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Changes in Intraocular Pressure after Phacoemulsification with Intraocular Lens Implantation Surgery

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ABSTRACT

Background: Cataract is one of the leading causes of blindness worldwide, and phacoemulsification and intraocular lens (IOL) implantation is still considered the gold standard for its treatment. Although this surgical intervention has been focused on the restoration of vision, some studies have reported that it can have certain effects on intraocular pressure (IOP). This phenomenon is of utmost importance, especially when cataract is often associated or can lead to ocular hypertension or, on many occasions, glaucoma. **Objective:** To determine the changes in intraocular pressure after phacoemulsification with intraocular lens implantation. **Study Design:** Descriptive cross-sectional study. **Duration and Place of Study:** The study was conducted from July 2024 to January 2025 at the Department of Ophthalmology, Khyber Teaching Hospital, Peshawar. **Methodology:** A total of 131 patients aged 40–70 years with clinically confirmed mature senile cataract were enrolled. All underwent phacoemulsification with posterior chamber IOL implantation under local anesthesia. IOP was measured preoperatively and on the seventh postoperative day using Goldmann Applanation Tonometry. **Results:** The mean preoperative IOP was 16.56 ± 0.34 mmHg, which significantly decreased to 15.03 ± 0.39 mmHg one week postoperatively ($p < 0.001$). The mean IOP change was -1.53 ± 0.19 mmHg. Stratified analysis showed a significantly greater IOP reduction in patients with BMI ≤25 kg/m^2 ($p = 0.001$), while other factors such as age, gender, and residence showed no statistically significant differences. **Conclusion:** Phacoemulsification with IOL implantation significantly reduces intraocular pressure in the early postoperative period.

INTRODUCTION

Phacoemulsification with intraocular lens (IOL) implantation, the most common approach for cataract surgery, has also been coupled with dramatic shifts in intraocular pressure (IOP) post-operatively.[1] This procedure involves the emulsification of the opacified natural lens and the replacement of the latter with an IOL, the latter restoring sight.[2] Several case reports have determined that phacoemulsification can yield a statistically significant IOP drop, particularly in those with coexisting ocular hypertension or primary open-angle glaucoma.[3] This IOP-lowering effect has been posited to be the result of enhanced aqueous humor outflow with the eradication of the large bulky cataractous natural lens, possibly increasing the anterior chamber and the iridocorneal angle.[4]

The degree of IOP reduction following phacoemulsification varies based upon preoperative pressure, anterior segment parameters, and personal factors.[5] Patients with increased baseline IOP also generally respond with significant improvement, frequently postulated secondary to relief from angle crowding and improved function of the trabecular meshwork.[6] Another factor for stable postoperative pressure control with modern techniques is minimized intraoperative trauma, complete cortical cleanup, and intact capsular stability.[7] Cataract surgery with narrow-angle glaucoma also generally leads to improved long-term IOP reduction through elimination of pupillary block and reorganization of the anterior segment.[8]

Actually, transient IOP spikes can be noticed during the first postoperative period, most commonly between 24 to 72 hours, secondary to residual viscoelastic material, inflammation, or micro-hyphemas.[9] These are usually self-limiting or easily controlled with the use of topical hypotensive medication. Long-term control of IOP following uneventful phacoemulsification is most satisfactory, therefore, not just therapeutic for cataract, but also potentially beneficial towards the long-term control of certain glaucomatous conditions.[10] However, meticulous postoperative control is always necessary, particularly amongst glaucomatous patients, for the timely control of any IOP variations that can jeopardize the well-being of the optic nerve.[11]

More recent evidence also clarifies the likely function of phacoemulsification in aqueous facility of outflow regulation through structural changes of the trabecular meshwork and of Schlemm's canal.[12] Surgery's fluid dynamics and ultrasound energy can enhance microstructural remodeling of the outflow tracts, their effectiveness improving with time.[13] Other biometric changes such as thinner lenses and deeper postoperative anterior chamber depth can rid the angle of crowding favorably impacting eyes with risk factors for angle closure.[14] The net result is that cataract surgery increasingly becomes an extension of the full glaucoma treatment, specifically for mild or moderate disease, where sufficient IOP lowering can be attained without filtering surgery.[15]

In a study conducted by Todorović M et al., the mean intraocular pressure (IOP) prior to phacoemulsification was reported as 15.10 ± 2.68 mm Hg. A significant transient rise in IOP was observed at 4 to 6 hours postoperatively, reaching a mean of 24.29 ± 7.56 mm Hg. This pressure gradually declined over time, with values recorded at 18 to 24 hours post-surgery being 18.37 ± 4.80 mm Hg, and further reducing to 16.24 ± 2.90 mm Hg one week after the procedure.[16]

Conversely, a study by Ahmad R et al. reported findings that diverge from those of Todorović and colleagues. In their study they has shown a consistent reduction in IOP was noted following surgery. In their study the mean preoperative IOP was 22.02 ± 1.403 mm Hg, which decrease to 20.39 ± 1.363 mm Hg on the first postoperative day and further to 19.61 ± 1.418 mm Hg after the end of the first postoperative week.[17]

Intraocular pressure changes following phacoemulsification and intraocular lens implant could be evaluated, as cataract surgeries have not only increased eye functionality but could potentially alter intraocular pressure forces as well. Specifically, this could be significant for people enduring glaucoma or ocular hypertension, for whom small changes could potentially have some influence on the disease development or progress as well. Despite numerous articles available, some changes in patient characteristics, surgeries, and post-operating success require research efforts towards better evidence-based practice and patient care as well. Evidently, this research plans on contributing meaningfully towards some clinical input on cataract and glaucoma patient care as well.

METHODOLOGY

A descriptive cross-sectional study was conducted at the Ophthalmology Department of Khyber Teaching Hospital, Peshawar, from July 2024 to January 2025. A total of 131 participants were considered, and the sample size was calculated using the WHO sample size calculator. Calculation was made at a level of significance of 5%, power of 90%, and estimated mean of intraocular pressures of 16.24mmHg, post-operatively, and a standard deviation of 2.90mmHg.[16]

Patients selected had to be male or female, aged between 40 and 70 years, and had to have mature senile cataract as confirmed by clinical and slit lamp examination. They had to be exclusively having phacoemulsification and posterior chamber intraocular lens implant under local anesthesia only. Carried out through phacoemulsification and ultrasonic emission of cataractuous lenses, followed by foldable intraocular lens implant inside the capsular bag. Excluded would be patients having systemic illnesses of diabetes mellitus, congestive cardiac failure, or renal disease on biologics, as well as patients having previous ocular trauma, previous intraocular surgeries, or retinal detachments, macular disease, or previous glaucoma. All participants gave consent for research work, having fully informed them about the aims, potential benefits, and potential risks of this proposed research project itself. Initial collection of data would be through demography and clinical details such as age, gender, body mass index (in Kg/m^2), residence, occupation, education, and socioeconomic classification.

Every patient was subjected to a detailed ophthalmologic evaluation, including measurement of both uncorrected and best-corrected visual acuity, slit-lamp biomicroscopy, and measurement of intraocular pressures (IOP) via Goldmann Applanation Tonometry. Goldmann Applanation Tonometry is a way of determining the eye's internal fluid pressures, measured and indicated in millimeters of mercury (mmHg). Normal eye pressures range from 10-21mmHg. All surgeries were done by an eye specialist consultant, having a minimum of five years of experience, and nucleus chopping via the horizontal chopping method of nucleus disassembly. Measurement of intraocular pressures was done again on postoperative days one and seven by the same observer via the same technique of measurement. Any change of 4mmHg or more from its preoperative value on the seventh postoperative day was considered as significant.

Data was collected, compiled, and then analyzed by IBM SPSS software version 23. For continuous variables, the representation of data was through mean and SD or median and IQ range depending on whether it was normally distributed as indicated by Shapiro-Wilk test or not, respectively. Categorical variables could be represented through frequency and percentage tables. Comparison of intraocular pressures before and after surgeries was carried out by paired t-test if normally distributed or through Wilcoxon's signed-rank test if non-normally distributed, as appropriate. Stratified analysis had been used based on variables, and then comparisons had been made post-stratification, as appropriate, through suitable statistical tests. p-value of <=0.05 was considered statistically significant.

RESULTS

The mean age of the study population was 51.89 years, with a standard deviation (SD) of 6.16 years. The mean body mass index (BMI) was 25.20 kg/m^2, with an SD of 0.93. The average duration of cataract was 3.34 years, with an SD of 1.07. The study population consisted of 57 males (43.5%) and 7 females4 (56.5%), with 72 patients (55.0%) residing in rural areas and 59 (45.0%) in urban areas (as shown in Table 1).

Preoperatively, the mean IOP was 16.56 mmHg, with a minimum of 16.1 mmHg and a maximum of 17.2 mmHg, and an SD of 0.34 mmHg. One week postoperatively, the mean IOP decreased to 15.03 mmHg, with a minimum of

14.5 mmHg and a maximum of 15.8 mmHg, and an SD of 0.39 mmHg. The mean change in IOP was -1.53 mmHg, with a minimum change of -2 mmHg and a maximum change of -1.2 mmHg, and an SD of 0.19 mmHg (as shown in Table 2).

Table 1

Demographic and Clinical Characteristics of Study Population (n = 131)

Demographic and Clinical Characteristics	Mean±SD
Age (years)	51.89 ± 6.16
BMI (kg/m^2)	25.20 ± 0.93
Duration of Cataract (years)	3.34 ± 1.07
Gender	n(%)
Male	57 (43.5%)
Female	74 (56.5%)
Residence	n(%)
Rural	72 (55.0%)
Urban	59 (45.0%)

Table 2

Mean Change in Intraocular Pressure (IOP) Following Phacoemulsification with Intraocular Lens (IOL) Implantation Surgery (n = 131)

Parameter	Minimum	Maximum	Mean Change ± SD
Preoperative IOP at One Week (mmHg)	16.1	17.2	16.56 ± 0.34
Postoperative IOP (mmHg)	14.5	15.8	15.03 ± 0.39
Change in IOP (mmHg)	1.2	2	-1.53 ± 0.19

A paired t-test was conducted to assess the difference between preoperative and postoperative IOP levels. The preoperative mean IOP was 16.57 mmHg (SD = 0.35 mmHg), and the postoperative mean IOP at one week was 15.05 mmHg (SD = 0.37 mmHg). The 95% confidence interval (CI) of the difference was 1.49 to 1.54 mmHg, with a t-value of 115.14 and a highly significant p-value of <0.001, indicating a substantial decrease in IOP postoperatively (as shown in Table 3).

Table 3

Effect of Phacoemulsification with Intraocular Lens Implantation on Pre and Postoperative Intraocular Pressure

Parameter	Time Point	Mean ± SD	95% CI of Difference	t Value	p-value
Intraocular Pressure (mmHg)	Postoperative at One Week	16.57 ± 0.35	-1.54 to -1.49	-115.14	<0.001*
	Preoperative	15.05 ± 0.37			

*Paired t test

For age, patients ≤50 years had a mean IOP change of -1.56 mmHg (SD = 0.23 mmHg), while those >50 years had a mean change of -1.51 mmHg (SD = 0.14 mmHg), with a p-value of 0.119. Regarding gender, males had a mean IOP change of -1.55 mmHg (SD = 0.20 mmHg), and females had a mean change of -1.51 mmHg (SD = 0.17 mmHg), with a p-value of 0.172. For BMI, patients with a BMI ≤25 kg/m^2 had a mean IOP change of -1.56 mmHg (SD = 0.19 mmHg), while those with a BMI >25 kg/m^2 had a mean change of -1.45 mmHg (SD = 0.16 mmHg), with a significant p-value of 0.001. For the duration of cataract, patients with a duration ≤3 years had a mean IOP change of -1.54 mmHg (SD = 0.20 mmHg), and those with a duration >3 years had a mean change of -1.51 mmHg (SD = 0.16 mmHg), with a p-value of 0.290. (as shown in Table 4).

Table 4

Mean Change in Intraocular Pressure (IOP) by Subgroups (n=131)

Demographic variables	Subgroup	N	Mean ± SD	p-value
Age (years)	≤50 years	60	-1.56 ± 0.23	0.119
	>50 years	71	-1.51 ± 0.14	
Gender	Male	57	-1.55 ± 0.20	0.172
	Female	74	-1.51 ± 0.17	
BMI (Kg/m^2)	≤25 kg/m^2	92	-1.56 ± 0.19	0.001
	>25 kg/m^2	39	-1.45 ± 0.16	
Duration of Cataract (months)	≤3 years	79	-1.54 ± 0.20	0.290
	>3 years	52	-1.51 ± 0.16	
Residence	Rural	72	-1.51 ± 0.18	0.264
	Urban	59	-1.55 ± 0.19	

DISCUSSION

It can be assumed that the major drop in IOP that was noticed post-operatively could be due to a number of considerations. First, the nature of this surgical intervention is aimed at lowering intraocular pressures through improved drainage of aqueous humor. It is often accomplished through removing any cataractuous material, as well as trying to get back normal ocular anatomy, thereby facilitating easier drainage of this fluid. The average difference of -1.53mmHg, along with a highly significant p-value of <0.001, highlights its clinical relevance.

Stratification was used to show that individuals with a BMI ≤25 kg/m^2 experienced a slightly larger mean IOP change compared with individuals with a BMI >25 kg/m^2. This could be due to differences between ocular anatomy and physiology. Patients who are more slender could experience a larger inflammatory response following surgery and therefore a larger influence on aqueous humor dynamics. Patients with a larger BMI could experience a larger outflow facility and therefore a leveling influence on surgical disruption on IOP.

Lack of significant differences between IOP alteration and age, gender, cataract history, and residence signifies that these factors potentially do not play a critical role in postoperative changes in IOP from this study. Such a finding signifies that patient factors are not at play but that surgical intervention itself must be responsible for IOP reduction. Work must aim at discovering optimal postoperative management methods for IOP changes and further establishing its causative mechanism.

Our study results exhibit a significant decrease in intraocular pressure (IOP) following phacoemulsification and intraocular lens (IOL) surgery, consistent with most research demonstrating postoperative IOP decrease. In our research specifically, we found a preoperative mean IOP of 16.56 mmHg that decreased postoperatively at one week to 15.03 mmHg with a preoperative-postoperative mean change of -1.53 mmHg ($p < 0.001$). This is same as Ahmad Zeeshan Jamil et al.'s study [18] demonstrating a post-phacoemulsification significant decrease in IOP both for normal and glaucomatous eyes. Mitra Zamani et al. [19] also demonstrated a great IOP reduction after phacoemulsification with significant reduction being greatest among preoperatively high IOP eyes. Our postoperative IOP reduction study reveals range in IOP response following surgery and warrants further study for

its causality.

When our results are contrasted with those from Mashal Tayyab et al. [20] who found a notable drop in IOP post-surgery, particularly among ocular hypertensives, our study also observed a notable drop in postoperative IOP. Specifically, our mean postoperative IOP reduction of -1.53 mmHg can be contrasted with their 2.21 mmHg reduction. This similarity indicates that phacoemulsification is a good surgical intervention for reducing IOP among different patient populations. Ahmad Zeeshan Jamil et al.'s research work [18] also showed a marked reduction of IOP at around 2 months post-surgery, stabilized after 4 months. These observations are concurrent with our study and indicate that postoperative changes in IOP might be different because of preoperative status and also because of surgical technique employed. This postoperative IOP drop observed in our study could very well be because of certain characteristics of our patient population, such as a fairly younger age and potentially different preoperative IOP levels.

Preoperative IOP and axial length were identified as good predictors of post-phacoemulsification IOP decrease by Norlina Ramli et al. [21] In our study, we were unable to detect a significant correlation between preoperative IOP and postoperative variation because of our patient population's distinctive demography and clinical characteristics. Raziye Dönmez Gün et al. [22] showed a significant postoperative IOP drop especially among POAG cases managed medicinally and with larger preoperative IOP values. Our study's decrease in IOP postoperatively suggests that the relationship between preoperative IOP levels and postoperative changes may be more complex and influenced by various factors. Specifically, our mean IOP reduction of -1.53 mmHg is comparable to their reported reduction of 10 mmHg in eyes with preoperative IOP ≥21 mmHg.

Mitra Zamani et al.19 showed a considerable reduction in IOP post-phacoemulsification, and this reduction was most notable in eyes that had a higher preoperative value of IOP. To be more precise, they demonstrated that eyes that had an IOP of ≥21mmHg had a postoperative reduction of means of 8.3mmHg IO-P value. Our study's conclusion of decreased IO-P value postoperatively indicates considerable fluctuations of IO-P value postoperatively and thereby indicates that more studies need to be conducted on this subject and its underlying mechanism. Mashal Tayyab et al.20 demonstrated a significant decrease in IO-P value as well as an augmentation of AC depth postoperatively, and this supports our conclusions of IO-P value decrease postoperatively. To be more precise, they showed that IO-P value decreased by means of -2.21mmHg, and this is relatively close to our value of -1.53mmHg IO-P value decrease postoperatively.

In a study, Ahmad Zeeshan Jamil et al.18 observed a considerable decrease in IOP and the need for eye drops for glaucoma post-phacoemulsification, especially for patients having high preoperative levels of IOP and occludable angles. They observed a reduction of 8.26 mmHg in IOP one year postoperatively. But, there was a considerable lowering of IOP postoperatively, and this indicates that there could be considerable variations of phacoemulsification on different patients concerning effects on IOP levels.

While assessing the result of our study, there are a few limitations that need to be remembered. First, our study is based on a solitary center, and this may pose a restriction on its generality for other people as well. Further, because of having fewer participants, we have assessed its effect only for one week post-operatively, and this may not be sufficient enough to determine its long-term effects on intraocular pressures. In addition, we have not considered a control group, and this may have helped us determine its effects more objectively on intraocular pressures. Future studies may help counter this restriction and illuminate more on its effects on intraocular pressures.

CONCLUSION

Our studies have shown that phacoemulsification and intraocular lens implantation can effectively reduce intraocular pressure in cataract patients. Moreover, our studies have shown that this particular surgical treatment may be considered one of the most efficient methods for lowering a patient's IOP, especially after surgeries such as this one. Future research would be helpful in clarifying exactly what lasting effects phacoemulsification has on intraocular pressures, as well as determining what role and impact patient variables have on this reduction of intraocular pressures.

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