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RESEARCH ARTICLE OPEN ACCESS

Changes in intraocular pressure and topical anti-glaucoma medication burden after phacoemulsification in medically controlled pseudoexfoliation glaucoma: A prospective cohort study

Phacoemulsification in pseudoexfoliation glaucoma

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Abstract

Objective: To describe short-term changes in intraocular pressure (IOP) and topical antiglaucoma medication burden following uneventful phacoemulsification in selected eyes with medically controlled pseudoexfoliation glaucoma (PXG).

Methods: This prospective single-arm before-and-after cohort study enrolled 30 patients with 30 eyes with medically controlled PXG and visually significant cataract who underwent uneventful phacoemulsification with posterior chamber intraocular lens implantation at two tertiary eye hospitals in Baghdad, Iraq, between April 2024 and April 2025. IOP was measured by Goldmann applanation tonometry preoperatively and at 1 week, 1 month, and 4 months postoperatively. Topical antiglaucoma medication burden was recorded before surgery and after postoperative stabilisation. Data were summarised descriptively using means, standard deviations, frequencies, and percentages.

Results: Mean IOP decreased from 19.9 ± 2.4 mmHg preoperatively to 15.5 ± 3.2 mmHg at 1 week, 15.4 ± 2.9 mmHg at 1 month, and 14.8 ± 2.7 mmHg at 4 months. The corresponding mean absolute reductions from baseline were 4.4 ± 3.6, 4.5 ± 3.0, and 5.1 ± 2.6 mmHg, respectively. Mean topical antiglaucoma medication use decreased from 2.00 ± 1.15 to 1.43 ± 1.25 medications after postoperative stabilisation, and 9 patients (30.0%) required no topical antiglaucoma medication at that assessment.

Conclusions: In this small, selected, uncontrolled cohort, phacoemulsification was followed by lower mean IOP and reduced topical antiglaucoma medication burden over four months. Because the study had no comparator group and perioperative medication regimens were modified, these findings should be interpreted as descriptive postoperative associations rather than evidence of a causal treatment effect.

Keywords: Pseudoexfoliation glaucoma, Phacoemulsification, Cataract, Intraocular pressure, Glaucoma medication

Plain English Summary

Pseudoexfoliation glaucoma is a form of glaucoma that occurs when abnormal material builds up in the eye. It often develops alongside cataract, and cataract surgery may sometimes be followed by lower eye pressure. However, the size and duration of this change remain uncertain. We studied 30 patients with medically controlled pseudoexfoliation glaucoma who underwent routine cataract surgery using phacoemulsification. We measured eye pressure before surgery and at 1 week, 1 month, and 4 months

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afterwards. We also recorded how many topical glaucoma medicines patients were using before surgery and after their treatment had stabilised postoperatively. Average eye pressure fell from 19.9 mmHg before surgery to 14.8 mmHg at 4 months. The average number of topical glaucoma medicines fell from 2.00 to 1.43, and 9 of the 30 patients no longer needed any topical glaucoma medication after their postoperative treatment had stabilised. These findings suggest that cataract surgery may be accompanied by lower eye pressure and fewer topical medicines in selected patients with medically controlled disease. However, the study was small, had no comparison group, and involved changes to glaucoma treatment around the time of surgery. The findings therefore do not prove that surgery itself caused the observed reductions, nor do they establish that cataract surgery alone can replace dedicated glaucoma treatment. Continued glaucoma monitoring remains essential after cataract surgery in these patients.

Introduction

Pseudoexfoliation syndrome is a degenerative, age-associated condition in which abnormal fibrillar extracellular material accumulates within various structures of the anterior segment of the eye (1, 2). The condition is clinically important because it is associated with cataract formation, zonular weakness, secondary open-angle glaucoma, and increased complexity during cataract surgery (1, 3). Pseudoexfoliation glaucoma (PXG) represents one of the most common forms of secondary open-angle glaucoma worldwide and is frequently associated with higher intraocular pressure (IOP) and more rapid disease progression compared with primary open-angle glaucoma (1, 2). The coexistence of visually significant cataract and PXG therefore presents both therapeutic and surgical challenges, including inadequate pupillary dilatation, zonular instability, and an elevated risk of intraoperative complications (3).

Phacoemulsification has been associated with postoperative reductions in IOP in eyes with exfoliation syndrome or exfoliation-related glaucoma (4, 5). Proposed mechanisms for this effect include deepening of the anterior chamber, widening of the iridocorneal angle, and alterations in aqueous outflow following removal of the crystalline lens (4, 5). The magnitude of postoperative IOP reduction appears to vary according to baseline IOP, disease severity, medication use, and duration of follow-up. Recent systematic reviews and meta-analyses have reported reductions in both IOP and glaucoma medication use after phacoemulsification, although the certainty of evidence remains limited, and pooled estimates vary considerably across studies (4, 5, 6).

It is important to emphasise that cataract surgery alone should not be regarded as a substitute for glaucoma-directed treatment in patients with uncontrolled IOP, advanced glaucomatous damage, fixation-threatening visual field loss, or a requirement for very low target IOP. Continued surveillance remains essential because PXG is a progressive disease even after cataract surgery (7, 8). Previous studies have demonstrated that pseudophakic eyes with PXG may continue to show visual field deterioration despite apparently adequate IOP control, underscoring the need for ongoing monitoring of optic nerve structure and function (7). Additionally, PXG may influence postoperative refractive outcomes after uneventful cataract surgery, further highlighting the clinical complexity of this condition (9).

Although previous evidence supports the possibility of IOP reduction after phacoemulsification in exfoliation-related disease, the magnitude of change varies across studies and may be influenced by patient selection, baseline disease characteristics, and perioperative treatment protocols (4, 5). The present study therefore sought to describe short-term changes in IOP and topical antiglaucoma medication burden over four months following uneventful phacoemulsification in selected patients with medically controlled PXG and visually significant cataract. The specific objective was to characterise the postoperative trajectory of IOP and the change in topical medication requirements in this selected population, without making causal claims about the isolated effect of surgery.

Materials and Methods

Study Design and Setting

This prospective single-arm before-and-after cohort study was carried out at two tertiary ophthalmic centres in Baghdad, Iraq: Ghazi Al-Hariry Surgical Specialisations Hospital and Ibn Al-Haitham Teaching Eye Hospital. Recruitment and follow-up took place from April 2024 to April 2025. All eligible eyes underwent phacoemulsification followed by posterior chamber intraocular lens implantation and were monitored for four months after surgery. The study was prepared and reported in accordance with the STROBE recommendations for cohort studies.

Study Population and Eligibility Criteria

Patients were eligible for inclusion if they had clinically diagnosed PXG and visually significant cataract requiring surgical intervention. Pseudoexfoliation glaucoma was defined by the presence of pseudoexfoliative material on

anterior segment examination, an open anterior chamber angle on gonioscopy, and glaucomatous disease documented by at least one of the following: elevated IOP, glaucomatous optic nerve damage, retinal nerve fibre layer abnormality when available, or visual field loss consistent with glaucoma. For the purposes of this study, "medically controlled" disease was interpreted clinically as IOP considered acceptable by the treating ophthalmologist on the basis of the patient's overall glaucoma status, without a prespecified numerical target. "Advanced glaucoma" was not formally staged using a validated classification system; patients were excluded if the treating clinician considered them to have advanced disease based on clinical assessment.

Patients were excluded if they had ocular trauma, previous intraocular surgery, conjunctival surgery, uveitis, recent or previous ocular inflammation, steroid use by any route during the preceding six months, corneal disease that could affect applanation tonometry accuracy, secondary glaucoma other than PXG, an anterior chamber angle grade of 2 or narrower, IOP greater than 24 mmHg despite full topical medical therapy, or advanced glaucoma. Where both eyes were eligible, only one eye per patient was included; the study eye was selected according to the eye with more advanced cataract or, where cataract severity was comparable, the eye with higher IOP.

Sampling and Sample Size

No formal sample-size calculation was performed before the study. The cohort comprised 30 consecutive patients who met the eligibility criteria and underwent surgery during the study period. This sample size was pragmatic and reflects the number of eligible patients managed at the participating centres during the recruitment window. The absence of a formal sample-size justification is acknowledged as a limitation.

Data Collection and Measurement Instruments

All patients underwent a comprehensive preoperative ophthalmic assessment including slit-lamp biomicroscopy, Goldmann applanation tonometry with fluorescein, gonioscopy, dilated fundus examination using a +90-dioptre lens, and standard automated perimetry using the Humphrey 24-2 programme when optic disc findings were not typical or when fundus visualisation was limited. IOP was measured using the same method at 1 week, 1 month, and 4 months after surgery. The number of topical anti-glaucoma medications was documented preoperatively and again after postoperative stabilisation. Postoperative stabilisation was defined clinically as the point at which the treating ophthalmologist considered the postoperative inflammatory response to have resolved and the glaucoma medication regimen to have been finalised, typically at the 4-month postoperative visit.

Variables and Operational Definitions

The primary outcome was the change in IOP from baseline to four months postoperatively. Secondary outcomes included IOP change at one week and one month postoperatively and the change in the number of prescribed topical antiglaucoma medications after postoperative stabilisation. Medication burden was defined as the total number of topical antiglaucoma agents prescribed, counting fixed-combination preparations as a single medication. The following baseline variables were recorded: age, sex, number of preoperative topical antiglaucoma medications, and IOP at each study visit.

Perioperative Medication Management

Preoperative topical antiglaucoma medications were generally continued postoperatively unless low IOP indicated discontinuation. Prostaglandin analogues, used by seven patients preoperatively, were stopped for two weeks after surgery and replaced with systemic acetazolamide for one week. In patients with preoperative IOP greater than 21 mmHg, systemic acetazolamide was added preoperatively and continued for five days postoperatively. The number of patients who received systemic acetazolamide perioperatively was not systematically recorded. Postoperatively, all patients received topical antibiotic therapy for one week, topical corticosteroid therapy tapered over three to four weeks, and topical non-steroidal anti-inflammatory therapy according to surgeon preference and macular risk profile. These perioperative medication changes represent potential confounders that must be considered when interpreting the observed changes in IOP and medication burden.

Surgical Procedure

All eyes underwent phacoemulsification with posterior chamber intraocular lens implantation. Phacoemulsification was performed through a temporal clear-corneal incision of about 2.2–2.8 mm. An ophthalmic visco-surgical agent was then placed in the anterior chamber, and a continuous curvilinear capsulorhexis was performed with a diameter of approximately 5.0–5.5 mm. Lens removal was performed by a standardised phacoemulsification approach tailored to the grade of lens opacity. The

remaining cortical material was aspirated, and a foldable posterior chamber intraocular lens was implanted in the capsular bag. The viscoelastic material was thoroughly cleared from the anterior chamber and the space behind the implanted lens at the end of the procedure. Corneal incisions were hydrated and inspected to confirm adequate wound closure. Concomitant glaucoma surgery was not performed. All procedures were performed by experienced cataract surgeons and with a uniform strategy for perioperative and postoperative management. Only eyes with uneventful surgery without intraoperative complications were included for the final analysis.

Statistical Analysis

The collected data were entered, coded, and analysed using SPSS version 20. Categorical data were described using counts and percentages, whereas continuous data were summarised as mean values with their corresponding standard deviations. The analysis was descriptive because patient-level paired data were not available for independent reanalysis. IOP outcomes were summarised at baseline, 1 week, 1 month, and 4 months using the available aggregate means and standard deviations. The number of topical antiglaucoma medications before and after surgery was also summarised descriptively. No inferential statistical testing, confidence intervals, or p-values have been calculated because the source data did not permit verification of such analyses. The standard deviations reported for absolute IOP reductions are those recorded in the original dataset; their method of derivation cannot be independently verified from the available material, and they should therefore be interpreted with caution.

Results

Baseline Characteristics

We included 30 patients, corresponding to 30 eyes, in the analysis. The mean age was 66.2 ± 7.8 years (range: 55-84 years). Fourteen patients (46.7%) were male, and 16 (53.3%) were female. All patients were receiving topical antiglaucoma medication before surgery. Thirteen patients (43.3%) were using one topical antiglaucoma medication preoperatively, while 17 patients (56.7%) were using more than one topical medication. Seven patients (23.3%) were using prostaglandin analogues preoperatively. Baseline demographic and medication characteristics are presented in Table 1.

Table 1: Baseline demographic and medication characteristics of the study cohort.

Variable	Value
Patients/eyes included, n	30/30
Age, years, mean ± SD	66.2 ± 7.8
Age range, years	55–84
Male sex, n (%)	14 (46.7)
Female sex, n (%)	16 (53.3)
One preoperative topical antiglaucoma medication, n (%)	13 (43.3)
More than one preoperative topical antiglaucoma medication, n (%)	17 (56.7)
Prostaglandin analogue use preoperatively, n (%)	7 (23.3)

SD, standard deviation

Intraocular Pressure Outcomes

Mean IOP decreased from 19.9 ± 2.4 mmHg preoperatively to 15.5 ± 3.2 mmHg at one week, 15.4 ± 2.9 mmHg at one month, and 14.8 ± 2.7 mmHg at four months after phacoemulsification. The corresponding mean absolute reductions from baseline were 4.4 ± 3.6 mmHg at one week, 4.5 ± 3.0 mmHg at one month, and 5.1 ± 2.6 mmHg at four months. These findings are presented in Table 2. The absolute reduction at four months represented approximately 25.6% of the baseline group mean IOP. All 30 eyes contributed data at each follow-up visit; no loss to follow-up occurred during the study period. Because patient-level paired data were unavailable for independent reanalysis, these results are presented descriptively without additional significance testing or confidence intervals, and the reported standard deviations of absolute change should be interpreted cautiously.

Table 2: Intraocular pressure before and after phacoemulsification

Measurement time point	IOP (mmHg), mean ± SD	Absolute reduction from baseline (mmHg), mean ± SD
Preoperative	19.9 ± 2.4	—
1 week postoperative	15.5 ± 3.2	4.4 ± 3.6
1 month postoperative	15.4 ± 2.9	4.5 ± 3.0
4 months postoperative	14.8 ± 2.7	5.1 ± 2.6

IOP, intraocular pressure; SD, standard deviation; —, not applicable. Positive absolute-reduction values indicate a decrease from baseline

Topical Antiglaucoma Medication Burden

The mean number of prescribed topical antiglaucoma medications decreased from 2.00 ± 1.15 before surgery to 1.43 ± 1.25 after postoperative stabilisation. The median number of medications decreased from 2.00 to 1.00, with a reported range of 1–4 before surgery and 0–4 after surgery. After postoperative stabilisation, nine patients (30.0%) required no topical antiglaucoma medication, while 21 patients (70.0%) remained on at least one topical medication. These findings are presented in Table 3. The mean reduction in topical medication burden was 0.57 medications per patient. The observed reduction in medication burden should be interpreted in the context of the perioperative medication protocol, which included temporary withdrawal of prostaglandin analogues in seven patients and selective use of systemic acetazolamide.

Table 3: Topical antiglaucoma medication burden before and after surgery.

Medication variable	Preoperative	Postoperative
Number of topical antiglaucoma medications, mean ± SD	2.00 ± 1.15	1.43 ± 1.25
Median number of medications	2.00	1.00
Range	1–4	0–4
Patients requiring no topical medication, n (%)	0 (0.0)	9 (30.0)
Patients requiring at least one topical medication, n (%)	30 (100.0)	21 (70.0)

SD, standard deviation. Postoperative assessment was performed after postoperative stabilisation, defined as the point at which the treating ophthalmologist considered the postoperative inflammatory response to have resolved and the glaucoma medication regimen to have been finalised

Discussion

This prospective single-arm before-and-after cohort study described short-term changes in IOP and topical antiglaucoma medication burden following uneventful phacoemulsification in 30 selected eyes with medically controlled PXG and visually significant cataract. Mean IOP decreased from 19.9 ± 2.4 mmHg preoperatively to 14.8 ± 2.7 mmHg at four months, with a mean absolute reduction of 5.1 ± 2.6 mmHg. The mean number of topical antiglaucoma medications decreased from 2.00 ± 1.15 to 1.43 ± 1.25 after postoperative stabilisation, and 30.0% of patients no longer required topical antiglaucoma medication at that assessment.

These findings are in line with previous reports that phacoemulsification may result in a long-term decrease in intraocular pressure in eyes with exfoliation-related glaucoma. Supporting this, Benekos et al.'s systematic review and meta-analysis of exfoliation disease alone showed pooled mean IOP reductions of 3.43 mmHg at 6 months and 2.75 mmHg at 12 months after uncomplicated phacoemulsification (4). The reduction observed in the present cohort appears numerically larger, particularly at four months. However, this comparison must be made cautiously because the apparent difference may reflect the shorter follow-up duration, the relatively high baseline IOP in this cohort, the perioperative medication protocol, the inclusion of only uneventful surgical cases, regression toward the mean, and the use of aggregate rather than patient-level data. A broader systematic review and meta-analysis by Benekos et al. also concluded that phacoemulsification may lower IOP across several open-angle glaucoma subtypes, including exfoliative disease (5). Similarly, a recent systematic review and meta-analysis by Hussein et al. reported that standalone phacoemulsification may reduce both IOP and glaucoma medication use in glaucomatous eyes (6). These findings collectively support the plausibility of the observations reported here, while also underscoring the uncertainty surrounding the magnitude of the effect.

Several mechanisms may plausibly contribute to the observed postoperative IOP reduction. Removal of the crystalline lens can deepen the anterior chamber, alter angle configuration, and reduce lens-related crowding of the iridocorneal angle. In eyes with pseudoexfoliation, intraoperative irrigation and aspiration may also modify the amount of pseudoexfoliative material, pigment, and inflammatory debris within the anterior segment, potentially improving aqueous outflow (4, 5). These mechanisms are biologically plausible and consistent with the existing literature. However, the present study did not measure anterior chamber depth, angle parameters, or trabecular meshwork changes and therefore cannot determine which, if any, of these mechanisms contributed to the observed changes. The findings should therefore be regarded as hypothesis-generating rather than mechanism-confirming.

The observed reduction in topical medication burden is potentially important from a clinical perspective. Fewer antiglaucoma medications may simplify treatment regimens, reduce ocular surface toxicity, decrease treatment costs, and

improve adherence, particularly in elderly patients who may have difficulty administering multiple topical agents. However, this outcome is difficult to attribute solely to the surgery because the perioperative protocol deliberately altered some glaucoma medications. Prostaglandin analogues were stopped for two weeks in seven patients and replaced with systemic acetazolamide for one week, and systemic acetazolamide was used selectively in patients with higher preoperative IOP. The postoperative medication count also depended on clinical decisions made after surgery, including the timing of medication withdrawal and the reintroduction of previously used agents. Thus, the observed reduction in topical treatment burden should be regarded as an observed postoperative change rather than a direct measure of the pharmacological effect of phacoemulsification.

The selected nature of the cohort is also important when interpreting these findings. Patients with IOP greater than 24 mmHg despite full topical therapy, narrow angles, and advanced glaucoma were excluded, and the study included only eyes in which surgery was described as uneventful. The findings therefore apply most directly to selected patients with medically controlled, non-advanced PXG who undergo uncomplicated cataract surgery and should not be generalised to patients with uncontrolled disease, advanced visual field loss, or a requirement for very low target IOP. Previous studies have emphasised the need for ongoing glaucoma monitoring after cataract surgery, including assessment of IOP and structural and functional disease progression (7). Kang et al. reported faster visual field mean deviation decline in pseudophakic PXG eyes compared with matched phakic eyes despite no significant differences in IOP parameters (8). Tekcan et al. also reported that PXG may predict refractive surprise after uneventful cataract surgery (9). These findings reinforce that cataract surgery in PXG should be followed by careful IOP monitoring and continued glaucoma follow-up, regardless of any apparent short-term improvement in IOP or medication burden.

The findings of this study should be interpreted within a before-and-after descriptive framework. Without a concurrent comparison group, it is not possible to determine how much of the observed IOP reduction was attributable to phacoemulsification itself rather than to regression to the mean, physiological IOP variation, perioperative treatment effects, postoperative inflammation-related management, or other time-dependent factors. The absence of patient-level data also prevented independent repeated-measures analysis and verification of the reported standard deviations of change. The study consequently provides a useful description of postoperative patterns in a selected population but does not establish causality.

Study Limitations

This study has several important limitations. First, the sample comprised only 30 eyes, limiting the precision of the estimates and the generalisability of the findings. Second, there was no control or comparison group, so the observed changes cannot be separated confidently from secular trends, natural IOP fluctuation, or treatment-related changes. Third, perioperative glaucoma medication regimens were modified, including temporary withdrawal of prostaglandin analogues and selective use of systemic acetazolamide, which may have influenced both postoperative IOP and medication outcomes. Fourth, patient-level paired data were not available for independent reanalysis, preventing verification of paired inferential statistics and limiting the analysis to aggregate descriptive summaries; the reported standard deviations of absolute IOP reduction should therefore be interpreted with particular caution. Fifth, the study did not report a formal sample-size calculation or a detailed participant-selection process, and the sample appears to have been one of convenience. Sixth, the manuscript did not provide a formal quantitative definition of medically controlled disease or an explicit staging system for advanced glaucoma, which limits reproducibility and interpretation of the selected population. Seventh, follow-up was limited to four months and therefore does not establish whether the observed reductions are sustained or associated with slower glaucomatous progression. Eighth, the study focused on IOP and medication burden and did not provide longitudinal outcomes for visual field progression or optic nerve structural change. Ninth, all procedures were performed by experienced cataract surgeons following a general protocol, but the number of surgeons and the degree of standardisation across surgeons were not reported. Finally, the absence of systematic safety data, including intraoperative and postoperative complications, limits the assessment of surgical risk in this population.

Future Directions

Future studies should use larger, prospectively defined cohorts with explicit diagnostic and disease-severity criteria, a prespecified sampling strategy, and appropriate sample-size justification. Longitudinal patient-level data should be retained to permit paired and repeated-measures analyses with measures of precision,

including confidence intervals and appropriate inferential statistics. Perioperative glaucoma medication protocols should be standardised and documented in sufficient detail to distinguish medication effects from changes associated with cataract surgery. Longer follow-up and clinically meaningful glaucoma outcomes, including visual field and structural progression, would help determine whether postoperative reductions in IOP and medication burden are sustained and whether they have implications for long-term disease control. Controlled comparative designs, where feasible, would provide stronger evidence regarding the isolated effect of phacoemulsification on glaucoma-related outcomes in this population.

Conclusion

In this prospective single-arm cohort of a small number of carefully selected eyes with medically controlled pseudoexfoliation glaucoma, cataract extraction by phacoemulsification was associated with a decrease in both mean IOP and the need for topical glaucoma medications over the 4-month follow-up period. However, in the absence of a control group, small study population, relatively short follow-up, and changes in medication use around the time of surgery, these observations should be considered descriptive rather than causal. Thus, regular post-cataract surgery glaucoma surveillance remains essential in this patient group. Larger controlled studies with longer follow-up are required to define the magnitude and durability of any treatment-related effect.

List of Abbreviations

IOP: intraocular pressure
IRB: Institutional Review Board
NSAID: non-steroidal anti-inflammatory drug
PXG: pseudoexfoliation glaucoma
SD: standard deviation
SPSS: Statistical Package for the Social Sciences
STROBE: Strengthening the Reporting of Observational Studies in Epidemiology

Declarations

Ethics Approval and Consent to Participate

Approved by the Institutional Review Board of the University of Fallujah, College of Medicine (No. 122-2024). Written informed consent was obtained from all participants, and the study followed the Declaration of Helsinki.

Consent for Publication

All authors consented to publish this work under the Creative Commons Attribution Non-Commercial 4.0 license.

Data Availability

Data are available from the corresponding author upon reasonable request.

Competing Interests

None.

Funding Sources

None.

Author Contributions

AAB worked on the conceptualisation, methodology, investigation, data curation, and writing the original draft.
FRA worked on the conceptualisation, methodology, investigation, supervision, writing the review and editing.
MOS worked on the investigation, data curation, validation, writing the review and editing.
All authors read and approved the final manuscript and agree to be accountable for all aspects of the work.

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