamp Examination*:*

The anterior chamber, iris, cornea, cells, anterior chamber depth, anterior chamber angle, and 3-mirrors Gonio lens were all examined using a slit-lamp in a poorly light room. A 78D dilated fundoscopy was used to access the fundus. Furthermore, intraocular pressure was measured using a calibrated Goldmann applanation tonometer that was connected to a Slit Lamp.

Gonioscopy:

The Slit Lamp and a 3-mirror Gonio lens were used for this on an earlier visit. Eye drops containing 0.5% Amethocaine were used to anaesthetise the eye. The Scheie grading system was used to assign grades according on how visible the angle's anatomical features were.

Ultrasound Biometry and Keratometry:

Measurements of ultrasound biometry and keratometry were conducted consecutively, both prior to and following pupil dilation, utilising the Tomey Biometer AL-100 and the Topcon Autokerato-refractometer KR8800, with a minimum of 80 eyes from 69 patients involved in the study. The parameters that were assessed and analysed included axial length (AL), anterior chamber depth (ACD), lens thickness (LT), keratometry (K), and the associated intraocular lens (IOL) power, with a predicted target aimed at achieving emmetropia. This was computed utilising the Sanders-Retzlaff-Kraff/Theoretical formula (SRK/T) and the Haigis formula, both prior to and following pupillary dilation.

Data Analysis

The process of data collection and entry was executed, followed by the application of statistical analysis utilising the International Business Machines Corporation-Statistical Package for Social Sciences (IBM SPSS-25) (2017) (IBM SPSS Inc., Chicago, Illinois, USA) on the Windows operating system (Microsoft Corporation, Redmond, USA). All foundational demographic variables were articulated through the use of frequencies and percentages. The assessment of normality was conducted utilising the Kolmogorov-Smirnov test alongside a Q-Q plot for all quantitative variables, including keratometry readings (K1, K2, and average K), axial length (AL), anterior chamber depth (ACD), lens thickness (LT), and intraocular lens (IOL) power values. The summary of quantitative variables was conducted through the calculation of means and standard deviations. The findings from the Kolmogorov-Smirnov test indicated that the majority of the data exhibited a normal distribution, thereby justifying the application of parametric tests for the comparisons.

Patients were categorised into three distinct groups based on the measurement of axial length. Group 1 - Short AL (AL < 22mm), Group 2 - Normal AL (AL 22-24.5mm), and Group 3 - Long AL (AL > 24.5mm). Continuous variables were assessed using a paired samples T-test both before and after the pupillary dilation procedure. A one-way analysis of variance (ANOVA) was employed to examine the differences among the means of the subgroups. The Tukey HSD (Honest Significance Difference) method was employed for conducting all pairwise comparisons among the groups. A P value of less than 0.05 was deemed statistically significant. The Pearson correlation test was employed to

conduct a binary correlation analysis. The findings were articulated through the correlation coefficient (R) and P-values.

RESULT

There were 80 eyes of 69 patients included in this study. There were 45% male and 55% female (M: F= 1:1.2). The age range was 30 – 101 years with a mean age of 68.39±13.18 years. In the subgroup classification of patients based on AL, Group 1 short axial length (AL <22 mm), Group 2 normal AL (AL 22–24.5 mm), Group 3 long AL (AL>.24.5mm), have 6, 70, and 4 numbers of eyes respectively [Table 1].

As shown in Table 2, ACD in all eyes studied showed a statistically significant increase in mean (-0.16±0.25 mm) and LT revealed a statistically significant decrease (0.09±0.41mm) in mean post-dilatation in comparison to mean pre-dilatation measurements (p.< 0.05). However, other parameters did not show any significant change, i.e. K1, K2, average K, AL, SRK/T, and Haigis measurements did not show statistically significant difference after pupillary dilatation with tropicamide (1%), phenylephrine (2.5%). The K1 had a mean difference of 0.01±0.68D, and K2 had a mean difference of- 0.08±0.56D, and the average K had a mean difference of- 0.07±0.56D, whereas AL had -0.05±0.34mm, SRK/difference of- 0.18±0.96D and Haigis had a mean difference of -0.16±1.04D.

In subgroup analysis based on AL, Group 1 short axial length (AL <22 mm), Group 2 normal AL (AL 22–24.5 mm), Group 3 long AL (AL>.24.5mm), each of which has 6, 70, and 4 numbers of eyes respectively, no significant change in K (flattest, K1 and steepest, K2 and average K) and AL was observed in all subgroups pre and post-dilatation as shown in Tables 6–8. There was no statistically significant change in other parameters, i.e. LT, SRK/T, and Haigis, which were measured in all subgroups apart from ACD, which had a statistically significant increase in Group 2 [Tables 3, 4, 5].

Analysis of variance (ANOVA) revealed a statistically significant relationship between the AL subgroups according to ACD, with a p value of <0.05 [Table 6]. However, Post hoc test with Tukey HSD revealed a statistically significant relationship only between group 1 and group 2 AL according to change in ACD [Table 7].

There was a statistically significant weak negative correlation between age and pre- and post-dilatation AL measurements within all study groups (p< 0.05) and a statistically significant moderately positive correlation between age and pre-dilatation ACD within all study groups (p.< 0.05) [Table 8].

Table 1: Demographic Characteristics of the Respondents

Characteristics	Frequency	Percentage (%)
Age (yrs)		
20-50	8	10.0
51-80	64	80.0
81-110	8	10.0
Range:	30 – 101 years	
Mean+/-SD	68.39±13.18 years	
Gender		
Male	35	50.7
Female	34	49.3
Laterality		
Right eye (RE)	39	48.8
Left eye (LE)	41	51.2
Axial length (AL) of examined eyes		
GROUP 1: AL <22mm	6	7.5
GROUP 2: AL: 22-24.5mm	70	87.5
GROUP 3: AL:>24.5mm	4	5

Table 2: Pre and post-dilatation ocular biometry and IOL Power measurements of all eyes

	Pre-Dilatation		Post-Dilatation		Mean difference (95% CI)	T	p-value
	MEAN	S.D	MEAN	S.D			
KI(D)	42.96	1.78	42.89	1.78	0.07(-0.84-0.22)	0.89	0.38
K2(D)	44.18	1.84	44.10	1.81	0.08(-0.05- 0.20)	1.24	0.22
Average_K(D)	43.57	1.75	43.49	1.74	0.07(-0.05- 0.20)	1.14	0.26
AL(mm)	23.16	0.90	23.21	0.83	-0.05(-0.12-0.03)	-1.25	0.21
ACD (mm)	2.90	0.39	3.06	0.42	-0.16(-0.21- -0.10)	-5.54	<0.001
LT (mm)	3.91	0.71	3.82	0.70	0.09(0.00-0.18)	2.03	0.05

SRK/T (D)	21.27	1.93	21.96	2.38	-0.18(-0.39-0.04)	-1.63	0.11
HAIGIS (D)	21.96	2.38	22.13	2.08	-0.16(-0.40-0.07)	-1.39	0.17

ACD- anterior chamber depth in mm; AL, axial length in mm; K1, flat keratometry, K2, steep keratometry, Average K (mean keratometry); SRK/T-(Sanders-Retzlaff-Kraff/Theoretical) in Diopters; Haigis- in Diopters.SD-standard deviation; CI-confidence interval; t- t value

Table 3: Pre and post-dilatation Ocular biometry measurements in group 1-short eyes (AL<22mm)

	Pre-Dilatation		Post-Dilatation		Mean difference (95% CI)	T	p-value
	MEAN	S.D	MEAN	S.D			
KI(D)	44.15	0.76	44.27	1.20	-0.12(-0.75- 0.51)	-0.49	0.64
K2(D)	44.90	0.82	44.75	0.89	0.15(-0.09- 0.38)	1.62	0.17
AverageK(D)	44.52	0.75	44.51	1.04	0.01(-0.37- 0.39)	0.09	0.94
AL(mm)	21.30	0.44	21.74	0.75	-0.44(-1.22-0.34)	-1.46	0.20
ACD(mm)	2.60	0.27	3.06	0.42	-0.42(-0.87- 0.03)	-2.40	0.06
LT(mm)	3.02	0.17	3.82	0.71	-0.15(-0.21- -0.88)	-1.81	0.13
SRK/T(D)	24.00	1.05	23.67	0.82	0.33(-0.10- 0.76)	2.00	0.10
HAIGIS(D)	24.58	1.20	24.42	0.74	-0.167(-0.38-0.71)	0.79	0.47

ACD- anterior chamber depth in mm; AL, axial length in mm; K1, flat keratometry, K2, steep keratometry, Average K (mean keratometry); SRK/T-(Sanders-Retzlaff-Kraff/Theoretical) in Diopters; Haigis- in Diopters; SD-standard deviation; CI-confidence interval; t- t value

Table 4: Pre and post-dilatation Ocular biometry measurements in group 2 normal eyes (AL=22-24.5mm)

	Pre-Dilatation		Post-Dilatation		Mean difference (95% CI)	T	p-value
	Mean	S.D	Mean	S.D			
KI(D)	43.01	1.71	42.94	1.68	-0.72(-0.09- 0.24)	0.87	0.39
K2(D)	44.27	1.81	44.20	0.89	0.075(-0.07- 0.22)	1.07	0.29
Average_K(D)	43.64	1.69	43.57	1.67	0.07(-0.07- 0.21)	1.05	0.30
AL(mm)	23.24	0.67	23.25	0.65	-0.02(-0.09-0.04)	-0.77	0.45
ACD(mm)	2.93	0.39	3.05	0.44	-0.13(-0.18- -0.07)	-4.72	0.001
LT(mm)	3.91	0.71	3.86	0.71	0.05(-0.04- -0.14)	1.10	0.28
SRK/T(D)	20.96	1.97	21.19	1.82	-0.24(-0.47- 0.003)	-1.97	0.05
HAIGIS(D)	21.84	2.31	22.02	2.04	-0.19(-0.45-0.07)	-1.43	0.16

ACD- anterior chamber depth in mm; AL, axial length in mm; K1, flat keratometry, K2, steep keratometry, Average K (mean keratometry); SRK/T-(Sanders-Retzlaff-Kraff/Theoretical) in Diopters; Haigis- in Diopters; SD-standard deviation; CI-confidence interval; t- t value

Table 5: Pre and post-dilatation Ocular biometry measurements in group 3-long eyes (AL>24.5mm)

	Pre-Dilatation		Post-Dilatation		Mean difference (95% CI)	T	p-value
	Mean	S.D	Mean	S.D			
K2(D)	41.47	1.39	41.46	1.31	0.003(-0.24- 0.24)	0.03	0.98
Average_K(D)	40.84	1.32	40.70	1.15	0.14(-0.54- 0.82)	0.64	0.57
AL(mm)	24.80	0.34	24.67	0.54	0.13(-0.58-0.84)	0.58	0.60
ACD(mm)	2.90	0.21	3.19	0.28	-0.29(-0.62- -0.04)	-2.83	0.07
LT(mm)	3.57	0.83	3.12	0..64	0.45(-0.55- 1.44)	1.43	0.25
SRK/T(D)	19..13	1.84	19.00	1.47	0.13(-0.88- 1.13)	0.40	0.72
HAIGIS(D)	20.25	2.47	20.50	1.87	-0.25(-1.63-1.13)	-0.58	0.60

ACD- anterior chamber depth in mm; AL, axial length in mm; K1, flat keratometry, K2, steep keratometry, Average K (mean keratometry); SRK/T-(Sanders-Retzlaff-Kraff/Theoretical) in Diopters; Haigis- in Diopters; SD-standard deviation; CI-confidence interval; t- t value

Table 6: Comparison of change in ACD between the three groups of the study

ANOVA					
ACD change					
	Sum of Squares	**Df**	**Mean Square**	**F**	**Sig.**
Between Groups	.553	2	.276	4.785	.011
Within Groups	4.448	77	.058		
Total	5.001	79			

ACD- anterior chamber depth in mm; df- degree of freedom; F-F value

Table 7: Post hoc analysis between the three groups of the study according to change in ACD

	(I) predilatation axial length (mm	(J) predilatation axial length (mm	Mean Difference (I-J)	Sig.
Tukey HSD	AL <22mm	AL: 22- 24.5mm	-.29290*	.015
		AL: >24.5mm	-.12583	.697
	AL: 22- 24.5mm	AL <22mm	.29290*	.015
		AL: >24.5mm	.16707	.371
	AL: >24.5mm	AL <22mm	.12583	.697
		AL: 22- 24.5mm	-.16707	.371

ACD- anterior chamber depth in mm Tukey HSD-Honest Significance Difference

Table 8: Pearson correlation between Age and pre and post-dilatation ocular measurements within all study groups

	AGE			AGE	
Predilatation	**Correlation(r)**	**p-value**	**Postdilatation**	**Correlation(r)**	**p.value**
AL	-0.27	0.02*	AL	-0.24	0.03*
ACD	0.34	0.02*	ACD	0.21	0.06
K1	0.13	0.24	K1	0.15	0.19
K2	0.22	0.05	K2	0.20	0.08
AverageK	0.18	0.11	AverageK	0.18	0.11
LT	-0.21	0.60	LT	-0.18	0.11
SRK/T	0.19	0.09	SRK/T	0.19	0.10
Haigis	0.17	0.12	Haigis	0.17	0.13

ACD- anterior chamber depth; AL, axial length; K1, flat keratometry, K2, steep keratometry, Average K (mean keratometry); SRK/T-(Sanders-Retzlaff-Kraff/Theoretical); Haigis

DISCUSSION

In this investigation, mean post-dilatation LT decreased and mean post-dilatation ACD increased significantly in all patients compared to mean pre-dilatation measures (p. < 0.05). The present study also found that pupillary dilatation had no effect on the Haigis formula or the SRK/T method used to calculate IOL power. These results are in line with those of the Egyptian study by Hegazy [9], in which the mean post-dilatation ACD was found to increase statistically, but the IOL power calculation using the SRK/T formula was unaffected by pupil dilatation using the AL Scan Optical Biometer and Mydrapid (tropicamide) 1% for dilatation. No significant difference was seen in individuals with AL<22mm, also known as short AL, in our current investigation. The findings of Hegazy [9], contradict this, since their subgroup analysis revealed significant alterations in individuals with AL<22mm. One possible explanation for this discrepancy is that the quoted research had a larger sample size than the index study did for this particular category. The current study found a weak negative relationship between age and pre and post dilatation AL measurements, in contrast to the Hegazy [9], study, which found a negative linear relationship between age and predilatation ACD and a positive linear relationship between age and predilatation K1, K2, and mean K. This discrepancy might be explained by the various biometry methods used.

Following dilatation with 1% Tropicamide, Bhatia [10], in Oman found mean increases in ACD and a mean reduction in LT, which is comparable to the current research. Similar to the A-Scan, biometry was performed; however, the mean AL increased, which was not seen in this index study and may be related to the research population's varying age groups. In addition, Cheung *et al*., [5], in China found that children aged 7 to 15 years had no change in AL but a rise in ACD of 0.05mm after dilatation with 1% Cyclopentolate hydrochloride and biometry with IOL Master. No other parameters were examined. Tropicamide 0.8%, Phenylephrine 2.5%, and A-Scan were employed in the current study, and the results were comparable, despite the younger age group being the subject of the investigation.

Although it was found that the average keratometry values dropped after dilatation in this investigation, the difference was not statistically significant. This contrasts with studies by Palamar *et al*., [11], Cheung *et al*., [5], and Huang *et al*., [12], all of which indicated a drop in the mean keratometry reading. These discrepancies may be explained by the age disparities between those studies and the index study. According to Huang *et al*., [12], there was no change in axial length but a notable rise in ACD. This is comparable to the findings of the current investigation. Pupillary dilatation had a slight increase in mean Keratometry and AL readings after dilatation with Tropicamide 1% and phenylephrine hydrochloride 0.5%, according to Rodriguez-Raton *et al*., [13]. However, pupillary dilatation had no significant effect on IOL power calculated using the SRK/T formula, but it did influence IOL power calculated using the Haigis formula, which determines the effective lens position (ELP) while accounting for the ACD.

The results of this present study are consistent with studies by Niyaz *et al*., [14], and Ozyol *et al*., [15], which found a reduction in mean lens thickness. Additionally, no variations in AL and K were found by the IOL Master during pupillary dilatation in this investigation, which used A-Scan biometry. This result is consistent across studies [15, 16]. In contrast with the present study, which did not show any significant change in AL and IOL power calculation, Simon *et al*., [17], recorded a significant increase in AL, and ACD with a decrease in LT post-pupillary dilatation with an increase in IOL dioptric power using the multivariable IOL power formula in a lenstar optical biometer. The differences might be due to different biometer technology deployed.

CONCLUSION

In this study, pupillary dilatation significantly affected biometry readings like ACD and LT but did not influence keratometry readings, AL and IOL Calculation formulae SRK/T and Haigis. As a result, the two procedures; biometry and pupillary dilatation can be performed interchangeably on the same day without affecting the surgically achieved visual restoration outcome, provided that the IOL power equations are taken into consideration.

DECLARATIONS

Ethical Approval

Approval for the study was obtained from the Ethics and Research Committee of Ekiti University Teaching Hospital, with reference number EKSUTH/A67/2021/03/020. Also, informed consent was obtained from each patient before including them in the study. The study was conducted according to the guidelines of the Declaration of Helsinki.

Author's Contributions

Conception and design of the study: Abah Emmanuel Chinwendu, Adegbehinde Bernice O, Ajite Kayode.

Writing: All authors.

Data Analysis and Interpretation of Data: All authors

Supervised the Conduct of the Study: Abah Emmanuel Chinwendu, Fadamiro Christianah, Ajayi Iyiade Adeseye.

All authors revised the paper critically for important intellectual content, participated in final approval of the version submitted, and all authors take responsibility for the paper as a whole.

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