A STUDY TO DETERMINE THE EFFECT OF LENS POSITION PARAMETERS ON INTRA OCULAR PRESSURE REDUCTION AFTER PHACOEMULSIFICATION

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ABSTRACT

BACKGROUND
Glaucoma is one of the leading causes of blindness in the world. Many studies show that cataract surgery is a novel way of IOP reduction in glaucomatous and non-glaucomatous eyes. Several studies have been performed to understand the parameters that affect the degree of IOP reduction after phacoemulsification. There are conflicting studies regarding the importance of the lens vault Therefore, there is a need for studies on newer lens parameters as predictors for post-operative Intra ocular pressure.

OBJECTIVES
A. To analyze the effect of lens position parameters on intra ocular pressure reduction following phacoemulsification in non-glaucomatous patients.
B. To compare the results between normal angle and narrow angle eyes.

MATERIALS AND METHODS
In a tertiary Centre, 104 eyes of patients with visually significant cataract were included in the study. 4 mirror Gonioscopy was performed in all the eyes, and they were divided into two groups: Eyes with narrow angles and eyes with open angles. Preoperative Intraocular pressure was recorded for all the patients and AS-OCT was performed, and the readings noted down. All the eyes were subjected to Phacoemulsification under local anesthesia with foldable Posterior chamber intraocular lens implantation in the bag. The follow up IOP was recorded in both the groups at 1 month, 3 months and 6 months postoperative days. The results were all tabulated in M.S. Excel and then analyzed.

RESULTS
The mean age of the patients was 57.29 ‧ 9.48 years. Out of 104 patients, 56.7 % were female while 43.3 % were males. Mean IOP reduction 3 months postoperatively: In narrow angle eyes 17.58‧1.474 mm of Hg to 13.77 ‧1.436 mm of Hg In open angle eyes the mean IOP reduced from 14.96‧1.793 mm of Hg to12.63‧1.772 mm of Hg. Thus the IOP reduction was found to be more in eyes with narrow angles when compared to eyes with open angles. In narrow angles, The mean IOP reduction at 1 month was 3.269 mm of Hg. There was a further mean reduction of 0.808mm of Hg at the 3 month follow-up. In the open angle group the mean IOP reduction at 1 month was 2.077 mm Hg with a further reduction of 0.25 mm of Hg at 3 months. In both the groups Preoperative IOP was a significant predictor for IOP reduction ($P < 0.001$). Other AS-OCT parameters like Central corneal thickness, Angle to angle distance, Anterior chamber area, Lens vault; anterior vault and relative lens vault were not found to be statistically significant predictors of IOP reduction in either of the groups.

CONCLUSION
Cataract surgery results in significant IOP reduction in both Open Angle and Narrow Angle eyes. Furthermore, we have found that preoperative IOP can be a useful predictor for IOP reduction which could be used to help potentially predict IOP response after cataract surgery.

KEYWORDS
Cataract, Phacoemulsification, AS-OCT, lens vault, IOP.

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INTRODUCTION

Glaucoma is defined as a chronic, progressive optic neuropathy in adults in which there is a characteristic acquired atrophy of the optic nerve and loss of retinal ganglion cells and their axons.[1] It is one of the leading causes of blindness in the world with the prevalence in South Asia being estimated at 2.6 %. In India, 9.4 % of the glaucoma patients are bilaterally blind.[2] In a study conducted by Tham Y.C[3] it has been projected that by 2040 111.82 million people around the world will be suffering from Glaucoma. Hence, we are in need of emerging and innovative ways to control the intraocular pressure to reduce the incidence and progression of glaucoma.

Many studies show that cataract surgery is a novel way of IOP reduction in glaucomatous and non-glaucomatous eyes. The mechanism for this is not fully understood. One hypothesis by Poley et al[4] suggests that age related thickening in cataractous lenses leads to narrowing of the angle. Lens extraction leads to widening of the angle, increasing the aqueous outflow and thereby reducing the IOP. Wang et al[5] suggested that upon receiving ultrasound energy by phacoemulsification, the trabecular meshwork cells release IL1 which in-turn increases the aqueous outflow. According to Johnstone et al[6] the aqueous outflow between the anterior chamber and the Schlemm's canal is based on an intrinsic pump mechanism. Aqueous valves which are oriented concentrically transfer aqueous from the AC to the Schlemm's canal. For Normal functioning of the valves, trabecular meshwork tissue has to shrink from the external wall of Schlemm's canal. A constant raised IOP in glaucoma causes failure of these pumps due to apposition of the Schlemm's canal walls and trabecular meshwork stiffening which leads to reduced outflow. Phacoemulsification causes increase in the Schlemm's canal lumen and therefore increases the aqueous outflow.

Several studies have been performed to understand the parameters that affect the degree of IOP reduction after phacoemulsification. It has been shown that higher pre-operative IOP, narrower pre-operative anterior chamber depth and greater angle opening distance all cause greater reduction in IOP.[7] The lens vault (perpendicular distance between the line joining the two scleral spurs and the anterior pole of the lens) is a modifiable factor that can influence the anterior chamber angle and thus the IOP. There are conflicting studies regarding the importance of the lens vault, as, in the presence of a deep Anterior chamber, even a large lens vault will not induce angle narrowing. Therefore, there is a need for studies on newer lens parameters as predictors for post-operative Intra ocular pressure.

In this study, conducted over a period of 1.5 years (November 2019 to May 2021) we aim to measure the effect of the anterior vault (defined as the maximum perpendicular distance between the corneal endothelium and the horizontal lines joining the two scleral spurs) on the intra ocular pressure after phacoemulsification on non-glaucomatous eyes with narrow angles and open angles. This parameter is an indicator of the combined effect of the lens vault and the anterior chamber depth and hence, maybe more closely related to the post-operative IOP reduction than the lens vault alone.

METHODOLOGY

Inclusion Criteria:

1. Patients of either sex or age above 18 years.
2. Patient willing to give informed consent (Annexure 1)
3. Patients with visually significant cataract who require cataract surgery.
4. Patients willing for phacoemulsification.
5. Patients with open angles
6. Patients with narrow angles

Exclusion Criteria:

7. Patient not willing to give informed consent
8. Major intra operative or postoperative complications during cataract surgery.
9. Glaucomatous optic neuropathy defined according to ICOG guidelines as optic disc cupping or glaucomatous visual field loss.
10. Pre-operative Intra ocular pressure over 23mm Hg.
11. Use of anti-glaucoma medications.
12. Presence of Peripheral anterior synechiae.
13. Presence of pseudo exfoliation.
14. Patients in whom the scleral spur could not be made out in AS-OCT.
15. Previous penetrating or laser ocular surgeries.

After obtaining approval and clearance from the institutional ethics committee, the patients fulfilling the inclusion criteria were enrolled for the study. (Annexure – 1). A detailed history along with the necessary demographic details were collected from the patients. Case record form is included in (Annexure 2). An Ocular examination comprising of the following was conducted amongst the patients:

1. Visual acuity for distant and near vision using Snellen's chart and Jaeger's chart respectively was assessed.
2. Intra ocular pressure was measured with an applanation tonometer by a single trained ophthalmologist. All the measurements were taken in the morning hours (0900-1200). The average of three measurements was considered.
3. Gonioscopy was performed and patients with Shaeffers Grade 3 and 4 in 3 or more quadrants were grouped as having open angles and those with Shaeffers grade 2 or less in 3 or more quadrants were grouped as having Narrow angles
4. Anterior segment Optical Coherence Tomography (AS-OCT) was performed with Zeiss Cirrus HD-OCT for all the patients in a dark room. The following parameters were measured:

a) Anterior Chamber Depth (ACD) – defined as the distance from the corneal endothelium at the corneal centre to the anterior pole of the cataractous lens or Intra ocular lens.
b) Lens Vault (LV) – defined as the maximum perpendicular distance between the anterior surface of the lens and the horizontal line joining the two scleral spurs.
c) Anterior Vault (AV) – defined as the sum of lens vault and anterior chamber depth. i.e. the maximum perpendicular distance from the corneal endothelium at the corneal centre to the horizontal line joining the scleral spurs.
d) Relative Lens Vault (RLV) - Lens vault divided by anterior vault
e) Other angle parameters

Phacoemulsification under local anesthesia or topical anesthesia with foldable intraocular lens implantation was performed for all the patients

Post-operative follow-up was done on day1, 1 month and 3 months and 6 months after surgery. In addition to the standard care, Intra ocular pressure measurement and AS-OCT were repeated as per protocol.

Outcome measures:

- Degree of Intraocular pressure change after phacoemulsification.
- Lens position and angle parameters like Anterior Chamber Depth (ACD), Lens Vault (LV), Anterior Vault (AV) and Relative Lens Vault (RLV).

RESULTS

	N	Minimum	Maximum	Mean	S.D
Age	104	24	78	57.29	9.482

Table 1: Mean Age Distribution Of The Subjects

Out of 104 patients, the minimum age was 24 years and maximum age was 78 years with a mean age of 57.29 ± 9.48 years.

Age (in years)	Frequency	Percent
24 to 40	2	1.9
41 to 50	24	23.1
51 to 60	32	30.8
61 to 70	40	38.5
> 70	6	5.8
Total	104	100

Table 2: Distribution Of Patients Based On Age

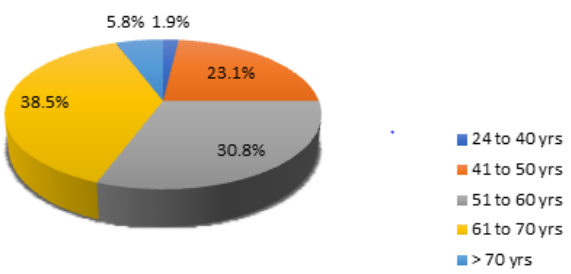

Fig 1: Distribution of the Subjects Based On Age

38.5% patients were between the age group of 61-70 years making it the most common age group of this study. 30.8% patients were between the 51-60 year age group followed by 23.1% patients in the 41-50 year age group. Only 1.9% patients were in the 24-40 year age group and 5.8% patients were above the age of 70 years.

Gender	Frequency	Percent
Females	59	56.7
Males	45	43.3
Total	104	100

Table 3: Distribution Of Subjects Based On Gender

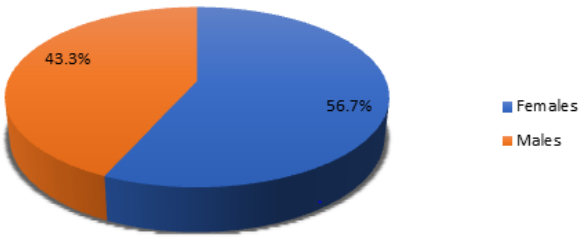

Fig 2: Distribution of the Subjects Based On Gender

Out of 104 patients, 56.7% were female while 43.3% were males.

Angle	Time intervals	N	Minimum	Maximum	Mean	S.D	p value
Narrow	Pre-op	52	16	20	17.85	1.474	<0.001*
	1 m	52	12	20	14.58	1.625	
	3 m	52	12	18	13.77	1.436	
	6 m	52	12	18	13.77	1.436	
Open	Pre-op	52	12	18	14.96	1.793	<0.001*
	1 m	52	10	16	12.88	1.875	
	3 m	52	10	16	12.63	1.772	
	6 m	52	10	16	12.63	1.772	

Table 4:Comparison Of The IOP At Different Time Intervals Based On The Angle Using Repeated Measures ANOVA

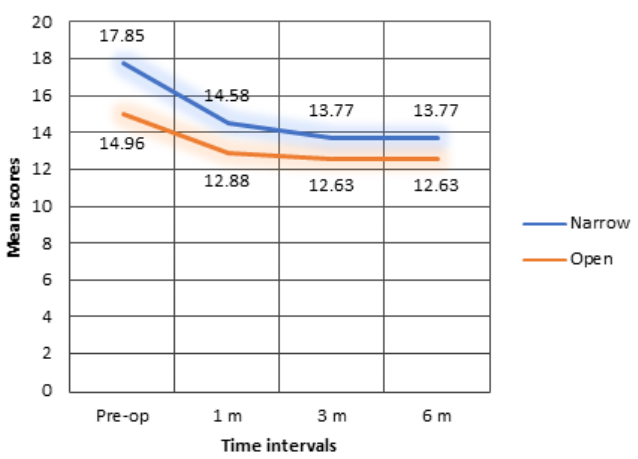

Fig 3: Comparison of the IOP at Different Time Intervals Based On the Angle

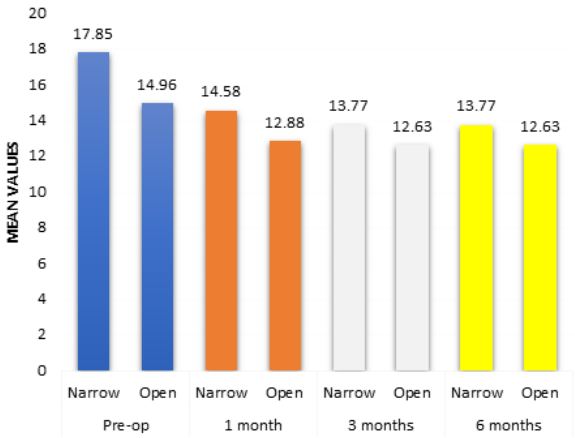

Fig 4: Comparison of the IOP between the Groups (Based On Angle)

In the narrow angles group, the mean IOP preoperatively was 17.58·1.474 mm of Hg with a minimum of 16 mm of Hg and a maximum of 20 mm of Hg. At 1 month, the mean IOP reduced to 14.58·1.625 mm of Hg with a minimum of 12mm of Hg and a maximum of 20 mm of Hg. At 3 months the mean IOP was 13.77 ·1.436 mm of Hg with a minimum of 12mm of Hg and a maximum of 18 mm of Hg which held constant at the 6 months follow up. In the open angles group, the mean preoperative IOP was 14.96·1.793 mm of Hg with a minimum of 12mm of Hg and a maximum of 18 mm of Hg. At the 1 month follow up the mean IOP reduce to 12.88·1.875 mm of Hg with a minimum of 10 mm of Hg and a maximum of 16 mm of Hg. At the 3 month follow up the mean IOP further reduced to 12.63·1.772 mm of Hg with a minimum if 10mm of Hg and a maximum of 16 mm of Hg which held constant at 6 months. The reduction of IOP in both the groups was found to be statistically significant (P<0.001).

	Narrow		Open	
	Mean Difference	p value	Mean Difference	p value
Pre op V/s 1 month	3.269	<0.001*	2.077	<0.001*
Pre op V/s 3 months	4.077	<0.001*	2.327	<0.001*
Pre op V/s 6 months	4.077	<0.001*	2.327	<0.001*
1 month V/s 3 months	0.808	<0.001*	0.25	0.086
1 month V/s 6 months	0.808	<0.001*	0.25	0.086
3 months V/s 6 months	0	-	0	-

Table 5:Comparison Of IOP Within The Group Between Two Time Intervals Using Post Hoc Bonferroni

In narrow angles, the mean IOP reduction at 1 month was 3.269mm of Hg. There was a further mean reduction of 0.808mm of Hg at the 3 month follow-up. In the open angle group the mean IOP reduction at 1 month was 2.077mm Hg with a further reduction of 0.25 mm of Hg at 3 months. The reduction in IOP from preoperative IOP to the IOP measured at 1month, 3 months and 6 months was statistically significant in both narrow angle group (p value <0.001) and in the open angle group (p value <0.001). There was a significant reduction of IOP from the 1 month follow up to the 3 month follow up (P<0.001) in the narrow angle group while the same reduction in the open angle group was not statistically significant.

Time intervals	Angle	N	Minimum	Maximum	Mean	S.D	Mean diff	p value
CCT (mm)	Narrow	52	456	591	542.231	37.381	13.65	0.096
	Open	52	351	629	528.577	45.021		
angle to angle distance (mm)	Narrow	52	7.82	12.42	10.922	1.129	-0.3	0.13
	Open	52	7.82	12.67	11.222	0.861		
lens vault (mm)	Narrow	52	0.216	0.794	0.509	0.142	0.002	0.93
	Open	52	0.274	0.841	0.507	0.139		
ACD (mm)	Narrow	52	1.78	3.81	2.636	0.572	-0.119	0.23
	Open	52	1.32	3.46	2.755	0.435		
AC area (mm2)	Narrow	52	13.55	31.2	20.461	4.383	-0.33	0.69
	Open	52	10.26	30.97	20.798	4.299		
Anterior vault(mm)	Narrow	52	2.363	4.245	3.145	0.537	-0.11	0.25
	Open	52	1.72	4.113	3.262	0.491		
relative lens vault	Narrow	52	0.068	0.247	0.167	0.055	0.011	0.22
	Open	52	0.093	0.234	0.156	0.038		

Table 6: Comparison Of The AS-OCT Between The Groups (Based On Angle) Using Independent Sample T Test

The mean central corneal thickness (in ·m) was found to be 542.23·37.381 in narrow angles and 528.57·45.021 in eyes with open angles. The mean angle to angle distance (in mm) was found to be 10.92·1.12 in narrow angles and 11.22·0.81 in eyes with open angles. The mean lens vault (in mm) was found to be 0.50·0.14 in narrow angles and 0.50·0.13 in eyes with open angles. The mean anterior chamber depth (in mm) was found to be 2.63·0.57 in eyes with narrow angles and 2.75·0.43 in eyes with open angles. The mean anterior chamber area (in mm2) was found to be 20.46 ·4.38 in narrow angles and 20.79·4.29 in eyes with open angles. The mean anterior vault (in mm) was found to be 3.14·0.53 in narrow angles and 3.26·0.49 in open angles. The mean anterior vault (in mm) was found to be 3.14·0.53 in eyes with narrow angles and 3.26·0.49 in eyes with open angles. The mean relative lens vault was found to be 0.16·0.05 in eyes with narrow angles and 0.15·0.03 in eyes with open angles. The differences between any of these values in the two groups were not statistically significant.

Groups		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	p value
Narrow	(Constant)	-6.626	4.164		-1.591	0.119
	PRE OP IOP	0.867	0.071	0.889	12.137	<.001*
	CCT (um)	0.006	0.004	0.155	1.369	0.178
	angle to angle distance (mm)	-0.18	0.148	-0.142	-1.219	0.229
	lens vault (mm)	-2.151	4.061	-0.212	-0.53	0.599
	AC area (mm2)	-0.086	0.053	-0.264	-1.639	0.108
	Anterior vault(mm)	1.377	0.927	0.515	1.486	0.144
	relative lens vault	13.15	13.642	0.504	0.964	0.34
Open	(Constant)	-8.981	6.454		-1.392	0.171
	PRE OP IOP	0.839	0.089	0.849	9.388	<.001*
	CCT (um)	0	0.004	0.003	0.032	0.975
	angle to angle distance (mm)	0.145	0.283	0.071	0.512	0.611
	lens vault (mm)	-15.056	9.643	-1.183	-1.561	0.126
	AC area (mm2)	-0.033	0.057	-0.08	-0.575	0.568
	Anterior vault(mm)	2.885	1.978	0.799	1.458	0.152
	relative lens vault	40.238	29.886	0.852	1.346	0.185

a. Dependent Variable: IOP at 3m

Table 7: Linear Regression With IOP At 3 Months As Dependent Variable

Linear regression was applied to compute the effect of AS - OCT Parameters and Preoperative IOP on IOP reduction measured at 3rd month. It was found that in both the groups Preoperative IOP was a significant predictor for IOP reduction ($P < 0.001$). Other AS - OCT parameters like Central corneal thickness, Angle to angle distance, Anterior chamber area; Lens vault; anterior vault and relative lens vault were not found to be statistically significant predictors of IOP reduction in either of the groups.

Statistical Analysis

SPSS (Statistical Package for Social Sciences) version 20.

IBM SPASS statistics [IBM corp. released 2011] was used to perform the statistical analysis

- Data was entered in the excel spread sheet.
- Descriptive statistics of the explanatory and outcome variables were calculated by mean, standard deviation for quantitative variables, frequency, and proportions for qualitative variables.
- Inferential statistics like
    - Independent sample t test was applied to compare the statistical difference of IOP, AS-OCT between the groups.
    - Repeated measures ANOVA was applied to compare the IOP among different time intervals within the group (based on angle) with post hoc Bonferroni for comparison between two-time intervals.
    - Linear regression was applied to compute the effect of AS-OCT on IOP at 3rd month.
- The level of significance is set at 5 %.

DISCUSSION

This study's findings back up previous claims of IOP reduction following cataract surgery.[4,7,8,9,10] After cataract surgery, the average IOP reduced 4.077 mm Hg from a preoperative reading of 17.58·1.474 mm of Hg in our group of non-glaucomatous patients with Narrow angles and in our open angle groups, The average IOP reduced by 2.327mm of Hg from a preoperative mean of 14.96·1.793 mm of Hg. There has been a lot of effort towards identifying predictors of IOP reduction. The preoperative IOP was revealed to be a significant predictor of IOP decline in our study. Several studies have also found that preoperative IOP is a strong predictor of postoperative IOP decline, which supports our findings.[11,12] Anatomic parameters of the anterior chamber, as evaluated by several anterior segment imaging modalities such as AS-OCT, have recently become the focus of attention for predicting the degree of IOP decrease after cataract surgery. The anterior chamber angle and ACD were evaluated as predictors of IOP decline in most of these investigations. Studies on lens-related anterior segment characteristics, on the other hand, are uncommon. The segment of the lens anterior to the scleral spur (LV), not the full LT, has been shown to have the most critical anatomic role in crowding the angle.[13]

The function of LT in predicting IOP decline is debatable. Yang et al[14] found that LT was a significant predictor of IOP decline in both univariate ($P < 0.05$) and multivariate analysis in non-glaucomatous participants ($P < 0.005$). The LV represents the anterior region of the lens, which may be more representational of the lens' role in angle closure than the LT [13] and has been demonstrated to be an independent risk factor for angle-closure glaucoma.[15] However, we found no significant relationship between LV and IOP decrease in other reports[16] which is similar with the findings of our investigation.

A large anterior chamber can compensate for the risk posed by even large LVs, lowering the total risk of angle closure, and vice versa. The LV, even when large, is less likely to

increase the risk of angle closure if the ACD is deep enough. These findings show that other metrics, such as AV and rLV, which are indications of the ACD and LV combined effect, may be more closely associated to angle-closure risk than absolute values. In our study we did not find a correlation between these factors and the IOP reduction.

CONCLUSION

The aim of the present study was to analyse the effect of lens position parameters on intra ocular pressure reduction following phacoemulsification in non-glaucomatous patients and to compare the results between normal angle and narrow angle eyes.

The following inferences were drawn:

• The mean age of the patients was 57.29 · 9.48 years. 38.5% patients were between the age group of 61-70 years making it the most common age group of this study.

• Out of 104 patients, 56.7% were female while 43.3% were males

• Mean IOP reduction 3 months postoperatively:

In narrow angle eyes 17.58·1.474 mm of Hg to 13.77 ·1.436 mm of Hg

In open angle eyes the mean IOP reduced from 14.96·1.793 mm of Hg to

12.63·1.772 mm of Hg. Thus the IOP reduction was found to be more in eyes with narrow angles when compared to eyes with open angles

• In narrow angles, the mean IOP reduction at 1 month was 3.269 mm of Hg. There was a further mean reduction of 0.808mm of Hg at the 3-month follow - up. In the open angle group, the mean IOP reduction at 1 month was 2.077mm Hg with a further reduction of 0.25 mm of Hg at 3 months.

• The mean AS - OCT parameters like Central corneal thickness, Angle to angle distance, Anterior chamber area, Lens vault; anterior vault and relative lens vault were similar in narrow angle and open angle groups with no statistical difference

• In both the groups Preoperative IOP was a significant predictor for IOP reduction ($P < 0.001$). Other AS - OCT parameters like Central corneal thickness, Angle to angle distance, Anterior chamber area; Lens vault; anterior vault and relative lens vault were not found to be statistically significant predictors of IOP reduction in either of the groups.

In summary, in our study we found that cataract surgery results in significant IOP reduction in both OA and NA eyes. Furthermore, we have found that preoperative IOP can be a useful predictor for IOP reduction which could be used to help potentially predict IOP response after cataract surgery.

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