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The Influence of Pupil Dilation on Predicted Postoperative Refraction Calculated by Using Third and Fourth Generation Calculation Formulas in Pre-Presbyopia Patients

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Abstract

The goal of this study is to assess the effect of pupillary dilation on predicted post-operative refraction (the Plano or least minus refraction) and on recommended intraocular lens (IOL) power calculated by using the third generation and fourth generation formula to measure the difference between pre and post pupil dilation on ACD. This study included 40 eyes with cataract will undergo phacoemulsification and divided into two group Group (A): 20 cataract patients with biometry by third formula (SRK/T and Hoffer Q). Group (B): other 20 cataract patients with biometry by fourth formula (Holladay 2). There were statically non-significant differences found between PPR before and after pupil dilation in Group A and Group B with p value 0.861and 0.181 respectively. The main age of our patient in group A ranged from (21 – 42) years and age ranged from (25 to 45) in group B with statically non-significant differences between two groups.

Keywords: Pupil dilation, predicted postoperative refraction ,third- and fourth-generation calculation formulas .

1. Introduction:

In recent years cataract surgery has been considered one of the refractive surgeries, both Ophthalmologists and patients regarded removal of opaque lenses and correction of blurred vision to be the only goal of cataract surgery. Thus, a minor refractive error after cataract surgery was acceptable. However, as patients' expectations of postoperative

refraction outcome have increased in recent years, merely correcting blurred vision is no longer a satisfactory outcome because patients expect less dependency on glasses after surgery.

In recent years cataract surgery has been considered one of the refractive surgeries. [1]. The IOL Master allows for fast and accurate measurement of multiple areas of the eye, such as eye length and surface curvature like: Axial Length (AL) and Anterior Chamber Depth (ACD) [2].The third-generation IOL calculation formulas such as (SRK/T and Hoffer Q) do not include anterior chamber depth (ACD) and Lens Thickness (LT) as a variable [3]. which can change between pre and post-pupil dilation, so the biometric measurements are most likely performed either pre or post-pupil dilation. [4]. But the fourth-generation IOL calculation formulas such as (Haigis and Holladay 2) include both ACD and LT as variables. [5].

The intraocular lens (IOL) power calculation is important for prediction of postoperative refractive outcome [6]. The IOL power is Calculated by using preoperative biometric measurement such as axial length (AL), corneal power (K) and Anterior Chamber Depth (ACD). [7]. The Previous studies have reported that every 1.0 mm error measurements of corneal radius, AL and ACD can result in 5.7D, 2.7D, and 1.5D of refractive error respectively , so the ACD performed to decrease refractive error a lot more than AL. [8].

Olsen showed that contribution to error from ACD, AL and corneal power is 42, 36, and 22%, respectively. [9].

2. Patients and Methods:

This was a prospective study performed in Research Institute of ophthalmology by Using the IOL Master carl Zeiss 2008. Within six months from April to October 2019. The patient are classified according to their AL and chosen formula. A constant of 118 was used. This study included 40 eyes with cataract All patients (40) will undergo phacoemulsification and divided into two group: Group (A): 20 cataract patients with biometry by third formula. (Hoffer Q and SRK/T) whose AL less than22mm and more than 26.5mm. Group (B): other 20 cataract patients with biometry by fourth formula. (Holladay 2) whose AL range between 24.5-26.5 mm. This study was approved by the ethical committees Patients gave consent to review their medical records for this study.

2.1 Inclusion criteria:

1- Any cataract patient. 2- Intraocular pressure (IOP) less than 21 mmHg

2.2 Exclusion criteria:

1- Any ocular trauma, any corneal opacity or previous ocular surgery. 2- History of ocular vascular disease or inflammation within eye as iridocyclitis or choroiditis.

3- Systemic vascular disease DM, HTN and Glaucoma. 4- Complication of surgery.

2.3 All patients were subjected to:

1- Full history taking. 2- Full ophthalmic examination. **3-** Refraction using auto refract meter. 4- Best corrected visual acuity using snellen chart. 5- After pupil dilatation both eyes examined using slit lamp with a hand held +90 lens. 6- All patients imaged by (IOLMaster) (Carl Zeiss Meditec AG, Jena, Germany) before and after pupil dilatation using one drop of an eye solution containing1 % tropicamide (Mydriacyl every 15 min or until full dilatation to compare PPR,IOL power, AL, and ACD between pre- and post-pupil dilatation.

Statistical methodology: • A Data were collected, revised, coded and entered to the Statistical Package for Social Science (IBM SPSS) version 23. The quantitative data were presented as mean, standard deviations and ranges when parametric. Also qualitative variables were presented as number and percentages.

The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following:

P-value > 0.05: Non significant (NS)

P-value < 0.05: Significant (S)

P-value < 0.01: Highly significant (HS)

3. Results:

Our study revealed that dilatation does not affect the PPR ,IOL power and AL in SRK/T,Hoffer Q and Holladay II and we found that the ACD was significantly increased post-dilatation by (0.194 ± 0.275) for third generation and (0.132 ± 0.137) for fourth generation. We found there were no statistically significant differences pre-dilatation and post-pupil dilatation for PPR , AL,IOL power However, the ACD was significantly increased post-dilatation in both formula.

Table (1): Comparison between third generation and forth generation formula regarding demographic data and affected side

		Group A	**Group B**	**Test value**	**P-value**	**Sig.**
		No. = 20	**No. = 20**			
Age (years)	Mean±SD	31.05 ± 6.88	33.50 ± 8.50	0.838•	0.407	NS
	Range	21 – 42	22 – 45			
Sex	Females	6 (30.0%)	5 (25.0%)	0.125*	0.723	NS
	Males	14 (70.0%)	15 (75.0%)			
Side	Right	7 (35.0%)	9 (45.0%)	0.417*	0.519	NS
	Left	13 (65.0%)	11 (55.0%)			

•: Independent t-test; *: Chi-square test

Table (1): show no significant difference between both groups as regarding demographic data and affected side.

Table (2): Comparison between two groups regarding PPR before and after pupil dilation

		Group A	**Group B**	**Test value**	**P-value**	**Sig.**
		No. = 20	**No. = 20**			
Paired comparison*	P-value	0.861 (NS)	0.181 (NS)			
PPR difference	Mean± SD	0.013 ± 0.155	0.067 ± 0.179	-0.804$^{\neq}$	0.421	NS
	Range	-0.300 – 0.410	-0.270 – 0.440			

$^{\neq}$: Mann-Whitney test;

Table (2): The table shows that there was no statistically significant difference found between PPR before and after in both groups .

Table (3-a) Comparison between two groups regarding ACD before and after pupil dilation in Group A

ACD	**Before dilatation**	**After dilatation**	**Mean difference**	**P-value**	**SIG**
	No. = 20	**No. = 20**			
Mean±SD	3.14 ± 0.61	3.34 ± 0.50	0.194 ± 0.275	0.005	HS
Range	2.16 – 4	2.63 – 4.09			

Table (3-b): Comparison between two groups regarding ACD before and after pupil dilation dilation in Group B

ACD	**Before dilatation**	**After dilatation**	**Mean difference**	**P-value**	**SIG**
	No. = 20	**No. = 20**			
Mean±SD	3.45 ± 0.38	3.59 ± 0.39	0.132 ± 0.137	<0.001	HS
Range	2.29 – 3.87	2.42 – 4.12			

Table (3 (a-b): The table shows that there was highly statistically significant difference found between ACD before and after in both groups .

Table (4): Comparison between third generation and forth generation formula regarding IOL before and after pupil dilatation.

		Group A	Group B	Test value	P-value	Sig.
		No. = 20	No. = 20			
Paired comparison *	P-value	0.091 (NS)	0.096 (NS)			
IOL difference	Mean±SD	-0.130 ± 0.29	-0.125 ± 0.319	0.435≠	0.663	NS
	Range	-1.000 – 0.500	-0.500 – 0.500			

≠: Mann-Whitney test;

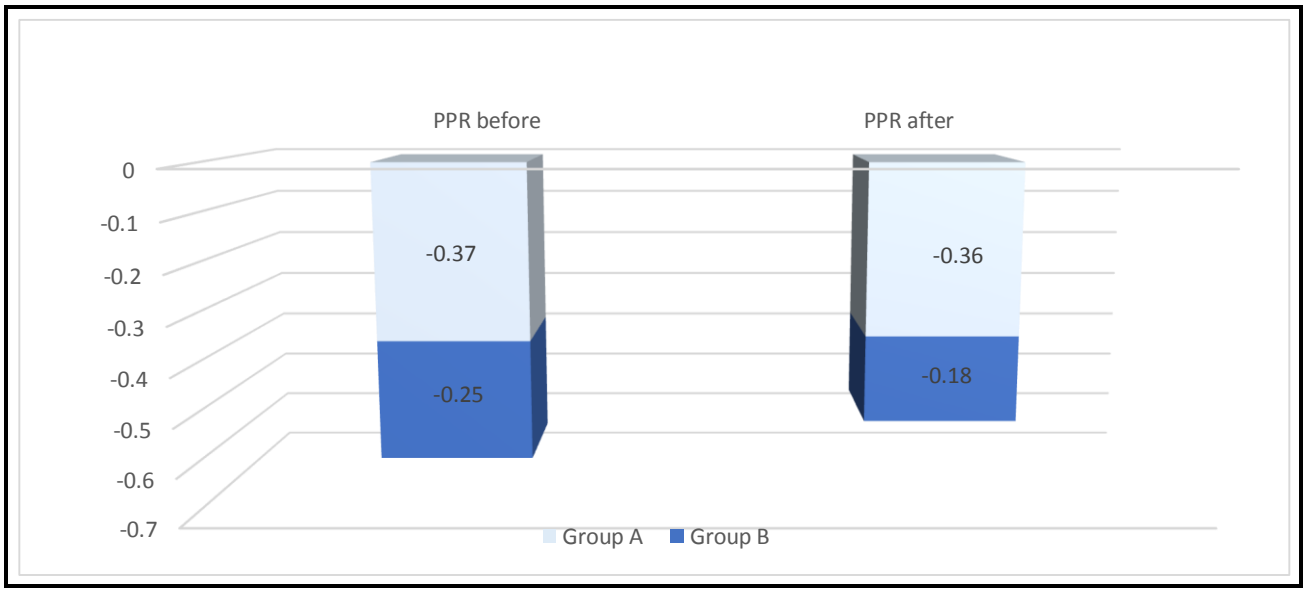
Table (4): The table shows that there was no statistically significant difference found between IOL before and after in both groups .

Table (5) Comparison between two groups regarding ALbefore and after pupil dilation .

		Group A	Group B	Test value	P-value	Sig.
		No. = 20	No. = 20			
AL (mm)	Mean±SD	25.49 ± 3.97	25.27 ± 0.58	0.239•	0.812	NS
	Range	20.54 – 31.16	24.57 – 26.32			

•: Independent t-test

The previous table shows that there was no statistically significant difference found between the two studied groups regarding AL with p-value = 0.812.



Figure(1): *Comparison between two groups regarding PPR before and after pupil dilation*

Figure (1) and Table (2): shows that there was no statistically significant difference found between PPR before and after in both groups .

Table (6) Correlation between difference of ACD and difference of PPR in all the studied patients

	ACD difference	
	r	**p-value**
PPR difference	-0.342	0.060

Spearman correlation coefficients

The previous table shows that there was no statistically significant correlation found between difference of ACD and difference of PPR in all the studied patients with p-value = 0.060.

4. Discussion:

A few studies have explored the influence of pupil dilation on biometric measurement. It is vital to improve the accuracy of PPR by choice of IOL calculation formula. The aim of our study was to determine the influence of pupil dilation not only on ACD but also on PPR and recommended IOL power calculated by third- and fourth – generation formulas. This study revealed that pupil dilatation does not affect PPR,AL and IOL power by using SRK/T, Hoffer Q and Holladay2; however, the ACD was significantly increased post-dilatation by mean difference 0.194 ± 0.275 for third generation formula and mean difference 0.132 ± 0.137 for fourth generation . That may be due to movement of the lens and iris plane backward on dilatation.

Proving the hypothesis that pupillary dilatation has no effect on PPR and IOL calculation power could reducing the steps of the preoperative cataract surgery process, saving time and expenses for the patients.

Our study greatly matched with Khambhiphant et al study In 2015 as found significant differences in ACD after dilation, while the AL, corneal curvature radius, and SRK/T -calculated PPR did not change . Significantly, They concluded that since SRK/T does not use ACD as a parameter [10].

This result is supported by many studies as Cheung study which found that the effect of cycloplegia on AL measurement with IOL master was insignificant in children aged from seven to 15 years; meanwhile, ACD measurement was significantly affected by cycloplegi [11]

Bharkbhum et al using IOLMaster deviceV.5 (Carl Zeiss Meditec AG, Jena, Germany) to compare IOL power, AL, keratometric reading, and ACD between pre- and post-pupil dilatation. It had financial support from the Quality Improvement Fund, King Chulalongkorn Memorial Hospital from February 2013 to July 2013 .195 patients (384 eyes) (48 men and 147 women) were included. The mean age of the study population was 52.39 ± 1.02 years (range of 21–79 years). The inclusion criteria patient with an age of more than 20 years .The exclusion criteria were previous ophthalmic surgery, active eye disease, angle closure suspect (examined under Sussman Four-mirror Gonioscope), lens opacity that limited the IOLmaster measurement, history of mydriatic drug allergy, history of contact lens wear and poor ocular fixation. The main outcomes were AL,keratometric reading(steepest K and flattest K), ACD, and IOL power pre dilatation and post-dilatation There were no statistically significant differences between the AL and keratometric

reading(steepest K and flattest K), and IOL power. However, the ACD was significantly increased post-dilatation (-0.12 mm; p\ 0.05) [10]. And another study of Arriola-Villalobos et al analysed 72 eyes in 2014 by using Lenstar LS 900 and they found that PPR calculated by Holladay II and SRK/T formula did not significantly change between pre- and post-pupil dilation. [12].

SRK/T formula is very complicated, the key point to understanding it is that ELP is predicted based on corneal curvature radius and AL. Also Hoffer Q formula usesd corneal curvature radius and AL to estimate ELP. One of the major differences between these formulas is that while SRK/T uses the Pythagorean theorem, Hoffer Q uses trigonometric function to calculate ELP. [13]. Regard to the influence of pupil dilation on IOL calculation formulas, the past studies vary according to the kind of IOL calculation formula used. Rodriguez-Raton et al presented that there is significant increase in ACD by Pupil dilation but IOL power calculation did not affect based on SRK/T formula .However, the PPR significantly changed calculated by the Haigis formula. They discussed these changes resulted in recommended IOL power prediction are due to uses ACD for calculation the effective lens position (ELP). However, the availability studies published on the influence of pupil dilation on PPR and recommended IOL using fourth-generation formulas is still less than that of third-generation formulas. [14].

In 2018 at Yokohama Tsurumi Chuoh Eye Clinic and Yokosuka Chuoh Eye Clinic a study of 162 eyes by Takeshi Teshigawara et al study presented that in the fourth-generation formulas there was a significant positive correlation between the change in PPR and the change in ACD . whereas the change in PPR showed significant negative correlation with the change in LT. The change in PPR was large enough to change the recommended IOL power .These correlations were not seen in third-generation formulas. This analysis indicated that ACD and LT can play important roles to calculate postoperative refraction in fourth-generation formulas, but not in third-generation formulas [15].

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