

Early Changes in Intraocular Pressure Following Phacoemulsification

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Purpose: To evaluate early postoperative changes in intraocular pressure (IOP) following phacoemulsification and intraocular lens (IOL) implantation.

Methods: This prospective study included 129 eyes with open angles and normal or high IOP undergoing phacoemulsification and IOL implantation for senile cataracts. The patients were divided into 3 groups (Gs) based on preoperative IOP: ≤ 15 mmHg (G1, n=76); from 16 to 20 mmHg (G2, n=43) and; from 21 to 30 mmHg (G3, n=10). IOP was measured by Goldmann applanation tonometry one day before surgery, and 1 and 6 weeks postoperatively.

Results: IOP was decreased postoperatively in all study groups 1 and 6 weeks after surgery as follows: 2.8 ± 1.5 and 1.8 ± 1.7 mmHg respectively in G1 ($P < 0.001$); 4.2 ± 1.9 and 4.3 ± 2.9 mmHg respectively in G2 ($P < 0.001$), and 8.3 ± 4.3 and 9.3 ± 4.1 mmHg respectively in G3 ($P < 0.001$). At the end of the sixth postoperative week, the percentage of IOP change for G1, G2 and G3 was $13.5\% \pm 12.7$, $24.5\% \pm 11.7$ and $38.3\% \pm 16.2$, respectively.

Conclusion: IOP significantly decreased after phacoemulsification and IOL implantation in normal subjects with open angles and those with ocular hypertension. IOP reduction was greater in eyes with higher preoperative IOP.

Keywords: Intraocular Pressure; Phacoemulsification

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INTRODUCTION

Cataract is the leading cause of visual loss and blindness in the world and its optimal management is surgery.¹ Cataract surgery may alter intraocular pressure (IOP) postoperatively and several studies have reported these changes which include increased IOP, decreased IOP and even hypotony.²⁻¹⁰ However, the majority of studies have reported a decrease in IOP in both normal and glaucomatous eyes.³⁻¹⁰

The magnitude of IOP reduction varies among patients. Factors which help predict the amount of reduction could be beneficial for timing of surgical intervention. Previous

studies have shown that shallower anterior chamber depth, shorter axial length and higher preoperative IOP are correlated with greater reduction in postoperative IOP.^{3-5,11-13}

This study evaluates early postoperative changes in IOP following phacoemulsification and intraocular lens (IOL) implantation.

METHODS

This prospective study was performed on 129 patients with senile cataracts who underwent phacoemulsification and in-the-bag implantation of a foldable IOL between December 2008 and March 2009. The study was approved by the

Ethics Committee at Ahvaz Jundishapour University of Medical Sciences and informed consent was obtained from all subjects enrolled in the study.

Preoperatively all patients underwent a complete ophthalmologic examination including gonioscopy. Only patients with a grade 3 or 4 angle using the Shaffer grading criteria were included. IOP was lower than 30 mmHg in all eyes. None of the eyes had an optic nerve/disc changes suggestive of glaucomatous damage and none of the patients were using glaucoma medications preoperatively.

All patients had postoperative corneal astigmatism of 0.50 diopter (D) or less. Patients with previous eye trauma, pseudoexfoliation syndrome, glaucoma, prior intraocular surgery and those developing any complication during or after surgery were excluded.

Goldmann applanation tonometry was performed one day before surgery, and 1 and 6 weeks postoperatively by the same examiner between 9AM and 11AM. IOP was measured twice and the mean value was recorded for the analysis.

Eyes were divided into 3 groups (Gs) based on preoperative IOP: ≤ 15 mmHg (G1, n=76); from 16 to 20 mmHg (G2, n=43), and from 21 to 30 mmHg (G3, n=10).

Surgical Technique

Clear corneal phacoemulsification and foldable IOL implantation was performed by two surgeons (MZ & MF) using a similar technique. All procedures were performed with the patient under general anesthesia. A 3.2 mm clear corneal temporal incision was made. Viscoelastic was injected (Ocucoat, 2% hydroxylpropylmethylcellulose; Bausch & Lomb Inc., Rochester, NY, USA), and a continuous curvilinear capsulorhexis and hydrodissection of the nucleus was performed. Phacoemulsification of the nucleus was performed using the stop and chop technique. A foldable IOL (Acrysof IQ SN60WF, Alcon Laboratories Inc., Fort Worth, TX, USA) was implanted in the bag, viscoelastic was removed by irrigation/aspiration and the corneal incision was left unsutured.

One day postoperatively, betamethasone eye drops were started every four hours and tapered over 4 weeks. Ciprofloxacin eye drops were prescribed 4 times a day for five days. Carbonic anhydrase inhibitors, alpha-receptor agonists or any other IOP lowering drugs were not prescribed pre- or postoperatively.

Statistical Analysis

Sample size was calculated according to previous studies with an α error of 0.05 and power of 0.80. Data were analyzed with SPSS software version 13 (IBM Corp., New York, NY, USA). Analysis of variances (ANOVA) and paired *t*-tests were used to compare mean preoperative and postoperative (1 week and 6 weeks) IOP values. The Kruskal-Wallis test was used to compare the magnitude of change in IOP at 6 weeks postoperatively. P values less than 0.05 were considered as statistically significant.

RESULTS

There was a significant decrease in IOP in all groups postoperatively. Eyes with higher preoperative IOP, demonstrated a greater decrease in IOP. Overall, mean preoperative IOP was 15.05 ± 3.72 mmHg which was decreased to 11.74 ± 2.48 mmHg at 1 week (7 ± 2 days) and 11.85 ± 2.34 mmHg at 6 weeks (45 ± 3 days) postoperatively (Fig. 1). The magnitude of

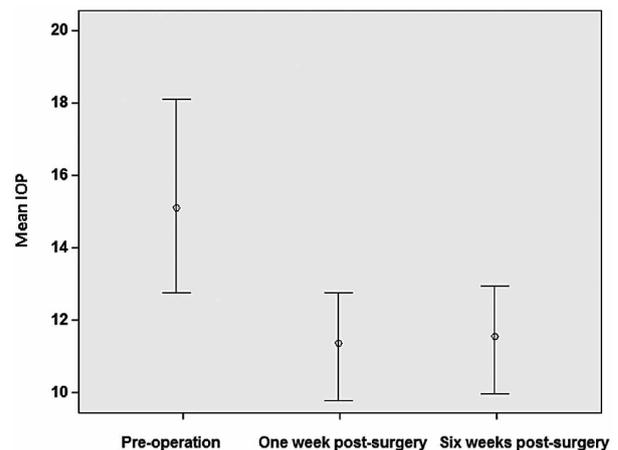


Figure 1. Changes in intraocular pressure (IOP) one and six weeks after phacoemulsification and intraocular lens implantation.

Table 1. Changes in intraocular pressure (IOP) after phacoemulsification and intraocular lens implantation based on preoperative IOP

IOP group (mmHg)	Eyes (no)	Mean±Standard Deviation (range)					Final percentage of change in IOP
		*Pre-op	1 week Post-op	Change at 1 week	6 weeks Post-op	Change at 6 weeks	
IOP ≤15	76	12.7±1.6 (8-15)	10.5±1.6 (6-14)	2.8±1.5	10.9±1.7 (8-16)	1.8±1.7	13.5±12.7%
16<IOP ≤ 20	43	17.1±1.3 (16-20)	13±1.3 (10-17)	4.2±1.9	12.9±2 (10-18)	4.3±2.9	29.5±11.7%
21<IOP ≤ 30	10	24±3.3 (21-30)	15.7±4.1 (9-21)	8.3±4.3	14.7±3.7 (10-19)	9.3±4.3	38.3±16.2%

no, number; op, operative

[P<0.001 for comparing pre-op and 1 week post-op IOPs in all groups; P<0.001 for comparing pre-op and 6 weeks post-op IOPs in all groups]

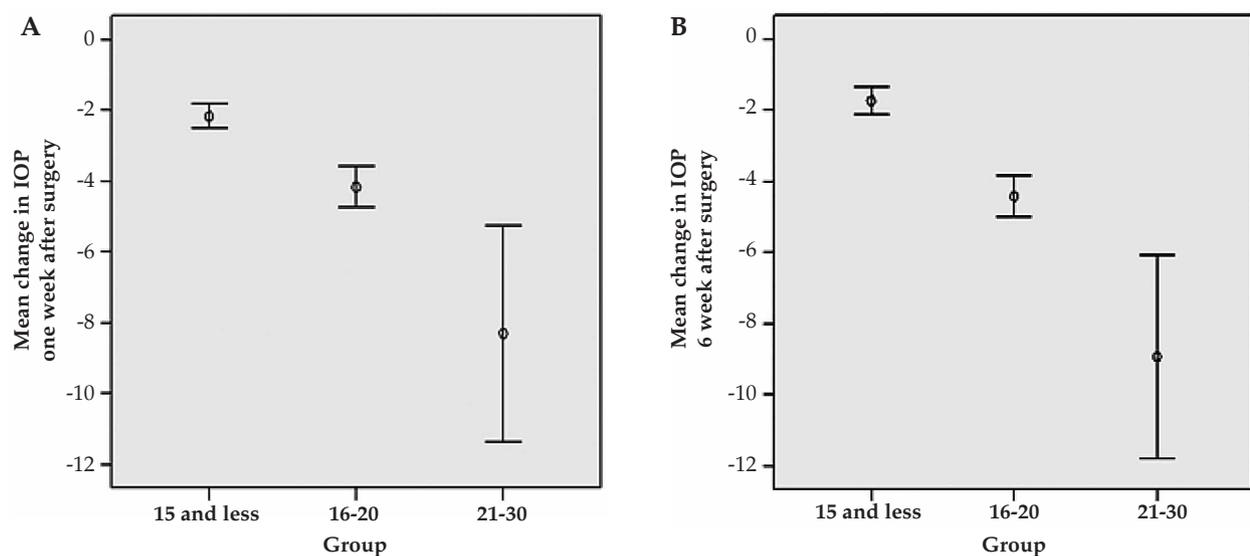


Figure 2. Mean changes in intraocular pressure (IOP) with 95% confidence intervals (A) one and (B) 6 weeks after phacoemulsification and intraocular lens implantation.

changes in IOP are summarized in Table 1.

At 1 week, mean IOP reduction was 2.8±1.5 mmHg in G1, 4.2±1.9 mmHg in G2 and 8.3±4.3 mmHg in G3 (P<0.001, for all comparisons). IOP reduction remained relatively steady at 6 weeks such that mean IOP reduction was 1.8±1.7 mmHg in G1, 4.3±2.9 mmHg in G2 and 9.3±4.1 mmHg in G3 (P<0.001 for all comparisons, Fig. 2). IOP changes from weeks one to six were not statistically significant in any subgroup (P=0.011, one way ANOVA).

Mean age of the patients was 65.6±9.65 years (range, 40-87 years). The magnitude of IOP reduction was slightly but not significantly greater with increasing age (Pearson correlation coefficient=-0.144, P=0.102, Fig. 3). The study included 64 (49.6%) male and 65 (50.4%) female

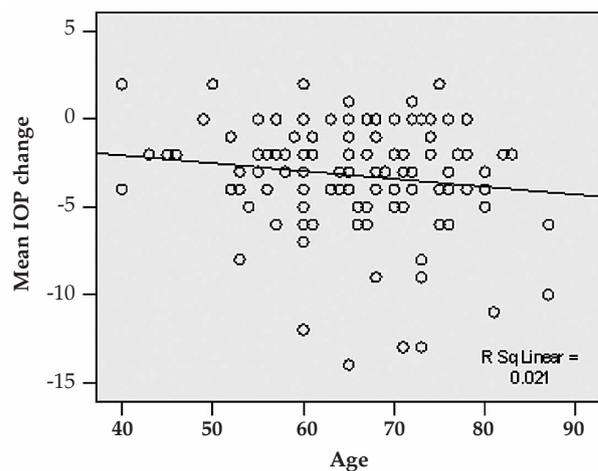


Figure 3. Correlation between age and change in intraocular pressure (IOP) in eyes undergoing phacoemulsification and intraocular lens implantation.

subjects. No statistically significant difference was found in the magnitude of IOP change based on gender ($P=0.995$).

DISCUSSION

In the current study, we observed a significant reduction in IOP in eyes with open angles and both normal or high IOP, 1 and 6 weeks after phacoemulsification and IOL implantation. IOP reduction was proportional to preoperative IOP, i.e. the higher the preoperative IOP, the greater the reduction in postoperative IOP. These results concur with previous studies. Poley et al³ evaluated postoperative IOP changes in 124 eyes after cataract surgery which were grouped according to preoperative IOP. They evaluated changes in IOP up to one year after surgery and at final visit, and reported mean reduction of 8.5 mmHg (34%) in eyes with preoperative IOP of 29 to 23 mmHg; 4.6 mmHg (22%) reduction in eyes with preoperative IOP of 22 to 20 mmHg; 3.4 mmHg (18%) reduction in eyes with preoperative IOP of 19 to 18 mmHg and; 1.1 mmHg (10%) reduction in eyes with preoperative IOP of 17 to 15 mmHg. Interestingly, in eyes with preoperative IOP from 14 mmHg to 5 mmHg, IOP was increased by 1.7 mmHg (15%). The authors stated that IOP reductions at one year were sustained for 10 years in the study cohort irrespective of age.³

In a separate but similar study, Poley et al⁴ reviewed 588 eyes undergoing phacoemulsification with IOL implantation and divided them into 5 groups based on IOP at surgery. They evaluated changes in IOP up to one year postoperatively and at final visit. Mean decrease in IOP was 6.5 mmHg (27%) in eyes with preoperative IOP of 31 to 23 mmHg; 4.8 mmHg (22%) in eyes with preoperative IOP of 22 to 15 mmHg IOP, and 2.5 mmHg (14%) in eyes with preoperative IOP of 14 to 9 mmHg.⁴ The decrease in IOP at 1 year was sustained over 10 years for patients of all ages.⁴ Mean postoperative IOP reduction in our study was similar to previous studies. The significant reduction in IOP in patients with elevated preoperative IOP (>20 mmHg) could be an important advantage of cataract surgery.

Several studies have emphasized the considerable decrease in IOP after cataract surgery in eyes with primary angle closure or narrow angles and shallow preoperative anterior chamber depth (ACD).¹¹⁻¹³ Shin et al¹¹ evaluated changes in ACD and IOP after phacoemulsification in 35 eyes with occludable angles and compared them with 35 eyes with normal open angles. They measured IOP and ACD before, 1 day, and 1, 4, 9 and 12 months postoperatively. They found that the occludable angle group had shallower ACD, higher preoperative IOP and greater IOP reduction compared to the open angle group. Kashiwagi et al¹² evaluated ACD in 28 eyes undergoing uncomplicated phacoemulsification and IOL implantation. They grouped the eyes based on the Van Herick technique into grades 1 to 4 and measured ACD with the Scanning Peripheral ACD Analyzer. They reported that cataract surgery increased ACD in all groups which was significantly larger in patients with shallower preoperative ACD and shorter axial length; IOP reduction was also more marked in eyes with shallow preoperative AC.¹²

Cho¹³ evaluated 71 eyes undergoing phacoemulsification and IOL implantation, and measured IOP one day preoperatively, and 3 and 5 weeks postoperatively. Eyes were divided into 4 groups based on axial length (AL): (1) 21 to < 23 mm; (2) 23 to < 25 mm; (3) 25 to < 27 mm; and (4) \geq 27 mm. The investigators found a statistically significant decrease in IOP in groups 1 and 2, and a statistically significant increase in IOP in groups 3 and 4.¹³

A possible explanation for IOP reduction after cataract surgery in eyes with primary angle closure and narrow angles is widening of the angle and altered configuration of the ciliary body. Nonaka et al¹⁴ evaluated 31 patients with primary angle closure or primary angle closure glaucoma (PACG) undergoing cataract surgery. Using ultrasound biomicroscopy, they found that ACD, angle opening distance at 500 microns anterior to the scleral spur and the trabecular-ciliary process distance increased significantly after cataract surgery. The authors concluded that cataract surgery attenuates anterior positioning of the ciliary processes and widens the anterior

chamber angle in eyes with PACG.¹⁴

The decrease in IOP following cataract surgery is greater in eyes with primary angle closure or narrow angles; this change is proportional to the level of preoperative IOP,^{15,16} which concurs with our results. Zhou et al¹⁵ studied 53 eyes undergoing cataract surgery and measured anterior chamber width and IOP before and 5 months after phacoemulsification. They found a significant and sustained decrease in IOP and a concurrent increase in anterior chamber angle width postoperatively. Of note, preoperative anterior chamber angle width did not predict the IOP lowering effect of cataract surgery.¹⁵

Shams et al¹⁶ reported a statistically significant reduction in IOP in 55 eyes with PACG. In their retrospective study they compared IOP before and 7.2 months after cataract extraction. IOP reduction was significantly greater in eyes with higher preoperative IOP. The number of glaucoma medications was also decreased after cataract surgery.¹⁶

A number of studies reported similar reductions in IOP after cataract surgery in patients with primary open angle glaucoma (POAG) and also in normal subjects.¹⁷⁻²⁰ Hayashi et al¹⁷ reported a significant decrease in IOP after cataract surgery in eyes with PACG and POAG. They measured IOP and the number of medications before and 1 month postoperatively and then every 3 months. Mean IOP and the number of medications decreased significantly postoperatively in both groups. However, these reductions were greater in the PACG group.¹⁷

In a separate report, Hayashi et al¹⁸ evaluated 73 eyes with POAG, 77 eyes with PACG, and 74 control eyes undergoing cataract surgery and IOL implantation. They measured angle width and ACD using a schiempflug videophotography system preoperatively, at 1 week, and 1, 3, 6, 9 and 12 months postoperatively. They reported that ACD and anterior chamber angle increased significantly after surgery in all patients. The magnitude of IOP reduction was greater in POAG and PACG eyes as compared to controls but mean IOP was comparable among the three groups at 1, 6, and 12 months.¹⁸

Altan et al¹⁹ investigated the influence of

uneventful phacoemulsification on ACD, angle width and IOP in non-glaucomatous eyes with open angles. IOP was measured 1 day before and 1 day, 1 week, and 1, 3 and 6 months after surgery. Mean IOP decreased postoperatively, however the magnitude of reduction was not correlated with changes in anterior chamber angle width or ACD. They concluded that preoperative IOP was the single predictor of postoperative IOP reduction.¹⁹

In a study spanning 5 years, Shingleton et al²⁰ evaluated 55 eyes with POAG, 44 glaucoma suspect eyes, and 59 eyes with no glaucoma undergoing phacoemulsification and IOL implantation. They evaluated IOP changes after 3 and 5 years. At final follow-up, the decrease in IOP was 1.8 ± 3.5 mmHg in the glaucoma group, 1.3 ± 3.7 mmHg in the glaucoma suspect group, and 1.5 ± 2.5 mmHg in no glaucoma subjects. The authors stated that postoperative IOP reduction was related to structural changes in the eye other than angle widening and an increase in ACD.²⁰

Hilton et al²¹ investigated systemic and ocular hemodynamics, and IOP preoperatively and 1 month postoperatively in 25 eyes undergoing small incision cataract surgery. They found that preoperative IOP was significantly higher in the cataract group as compared to age-matched controls. Surgery led to an 8.3% increase in pulsatile ocular blood flow, 15.5% increase in pulse volume, and 16.7% decrease in IOP.²¹

An MRI imaging study has shown that the crystalline lens grows throughout life. During lens growth, its thickness increases and the uveal tract is displaced to an inward and more anterior position. Concomitant with these changes, both the diameter of the ciliary muscle and circumlental space decreased significantly with age. It is thought that forces applied by the lens to the iris and iris root, along with the constraints of scleral curvature, displace the ciliary muscle anteriorly and inward with age, reducing the circumlental space.²²

Poley et al³ believe that a phacomorphic component contributes to the increase of IOP in many phakic eyes which have non-occludable, open angles. Compression of the meshwork itself may have a greater effect in this regard

rather than impeded access of aqueous to the trabecular meshwork by the iris.

Phacoemulsification and IOL implantation reconfigures the anterior segment to its position earlier in life. By returning the anterior lens capsule to a more posterior location, the zonules exert posterior traction on the ciliary body and scleral spur. This results in expansion of the trabecular meshwork and Schlemm's canal. This expansion improves function of the trabecular meshwork and valves in Schlemm's canal. Ultimately outflow facility increases and IOP decreases. The implanted artificial lens does not enlarge with time, hence IOP does not change postoperatively.

In summary, our findings indicate that phacoemulsification and IOL implantation result in IOP reduction which is more prominent in eyes with higher preoperative IOP. It is plausible that structural changes following cataract surgery relieve compressive forces on the trabecular meshwork and Schlemm's canal. Therefore, regardless of ACD and anterior chamber angle width, outflow facility improves and IOP decreases with lens extraction which can be an effective treatment for ocular hypertension. However, as with any biologic parameter, we should consider the "regression to mean" phenomenon which may cause the greater decrease in IOP observed following cataract surgery in patients with higher preoperative IOP.²³

Conflicts of Interest

None.

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