Study of the Intraocular Pressure Changes after Phacoemulsification in Patients with Refractive Errors

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Abstract

Purpose: to investigate the intraocular pressure (IOP) changes after phacoemulsification surgery, and its relationship with refractive conditions.

Materials and Methods: This prospective, observational study comprised 100 eyes from 100 patients who had no glaucoma and underwent phacoemulsification and intraocular lens implantation in one eye. Patients were classified into four groups by refractive conditions: Emmetropia, mild to moderate myopia, high myopia and hyperopia. Basic information was collected including age, sex, anterior chamber depth and axial length before surgery. IOP and refractive conditions measured before surgery, and at 1st day, 1st week, 1st month, and 3rd months after surgery.

Results: all group showed a significant lower IOP at 3rd month compared with that before surgery. patients with emmetropia, mild to moderate myopia and hyperopia showed exactly the same results. In these 3 groups, IOP after surgery presented with a statistically significant drop at 1st week, 1st month and 3rd months after operation, especially at 1week. In patients with high myopia, IOP showed a lower IOP at 1st week and 1st month compared with IOP before surgery but this drop was not statistically significant (P=0.505 and P=0.146, respectively) but there is a statistically significant reduction between preoperative IOP and postoperative IOP at 3rd months (P =0.001).

Conclusions: a significant lower IOP at 3rd month than that before surgery was found in patients groups with different refractive conditions. This indicate that cataract surgery had an effect on IOP reduction despite the refractive conditions. However, high myopic patients showed a non-significant lower speed of IOP reduction at 1st week and 1st month. This conclude that refractive conditions might influence the IOP fluctuation in first 90 days after surgery.

Introduction

Cataract is identified as a leading cause of reversible vision loss worldwide. The prevalence of cataract is going high as the population aging phenomenon making it a global health problem. [1, 2, 3]

With the new advances of cataract surgery technology, phacoemulsification has been the gold standard technique providing the advantage of being small incision suture less surgery with good visual outcomes, minimal complications and rapid visual recovery .The advances of intraocular lenses technology, has made phacoemulsification a refractive surgery not only a lens opacity removal. [2]

Cataract surgery is now considered as one of the most commonly performed surgical procedures worldwide with proved clinical benefit for both cataract and glaucoma treatment. Besides removing lens opacity and restoring vision, cataract surgery has been proved to reduce intraocular pressure (IOP) in patients either with or without glaucoma, with variable magnitude and affected by many factors, including anterior chamber angle configuration. [4, 5]

There are many factors affecting IOP change after cataract surgery, preoperative mean IOP was proved to be the most significant single factor. [6, 7] Another biometric factors which are proposed as independent predictors of IOP post cataract surgery were anterior chamber depth, anterior chamber angle and lens thickness. [8, 9, 10]

Refractive error is one of the leading causes of visual impairment decreasing quality of life. Refractive errors are known to be associated with a lot of ocular comorbidities. Myopia, especially high myopia, is a risk factor for retinal detachment, macular degeneration, and for open angle glaucoma (POAG). On the other hand hyperopia is a risk factor for acute ischemic optic neuropathy or primary angle closure glaucoma (PACG). [11]

Although a notable correlation between refractive errors and IOP elevation has long been suggested, [12, 13] the role of refractive errors in IOP changes after cataract surgery remains unclear. In this study, we have tried to reveal the relationship between refractive conditions and post-phacoemulsification IOP change.

Materials And Methods

The study protocol was approved by the Local Ethics Committee of the Faculty of Medicine, Alexandria University, Egypt. An informed consent was obtained from the patients for the cataract surgery as well as participation in the study. The study was carried out according to the tenets of the Declaration of Helsinki.

This study is designed as a prospective one conducted between September 2019 and February 2020. It included 100 eyes of 100 patients scheduled for routine phacoemulsification and were classified into four groups according to their refractive errors, near emmetropia (within ± 1.00D), mild to moderate myope (− 1.00D to − 6.00D), high myope (more than − 6.00D), and hyperope (more than + 1.00D).

Patients with complicated cataracts, history of glaucoma, previous ocular surgeries,history of corneal abnormalities and Active ocular inflammation were excluded from the study. Also patients with dense cataract making autorefractometer reading not possible or not reproducible were excluded from the study.

All patients received a comprehensive ophthalmic examination : uncorrected distance visual acuity (UDVA), best spectacle -corrected visual acuity (BCVA), measurement of refractive errors and slit lamp biomicroscopy, dilated fundus examination followed by baseline intraocular pressure assessment by Goldmann applanation tonometry.

Evaluation of refractive conditions:

The objective monocular refractive condition for the operating eye was measured before surgery, using Auto Ref/Keratometer, and the final refractive conditions were determined according to the autorefractometer diopteric reading

IOP measurement:

The IOP in each group was assessed by Goldmann applanation tonometry, all patients received a topical anesthesia twice in both eyes with an interval of 5 minutes, then applied with sodium fluorescein, and IOP was taken as an average of 2 readings by Goldmann tonometry.

Surgery:

All patients underwent phacoemulsification surgery with foldable posterior chamber IOL implantation through clear corneal tunnel incision.

Postoperative:

follow-up at 1st day,1st week,1st month,3rd month postoperative. At each follow-up we examined refractive conditions and intraocular pressure (IOP).

ΔIOP at each follow-up was defined as IOP at this follow-up minus IOP at last follow-up (e.g., ΔIOP at 1st month postoperative = IOP at 1st month postoperative –IOP at 1st week postoperative).

Statistical analysis

Quantitative data were presented in mean ± SD. Statistical analysis was carried out by SPSS, version 20.0 (SPSS Inc., New York, New York, USA). The difference was considered statistically significant if the P value was less than 0.05.

Results

A total of 100 eyes of 100 patients who underwent cataract surgery and fit all of the inclusion criteria were enrolled, of which 20 were emmetropia, 25 were mild to moderate, 15 were high myopia, and 40 were hyperopia. The age of cases is ranged between 40 to 80 years with 57.56 ± 9.18 as mean ± SD and a median value as 56. The selected patients were 53 males (53%) and 47 females (47%). This group comprised 41 right eyes (41%) and 59 left eyes (59%). There are thirty-five cases presented with nuclear cataract (35%), forty-eight cases with PSC cataract (48%) and seventeen cases with cortical cataract (17%). Pre-operative SE ranged from − 18.75–9.38 with − 2.31 ± 5.66 as mean ± SD. ACD ranged from 2.39–3.99 with 2.91 ± 0.40 as mean ± SD. AL ranged from 20.12–31.81 with 23.86 ± 2.19as mean ± SD. IOL power ranged from − 9–30 with 18.86 ± 6.55 as mean ± SD. preoperative UDVA ranged from 0.05–0.30 with 0.10 ± 0.06 as mean ± SD. preoperative BCVA ranged from 0.05–0.70 with 0.24 ± 0.12 as mean ± SD. Preoperative IOP ranged from 9–25 with 16.40 ± 3.41 as mean ± SD. (see Table 1)

Table (1): Distribution of the studied cases according to preoperative patients characteristics (n = 100)

	No.	%
Age (years)		
40 – 50	20	20.0
>50 – 60	41	41.0
>60	39	39.0
Range	40.0 – 80.0	
Mean ± SD.	57.56±9.18	
Median	56.0(52.0 – 63.0)	
Gender		
Male	53	53.0
Female	47	47.0
Eye		
OD	41	41.0
OS	59	59.0
Refraction		
Emmetrope	20	20.0
mild to moderate myope	25	25.0
High myope	15	15.0
Hyperope	40	40.0
Cataract		
Nuclear	35	35.0
PSC	48	48.0
Cortical	17	17.0
SE		
Range	-18.75 – 9.38	
Mean ± SD.	-2.31± 5.66	
Median	-0.19(-4.94 – 1.44)	
ACD		
Range	2.39 – 3.99	

Mean ± SD.	2.91±0.40
Median	2.83(2.55 – 3.18)
AL	
Range	20.12 – 31.81
Mean ± SD.	23.86±2.19
Median	23.26(22.49–24.91)
IOL Power	
Range	-9.0 – 30.0
Mean ± SD.	18.86±6.55
Median	21.0(16.0 – 23.0)
UDVA	
Range	0.05 – 0.30
Mean ± SD.	0.10±0.06
Median	0.10(0.05 – 0.10)
BCVA	
Range	0.05 – 0.70
Mean ± SD.	0.24±0.12
Median	0.20(0.18 – 0.30)
Preoperative IOP	
Range	9.0–25.0
Mean ± SD.	16.40±3.41
Median	16.0(13.5–19.0)

Abbreviations: SE, spherical equivalent; ACD, anterior chamber depth; AL, axial length; IOL Power, intraocular lens power; VA, visual acuity values are represented in decimal; UDVA, uncorrected distance visual acuity; CDVA, corrected distance visual acuity.

Differences of IOP at each follow-up in all studied patients

Postoperative IOP at 1st week was 14.09±2.66 (Mean ±SD), at 1st month was 13.95±2.34 (Mean ±SD) and at 3rd months was 13.30±2.26 (Mean ±SD). A statistically significant reduction between preoperative IOP and postoperative IOP at 1st week, 1st month and 3rd months occurred (all with P <0.001) (see Table 2).

Table (2): Comparison between the different periods according to IOP

IOP	Preoperative (n = 100)	Postoperative			F(p)
		1st week (n = 100)	1st month (n = 100)	3rd months (n = 100)	
Range.	9.0–25.0	8.0–22.0	9.0–20.0	8.0–19.0	79.936* (<0.001*)
Mean ± SD.	16.40±3.41	14.09±2.66	13.95±2.34	13.30±2.26	
Median (IQR)	16.0(13.5–19.0)	14.0(12.0–16.0)	14.0(16.0–15.0)	13.0(12.0–15.0)	
p_0		<0.001*	<0.001*	<0.001*	

F: F test (ANOVA) with repeated measures, Sig. bet. periods was done using **Post Hoc Test** (**adjusted Bonferroni)**

p_0: p value for comparing between **Preoperative** with each other periods

*: Statistically significant at $p \leq 0.05$

Differences of IOP between groups

There was no statistically significant difference in preoperative IOP and IOP at 1st day, 1st week, 1st month, and 3rd months (P=0.873, P=0.081, P=0.282, and P=0.433 respectively) between 4 groups (see Table3).

Table (3): Relation between Refraction with IOP

IOP	Refraction				F	p
	Emmetrope	Mild to moderete myope	High myope	Hyperope		
Preoperative	**(n = 20)**	**(n = 25)**	**(n = 15)**	**(n = 40)**		
Range.	11.0 – 25.0	9.0 – 22.0	11.0 – 21.0	12.0 – 25.0	0.234	0.873
Mean ± SD.	16.60±3.90	16.0± 3.28	16.13±3.14	16.65±3.44		
Median	16.0	16.0	16.0	16.0		
1st day	**(n = 4)**	**(n = 8)**	**(n = 6)**	**(n = 6)**		
Range.	12.0 – 17.0	15.0 – 23.0	14.0 – 21.0	10.0 – 22.0	2.593	0.081
Mean ± SD.	14.25±2.63	17.13±2.85	18.50±2.81	14.17±4.12		
Median	14.0	16.0	20.0	13.50		
1st week	**(n = 20)**	**(n = 25)**	**(n = 15)**	**(n = 40)**		
Range.	8.0 – 20.0	8.0 – 21.0	10.0 – 19.0	10.0 – 22.0	1.291	0.282
Mean ± SD.	13.80±3.19	14.28±2.76	15.20±2.62	13.70±2.27		
Median	13.50	14.0	15.0	14.0		
1st month	**(n = 20)**	**(n = 25)**	**(n = 15)**	**(n = 40)**		
Range.	9.0 – 20.0	9.0 – 18.0	11.0 – 19.0	11.0 – 20.0	0.923	0.433
Mean ± SD.	13.70±2.60	13.76±2.52	14.87±2.56	13.85±1.98		
Median	13.50	14.0	15.0	14.0		
3rd months	**(n = 20)**	**(n = 25)**	**(n = 15)**	**(n = 40)**		
Range.	10.0 – 20.0	8.0 – 18.0	11.0 – 18.0	10.0 – 19.0	1.168	0.326
Mean ± SD.	13.35±2.68	13.08±2.31	14.27±2.40	13.05±1.91		
Median	12.50	12.0	15.0	13.0		

F: F for ANOVA test

p: p value for comparing between the studied groups

Discussion

Cataract surgery considered as one of the most common surgical procedures performed worldwide. It has been suggested to be of clinical benefit for both cataract and glaucoma management. Besides removing cataracts to restore vision, cataract surgery has been proved to reduce intraocular pressure (IOP) in patients either with or without glaucoma. [14] Arecent study revealed that cataract surgery can cause a significant IOP reduction, considering cataract surgery to be a possible line of management of glaucoma. [15] the effect on IOP is with variable magnitude and affected by many factors.[4]

Several factors affecting the IOP after cataract surgery have been explored in previous studies. These factors include Preoperative IOP value, angle configuration and anterior chamber anatomy. [16,17,18]

Although a notable correlation between refractive errors and IOP elevation has long been identified, [12,13] the role of refractive errors in IOP drop after cataract surgery remains unclear

previous studies showed that, the IOP-lowering effect of cataract surgery has been long known ranging from 3 to 60 months; for example: Melancia D, et al [1] and Lv H, et al [19]. our current study agrees with that as all groups showed a significant lower IOP at 3rd month compared with that before surgery. It may be the result of the thin inserted IOL that deepening the anterior chamber. [20]

Some of the most important similar studies results are illustrated in Table (4), which reflecting a variable IOP decrease after cataract surgery.

Table (4): Clinical studies reflecting the effect of lens extraction on IOP

Study*	n	Follow up	IOP pre mm Hg	IOP post mm Hg	ΔIOP	P value
Pohjalainen [21], 2001	137	25 months	16.3	12.7	-3.4	0.001
Shingleton [22], 2006	59	60 months	15.9	13.4	-1.5	<0.0001
Lv H [19], 2018	353	3 months	14.3	12.1	-2.2	<0.001
Current study	100	3 months	16.4	13.3	-3.1	<0.001

Mean IOP at 1st week (14.09±2.66), 1st month (13.95±2.34), and 3rd month (13.30±2.26) was significantly lower than that before surgery (16.40±3.41) (all with P<.001), and the mean IOP was lower at 1st week compared with that at 1 day, 1st month compared with 1st week, and 3rd month compared with 1st month. These results indicated that IOP was decreasing with the elongation of time after surgery (see Table 3).

Transient IOP elevation in the early postoperative period after cataract surgery may exist. Previous studies showed that IOP elevation may initiate at 2hours with a peak at 3–7 h after surgery and may

persist during the first 24 h. [23]

In a retrospective cohort study, Bonnell, et al [24] showed that there was a significant IOP elevation at 1 day after surgery, as 4.4% patients had an IOP elevation of 10mmHg and 2.1% had an IOP 30mmHg or higher after cataract surgery. in contrast, Lv H, et al [19] found that there was Transient IOP elevation. In our study, IOP was found to be slightly elevated at 1st day after surgery, with the difference not statistically significant.

High myopia is a significant predisposing risk factor for development of primary open-angle glaucoma (POAG), and in patients with POAG, myopia is a predisposing factor for IOP fluctuations as well as POAG progression. Hyperopia is a risk factor for primary angle closure glaucoma (PACG). [25]

Slabaugh MA et al [26] showed no correlation between spherical refractive error and IOP at 3 to 6 months after cataract surgery. While in another study, Lv H, et al [19] showed statistically significant difference in IOP changes after surgery at 7 and 30 days either in emmetropic or myopic patients.

In our study, patients with emmetropia, mild to moderete myopia and hyperopia showed exactly the same results. In these 3 groups, IOP after surgery presented with a statistically significant decrease at 1st week, 1st month and 3rd months after operation, especially at 1w according to ΔIOP analysis.

In patients with high myopia, IOP showed a lower IOP at 1st week and 1st month compared with IOP before surgery, while it did not reach a statistically significant level (P=0.505 and P=0.146, respectively) but there is a statistically significant reduction between preoperative IOP and postoperative IOP at 3rd months occurred (P =0.001). This phenomenon indicated that high myopia may lead to a more smoothly IOP change in the early post operational period and a relevantly delayed reduction compared with emmetropia, low myopia patients and hyperopia.

The role of myopia in IOP changes after cataract surgery remains unclear. In our study, though IOP before surgery was closely matched between 4 groups, different patterns of IOP change after surgery were observed. We suspect that, especially in high myopia eyes, anatomic changes e.g. (increased visual axis length, retinal and choroidal thinning, enlarged optic disc, peripapillary atrophy, and insufficient hemoperfusions on choroid and the retina), [27] still existed and remained after cataract surgery, which might have an opposite beneficiation to the IOP reduction effect of cataract surgery. These anatomical changes might have already created more space in the anterior chamber, especially choroidal thinning along with thinner lens and the long visual axis length in high myopia patients, and therefore phaco with IOL implantation surgery may not have an instant effect on chamber angle, so the reduction of IOP may not be immediately observed in those patients.

Overall change of IOP at1st week was higher than that at 1st day after surgery, ΔIOP at 1st month was lower than that at 1st week, ΔIOP at 3rd months was lower than that at 1st month. This indicate that IOP is decreasing relatively faster at the period of 1 to 7 days after surgery than other follow-up period.

In a relevant retrospective cohort study, Lv H, et al [19] compared the IOP between 3 refractive conditions in each follow-up period, and found a significant difference at 30 days, with IOP higher in high myopia patients than that in emmetropic and mild to moderate myopic patients. Correspondingly, an IOP increase was identified from 7 to 30 days in high myopia group.

As for IOP changes, though Total IOP Changes at 1st week and 1st month differed between groups, we found no significant difference with Total IOP Changes at 3rdnth month, which proves that all the patients reached a satisfactory IOP reduction post cataract surgery regardless of their refractive conditions. This might consider that phaco with IOL implantation surgery played a more important role compared with structural features in high myopia eyes might finally came to be effective and steady at 30 to 90 days after operation.

We also observed a younger age in myopic patients than other groups in our study with 50.40± 8.60 as mean ± SD. it might indicate that myopia contributed to the younger onset of cataract. This result was also reported in previous studies as a complication of pathologic myopia [28] and suggested that a more frequent examination for myopic eye was required for screening and early diagnosis of both cataract and complications.

Several limitations encountered in our study. First, evaluation of long-term changes in IOP may require follow up greater than one year. Second, the study was performed on normal subjects with cataract. Patients with glaucoma should be included in the future studies. third, the protocol does not include the evaluation of chamber angle configuration or corneal thickness before and after surgery Our definition of refractive errors according to autorefractometer readings may be affected with refractive effect of cataract .Further studies with anatomical classification of cases according to axial length may yield a different outcomes

Conclusion

In conclusion, a significant lower IOP at 3rd month than that before surgery was found in emmetropic, mild to moderate myopic, high myopic, and hyperopic patients. This indicate that cataract surgery had an effect on IOP reduction despite the refractive conditions. However, high myopic patients showed a non-significant lower speed of IOP reduction at 1st week and 1st month. This conclude that refractive conditions might influence the IOP fluctuation in first 90 days after surgery.

Declarations

Ethics approval and consent to participate

Ethics committee at Alexandria university, Faculty of Medicine approved this study. Methods were performed in accordance with the relevant guidelines and regulations.Written informed consents with all details were obtained from all participants to be enrolled in the study and allow the results for publications. All data mentioned in the study are available

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Conflicts of interest

there are no conflicts of interest for any of the author

Availability of data and materials

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request

Authors contribution

Amr Said and Mona zeid wrote the manuscript. Hany helaly and Tarek abdelrazek reviewed the manuscript and performed the statistical analysis**,**

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