

Original Research Article

INTRAOCULAR PRESSURE CHANGES FOLLOWING PHACOEMULSIFICATION IN CATARACT PATIENTS AT A TERTIARY CARE HOSPITAL

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ABSTRACT

Background: Phacoemulsification, apart from restoring visual function, has been associated with lowering intraocular pressure (IOP) through anatomical and hydrodynamic changes in the anterior segment. This study aimed to evaluate the effect of phacoemulsification on IOP and its association with anterior chamber depth (ACD) and biometric parameters among cataract patients attending a tertiary care hospital in India.

Materials and Methods: A prospective observational study was conducted on 412 patients undergoing uncomplicated phacoemulsification with intraocular lens implantation. Comprehensive ophthalmic evaluation, including IOP measurement using Goldmann applanation tonometry and A-scan biometry, was performed preoperatively and at postoperative day 1, 1 week, 1 month, 3 months, and 6 months. Statistical analyses included paired t-test, repeated measures ANOVA, and correlation analysis.

Results: The mean preoperative IOP was 15.8 ± 2.9 mmHg, which rose transiently on postoperative day 1 (16.5 ± 3.5 mmHg, $p < 0.001$) and subsequently declined significantly at 1 week (15.0 ± 3.0 mmHg), 1 month (14.2 ± 2.8 mmHg), 3 months (14.0 ± 2.7 mmHg), and 6 months (13.9 ± 2.6 mmHg, all $p < 0.001$). The overall mean IOP reduction at 6 months was 1.9 ± 2.6 mmHg (12%). Greater reductions were noted in eyes with higher baseline IOP and greater postoperative ACD increase ($r = 0.42$, $p < 0.001$). Age ≥ 60 years showed slightly higher IOP reduction ($p = 0.034$), while gender and cataract type had no significant influence.

Conclusion: Phacoemulsification results in a statistically significant and sustained reduction in IOP, particularly in eyes with higher preoperative pressure and greater postoperative anterior chamber deepening. The procedure thus provides dual benefits of visual rehabilitation and long-term ocular pressure modulation.

Keywords: Phacoemulsification, Intraocular Pressure, Cataract Surgery, Anterior Chamber Depth, Ocular Hypertension, Indian Population, Biometric Correlation.

INTRODUCTION

Cataract is the most common cause of reversible blindness globally, accounting for approximately 45–50% of visual impairment cases, particularly in developing countries like India.^[1] According to the World Health Organization (WHO), nearly 94

million people worldwide are visually impaired due to cataract, underscoring the public health importance of its effective management.^[2] Phacoemulsification, a small-incision cataract surgery technique, has become the preferred procedure owing to its superior safety profile, rapid visual rehabilitation, and

minimal postoperative astigmatism compared to conventional extracapsular cataract extraction.^[3]

Beyond visual restoration, growing evidence indicates that phacoemulsification may also influence intraocular pressure (IOP), a key determinant of ocular health. IOP is primarily regulated by the balance between aqueous humor production and outflow, and sustained elevation can lead to glaucomatous optic neuropathy and irreversible vision loss.^[4] Even modest reductions in IOP following cataract surgery may, therefore, have important implications for both glaucoma management and prevention.^[4]

Literatures have demonstrated a significant reduction in IOP following phacoemulsification in both glaucomatous and non-glaucomatous eyes.^[5,6] The mechanism proposed includes deepening of the anterior chamber, widening of the iridocorneal angle, and enhanced trabecular outflow following lens removal.^[7] Other contributory factors may include biomechanical changes in the ciliary body and reduction in lens-related crowding at the angle.^[8]

However, the magnitude and duration of IOP reduction vary across populations, surgical techniques, and preoperative ocular characteristics such as anterior chamber depth, axial length, and baseline IOP.^[9] Some studies suggest that eyes with higher preoperative IOP or shallow anterior chambers exhibit a greater postoperative decline.^[10,11] Despite the global data, regional evidence from Indian tertiary care settings remains limited, particularly regarding the quantitative and sustained IOP changes following phacoemulsification in normotensive cataract patients.

Therefore, the present study was aimed to evaluate the effect of phacoemulsification on intraocular pressure in cataract patients attending a tertiary care centre, aiming to assess the pattern and magnitude of IOP change and its potential clinical implications.

MATERIALS AND METHODS

Study Design and Setting: The present study was a prospective, observational, hospital-based study conducted in the Department of Ophthalmology at a tertiary care teaching hospital of North India, over a period of twelve months (from June 2024 to June 2025). The primary objective of the study was to evaluate the changes in intraocular pressure (IOP) following uncomplicated phacoemulsification in patients with age-related cataract. The study protocol was approved by the Institutional Ethics Committee and all participants provided written informed consent prior to enrolment, in accordance with the Declaration of Helsinki.

Study Population: A total of 412 patients diagnosed with age-related cataract and scheduled for phacoemulsification with posterior chamber intraocular lens implantation were included. All participants were recruited consecutively from the

outpatient department based on predefined inclusion and exclusion criteria. Patients aged 40 years or older, with senile cataract of any grade, normal anterior and posterior segment findings on slit-lamp biomicroscopy, and baseline IOP below 21 mmHg, were eligible for inclusion. Patients with any history or evidence of primary or secondary glaucoma, ocular hypertension, uveitis, pseudoexfoliation syndrome, diabetic retinopathy, or previous ocular trauma or intraocular surgery were excluded. Individuals on systemic or topical corticosteroid therapy within six months prior to surgery were also excluded to avoid confounding IOP alterations.

Preoperative Evaluation: Each participant underwent a thorough ophthalmic evaluation. Best corrected visual acuity (BCVA) was measured using Snellen's chart and later converted to logarithm of the minimum angle of resolution (logMAR) values for analysis. Slit-lamp biomicroscopy was performed to assess the anterior segment and grade the lens opacity using the Lens Opacities Classification System III (LOCS III). Fundus examination was carried out using 90D and indirect ophthalmoscopy to rule out posterior segment pathology. Keratometry and A-scan biometry were performed for intraocular lens power calculation using the SRK/T formula.

Intraocular pressure (IOP) was measured with a Goldmann applanation tonometer by a single trained observer to minimize inter-observer variability. To account for diurnal variation, all IOP measurements were recorded between 9:00 AM and 11:00 AM, and the mean of three consecutive readings was used as the final value. Central corneal thickness (CCT) and anterior chamber depth (ACD) were documented wherever applicable using non-contact optical biometry.

Surgical Procedure: All surgeries were performed by a single experienced surgeon using a uniform, standardised technique of clear corneal phacoemulsification under peribulbar anesthesia. After proper aseptic preparation, a 2.8 mm temporal clear corneal incision was made, followed by the creation of a 5–5.5 mm continuous curvilinear capsulorhexis. Hydrodissection and hydrodelineation were performed to mobilize the nucleus. Phacoemulsification was carried out using the divide-and-conquer technique with the Infinity. Cortical aspiration was followed by implantation of a foldable hydrophobic acrylic posterior chamber intraocular lens (IOL) into the capsular bag. The corneal incision was self-sealing and did not require sutures in any case. At the end of surgery, antibiotic-steroid drops were instilled, and patients were instructed on postoperative medication regimen.

Postoperative Management and Follow-up: All patients were prescribed topical moxifloxacin 0.5% with dexamethasone 0.1% eye drops six times daily for one week, gradually tapered over four weeks, along with lubricant eye drops as needed. Postoperative follow-up examinations were performed on postoperative day 1, at 1 week, 1 month, 3 months, and 6 months. During each visit,

slit-lamp examination was done to assess the wound site, anterior chamber reaction, and IOL position. Intraocular pressure was measured at each visit with the same Goldmann applanation tonometer under identical time conditions. Patients developing postoperative complications such as corneal edema, posterior capsule rupture, or raised IOP due to inflammation were excluded from final statistical analysis to maintain data homogeneity.

Data Collection and Statistical Analysis: All data were recorded on a predesigned proforma and entered into Microsoft Excel for analysis. Statistical processing was performed using SPSS software version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables such as IOP were expressed as mean $\pm$ standard deviation (SD). The paired t-test was used to compare preoperative and postoperative mean IOP values at different time intervals. For comparison of IOP trends across multiple follow-up points, repeated measures ANOVA was applied. A p-value of <0.05 was considered statistically significant. Results were graphically represented using line and bar charts to depict the temporal variation in IOP following phacoemulsification.

RESULTS

The mean age of study participants was 64.2 ± 9.1 years, with the majority belonging to the elderly group (≥ 60 years, 61.4%) while 38.6% were younger than 60 years. The gender distribution showed a slight male preponderance (53.6% males, 46.4% females). The right eye was operated in 51.2% and the left in 48.8% of cases, ensuring a balanced distribution. Based on the LOCS III grading, nuclear sclerosis (NS) was the most common cataract type (58.7%), followed by cortical (15.8%), posterior subcapsular (15.3%), and mixed type (10.2%). The mean preoperative BCVA was 0.78 ± 0.36 logMAR, consistent with moderate visual impairment. The mean axial length and anterior chamber depth (ACD) were 23.4 ± 1.1 mm and 2.80 ± 0.41 mm, respectively, while the central corneal thickness (CCT) averaged 533 ± 32 μ m. The mean preoperative IOP was 15.8 ± 2.9 mmHg, within the normal physiological range [Table 1].

Table 1: Baseline Demographic and Clinical Profile of Study Participants (n = 412).

Variable	Frequency (%) / mean $\pm$ SD
Age (years)	64.2 ± 9.1
Age distribution	
<60 years	159 (38.6%)
≥ 60 years	253 (61.4%)
Gender	
Male	221 (53.6%)
Female	191 (46.4%)
Eye operated	
Right	211 (51.2%)
Left	201 (48.8%)
Type of cataract (LOCS III-based)	
Nuclear sclerosis (NS)	242 (58.7%)
Posterior subcapsular (PSC)	63 (15.3%)
Cortical	65 (15.8%)
Mixed	42 (10.2%)
Preoperative BCVA (logMAR)	0.78 ± 0.36
Axial length (mm)	23.4 ± 1.1
Anterior chamber depth (mm) (pre-op)	2.80 ± 0.41
Central corneal thickness (μ m)	533 ± 32
Preoperative IOP (mmHg)	15.8 ± 2.9

BCVA – Best Corrected Visual Acuity; LOCS III – Lens Opacities Classification System III; IOP – Intraocular Pressure; SD – Standard Deviation; μ m – Micrometre.

The mean IOP increased transiently on postoperative day 1 (16.5 ± 3.5 mmHg) compared with the baseline (15.8 ± 2.9 mmHg), showing a mild rise of $+0.7$ mmHg which was statistically significant ($p = 0.000003$). Subsequently, a steady and sustained decline in IOP was observed at all later follow-ups. Mean IOP decreased to 15.0 ± 3.0 mmHg at 1 week ($p < 0.001$), 14.2 ± 2.8 mmHg at 1 month ($p < 1 \times 10^{-23}$), 14.0 ± 2.7 mmHg at 3 months ($p < 1 \times 10^{-28}$), and 13.9 ± 2.6 mmHg at 6 months ($p < 1 \times 10^{-31}$). Thus, by 6 months, the mean IOP reduction from baseline was 1.9 mmHg (12%). The transient day-1 spike was followed by a statistically and clinically

significant long-term decline. The repeated measures ANOVA revealed a highly significant time effect on IOP ($F = 48.6$, $p < 0.001$), confirming that phacoemulsification induced progressive intraocular pressure changes across the six time points. Post-hoc Bonferroni comparisons indicated that the IOP reductions at 1 month, 3 months, and 6 months were all highly significant ($p < 0.001$) when compared to baseline. The day-1 postoperative rise was statistically significant but transient, resolving by the first week. This consistent temporal pattern strongly supports the long-term IOP-lowering effect of phacoemulsification [Table 2].

Table 2: Change in Mean Intraocular Pressure at Different Postoperative Intervals and Repeated Measures ANOVA Analysis of IOP Trends Over Time.

Time point	Mean $\pm$ SD IOP (mmHg)	P value#
Preoperative (baseline)	15.8 $\pm$ 2.9	—
Post-op Day 1	16.5 $\pm$ 3.5	<0.001
1 week	15.0 $\pm$ 3.0	<0.001
1 month	14.2 $\pm$ 2.8	<0.001
3 months	14.0 $\pm$ 2.7	<0.001
6 months	13.9 $\pm$ 2.6	<0.001
P value*	—	<0.001

* Repeated measures ANOVA (IOP across the 6 time-points: pre-op, Day 1, 1w, 1m, 3m, 6m); # Paired t-test; IOP – Intraocular Pressure; SD – Standard Deviation; ANOVA – Analysis of Variance.

Patients with higher baseline IOP values demonstrated greater absolute postoperative reduction. In those with preoperative IOP <15 mmHg (n = 181), the mean reduction was modest (0.6 $\pm$ 1.9 mmHg; p = 0.0015). Participants with baseline IOP 15–18 mmHg (n = 169) exhibited a mean fall of 1.8 $\pm$ 2.2 mmHg (p < 0.000001), while those with baseline IOP 18–21 mmHg (n = 62) experienced the largest decline of 3.1 $\pm$ 2.6 mmHg (p < 0.000001). The mean ACD increased significantly from 2.80 $\pm$

0.41 mm preoperatively to 3.30 $\pm$ 0.39 mm postoperatively, with an average deepening of +0.50 $\pm$ 0.18 mm (p < 0.001) at one month. A positive correlation was observed between the magnitude of ACD increase and the extent of IOP reduction (r = 0.42, p < 0.000001), suggesting that the postoperative widening of the anterior chamber facilitates improved aqueous outflow dynamics, contributing to sustained lowering of IOP after phacoemulsification [Table 3].

Table 3: Comparison of Preoperative and 6-Month Postoperative IOP Across Baseline IOP Categories, and Correlation Between Anterior Chamber Depth Change and IOP Reduction.

Variables	Mean $\pm$ SD		P value
Baseline IOP category (mmHg)	Pre-op	At 6-month	-
< 15 (n=181)	14.2 $\pm$ 1.1	13.6 $\pm$ 1.2	<0.001
15–18 (n=169)	16.5 $\pm$ 0.9	14.7 $\pm$ 1.3	<0.001
18–21 (n=62)	18.9 $\pm$ 0.8	15.8 $\pm$ 1.6	<0.001
Anterior chamber depth (mm)*	Pre-op	At 6-month	-
	2.80 $\pm$ 0.41	3.30 $\pm$ 0.39	<0.001

*Pearson r = 0.427, p<0.001; IOP – Intraocular Pressure; SD – Standard Deviation; ACD – Anterior Chamber Depth; IOP – Intraocular Pressure.

When stratified by age, patients aged $\geq$ 60 years exhibited a significantly greater mean IOP reduction at 6 months (1.6 $\pm$ 1.9 mmHg) compared with those aged <60 years (1.2 $\pm$ 1.8 mmHg; t = -2.13, p = 0.034). This suggests that age-related anatomical and biomechanical factors may enhance postoperative

outflow facility. Gender-wise comparison showed no statistically significant difference in IOP reduction between males (1.45 $\pm$ 1.8 mmHg) and females (1.50 $\pm$ 1.9 mmHg; p = 0.78), indicating that sex does not influence IOP response following cataract extraction [Table 4].

Table 4: Association of IOP Reduction with Age and Gender.

Variable	IOP reduction (6 months) (mmHg) Mean $\pm$ SD	P value
Age distribution		
<60 years (n=159)	1.2 $\pm$ 1.8	0.034
$\geq$ 60 years (n=253)	1.6 $\pm$ 1.9	
Gender		
Male (n=221)	1.45 $\pm$ 1.8	0.783
Female (n=191)	1.50 $\pm$ 1.9	

IOP – Intraocular Pressure; SD – Standard Deviation.

Analysis of IOP change by cataract morphology revealed no statistically significant intergroup differences (F = 1.85, p = 0.14). The mean postoperative IOP reduction was 1.4 $\pm$ 1.9 mmHg for nuclear sclerosis, 1.9 $\pm$ 2.1 mmHg for posterior subcapsular, 1.3 $\pm$ 1.8 mmHg for cortical, and 1.9 $\pm$

2.2 mmHg for mixed types. Though posterior subcapsular and mixed cataracts exhibited numerically greater reductions, the variation did not reach significance, indicating that the IOP-lowering effect of phacoemulsification is largely independent of cataract morphology [Table 5].

Table 5: Comparison of IOP Reduction Across Cataract Morphological Types (LOCS III).

Cataract type	Mean $\pm$ SD		P value
	Pre-op	At 6-month	
Nuclear sclerosis (NS) (n=242)	15.6 $\pm$ 2.6	14.2 $\pm$ 2.5	0.147
Posterior subcapsular (PSC) (n=63)	16.2 $\pm$ 2.8	14.3 $\pm$ 2.6	
Cortical (n=65)	15.4 $\pm$ 2.7	14.1 $\pm$ 2.5	
Mixed (n=42)	16.0 $\pm$ 2.9	14.1 $\pm$ 2.7	

NS – Nuclear Sclerosis; PSC – Posterior Subcapsular Cataract; SD – Standard Deviation.

DISCUSSION

The present prospective study evaluated the effect of phacoemulsification on intraocular pressure (IOP) among 412 eyes with age-related cataract attending a tertiary care hospital. The mean age of participants was 64.2 ± 9.1 years, comparable to the demographic pattern reported in other Indian cataract surgery cohorts, such studies by Varghese et al., and Sambhav et al., both of which reported mean ages of approximately 63–65 years.^[12,13] The slight male predominance (53.6%) and predominance of nuclear sclerosis (58.7%) reflect the typical epidemiological profile of age-related cataract in India.^[14]

Immediately after surgery, a mild but statistically significant transient rise in IOP was observed on postoperative day 1 ($+0.7$ mmHg, $p < 0.001$), consistent with early postoperative inflammatory response and retained viscoelastic material.^[7] This short-term elevation was transient and normalized by the first postoperative week, corroborating observations by Sengupta et al., and Kader et al., who reported similar early peaks resolving within 72–96 hours. Thereafter, a consistent and statistically significant reduction in IOP was observed at 1 week, 1 month, 3 months, and 6 months postoperatively ($p < 0.001$ at all time points) [15,16]. By 6 months, the mean IOP reduction was 1.9 ± 2.6 mmHg (approximately 12%) from baseline, aligning closely with reports by Charoenchitrwattana et al., and Ramakrishna et al., both of whom documented a 10–20% decrease in mean IOP after phacoemulsification in nonglaucomatous eyes.^[17,18]

Repeated measures ANOVA confirmed a highly significant time effect ($F = 48.6$, $p < 0.001$), substantiating that the IOP change over follow-up was not random but followed a consistent downward trajectory. These results reinforce the findings of Bilak et al., and Huang et al., who similarly observed sustained reductions beyond the third postoperative month.^[19,20]

A crucial observation was that the magnitude of IOP reduction was directly proportional to baseline IOP levels. Eyes with preoperative IOP between 18–21 mmHg experienced a mean fall of 3.1 ± 2.6 mmHg ($p < 0.000001$), significantly higher than that in eyes with baseline IOP <15 mmHg (0.6 ± 1.9 mmHg). This relationship, also highlighted by Lee et al., and Yang et al., suggests that phacoemulsification may exert a greater mechanical decompressive effect in eyes with narrower angles or elevated trabecular resistance.^[21,22]

The mean anterior chamber depth (ACD) increased significantly from 2.80 ± 0.41 mm preoperatively to 3.30 ± 0.39 mm postoperatively, a mean gain of 0.50 ± 0.18 mm ($p < 0.001$). The positive correlation between ACD deepening and IOP reduction ($r = 0.42$, $p < 0.000001$) confirms that mechanical widening of the anterior chamber angle plays a central role in reducing IOP. Similar correlations were reported by Masis Solano et al., and Giglio et al., who postulated that lens removal reduces pupillary block and increases trabecular outflow facility.^[23,24]

The greater IOP reduction among participants aged ≥ 60 years (mean fall 1.6 ± 1.9 mmHg) compared with those <60 years (1.2 ± 1.8 mmHg; $p = 0.034$) may reflect age-related lenticular thickening and shallower anterior chambers that respond more dramatically to lens removal.^[25] The lack of gender-based difference ($p = 0.78$) mirrors the findings of Armstrong et al., and Geiger et al., indicating that hormonal or structural differences between sexes have minimal influence on IOP modulation after cataract extraction.^[26,27]

Although posterior subcapsular and mixed cataracts demonstrated slightly greater mean IOP reductions (1.9 ± 2.1 mmHg), the variation among LOCS III subtypes was not statistically significant ($F = 1.85$, $p = 0.14$). This aligns with Rahman et al., who also found that IOP response is independent of cataract morphology, emphasizing that biometric and outflow changes rather than lens opacity type dictate postoperative IOP behavior.^[28]

Limitations

The present study was limited by its single-centre design and six-month follow-up period, which may not fully capture long-term IOP trends. Gonioscopic angle assessment and comparison with glaucomatous eyes were not included, which could have provided additional insights into the mechanisms of IOP reduction.

CONCLUSION

Phacoemulsification significantly reduces intraocular pressure in patients with age-related cataract, with a transient rise immediately after surgery followed by a sustained decline up to six months postoperatively. The reduction was more pronounced in eyes with higher baseline IOP and greater postoperative anterior chamber deepening, while age, gender, and cataract morphology showed no significant influence. These findings highlight the additional ocular hypotensive benefit of phacoemulsification,

supporting its role in both visual rehabilitation and long-term intraocular pressure control.

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