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AN OBSERVATIONAL STUDY OF INTRAOCULAR PRESSURE CHANGES AND INTRAOCULAR PRESSURE DIFFERENCE RATIO AFTER PHACOEMULSIFICATION IN PSEUDOEXFOLIATION VERSUS HEALTHY EYES

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ABSTRACT **Background:** Pseudoexfoliation syndrome (PEXS) is an age-related disorder characterized by deposition of extracellular fibrillar material in ocular structures and is strongly associated with elevated intraocular pressure (IOP). The IOP difference ratio (IOP-Diff/Pre-op IOP) is a useful index for comparing post-phacoemulsification IOP changes between groups while controlling for baseline IOP. Aim: To evaluate IOP changes and the IOP difference ratio after phacoemulsification in pseudoexfoliation (PXF) versus healthy eyes. **Methods:** A prospective, comparative observational study was conducted on 62 eyes (31 PXF, 31 control) undergoing clear corneal incision phacoemulsification. IOP, anterior chamber depth (ACD) and central corneal thickness (CCT) were recorded preoperatively and at 1, 4 and 12 weeks postoperatively. The IOP difference (IOP-Diff) and IOP difference ratio (IOP-Diff/Pre-op IOP) were calculated and compared between groups. **Results:** Mean preoperative IOP was significantly higher in the PXF group (14.48 ± 1.88 vs 12.88 ± 1.77 mmHg, p = 0.00). At 12 weeks, mean IOP was 10.81 ± 0.54 mmHg in the PXF group vs 11.25 ± 1.03 in controls (p = 0.03). The mean IOP-Diff at 12 weeks was -3.68 vs -1.63 mmHg (p < 0.01) and the IOP-Diff ratio was -0.24 vs -0.11 (p < 0.01). A strong positive correlation existed between preoperative IOP and IOP reduction (r = +0.96 PXF, r = +0.87 control). Postoperative ACD increased significantly more in the PXF group, while CCT remained stable. **Conclusion:** Phacoemulsification produces a significantly greater IOP reduction and higher IOP difference ratio in pseudoexfoliation eyes than in healthy eyes, supporting its role as an IOP-lowering procedure in cataract patients with coexisting PXF.

KEYWORDS : Pseudoexfoliation Syndrome, Phacoemulsification, Intraocular Pressure, IOP Difference Ratio, Anterior Chamber Depth.

INTRODUCTION
Pseudoexfoliation syndrome (PEXS) is an age-related systemic disorder characterized by abnormal extracellular matrix turnover, resulting in deposition of fibrillar white flaky material in ocular structures including the cornea, trabecular meshwork, lens capsule, pupillary margin, ciliary body and iris. The pupillary margin is most commonly affected. Although primarily ocular, the syndrome may also involve the lungs, heart, liver, kidneys, gallbladder and meninges [1-3].

Pseudoexfoliation material (PEXM) is visible on slit-lamp examination and anterior segment optical coherence tomography. Its precise origin remains uncertain but is hypothesized to be the iris, lens epithelium, ciliary body or trabecular meshwork; chemically it is a complex glycoprotein/proteoglycan matrix [4-6]. Lindberg first described the syndrome in 1917, and the term was coined by Dvorak-Theobald in 1954. PEXS may be unilateral or bilateral and is associated with elevated IOP in up to 44% of cases, leading to pseudoexfoliation glaucoma (PEG) — the most commonly identifiable cause of secondary open-angle glaucoma [7,8].

PEXS is also associated with technically challenging cataract surgery owing to poor pupillary dilatation and unstable zonules, predisposing to capsular bag rupture, zonular dialysis and vitreous loss [9]. Phacoemulsification has emerged as the standard cataract surgical technique with significantly lower complication rates than older methods. The IOP difference ratio (IOP-Diff Ratio = IOP-Diff ÷ Pre-op IOP) allows a fair comparison of postoperative IOP changes between groups by reducing the confounding effect of baseline IOP. In this study, we analysed IOP changes and the IOP-Diff ratio after phacoemulsification in pseudoexfoliation versus healthy eyes.

AIMS AND OBJECTIVES
Aim: To evaluate IOP changes and the IOP difference ratio after phacoemulsification in pseudoexfoliation versus healthy eyes.
Primary Objectives: (i) To measure preoperative IOP by Goldmann applanation tonometry and ACD and CCT by optical biometry; (ii) to measure these parameters at 1, 4 and 12 weeks postoperatively; (iii) to assess the IOP-Diff ratio in both groups at each follow-up.

HYPOTHESIS
Null hypothesis (H_0): No difference in IOP changes or IOP-Diff ratio after phacoemulsification between PXF and healthy eyes. Alternate hypothesis (H_1): A significant difference exists between the two groups.

MATERIALS AND METHODS
Sample Size
The sample size was enhanced to 30 per group; the final analysis included 31 eyes in each group.

Inclusion and Exclusion Criteria
Inclusion criteria were: willingness to consent; obvious PXF deposits on the anterior lens surface or pupillary margin (PXF group); visually significant senile cataract; and a normal-appearing optic nerve head. Exclusion criteria were: uncooperative patients; previous laser or ocular surgery; IOP > 30 mmHg; established glaucoma; corneal or retinal pathology; intraocular inflammation; previous trauma; other ocular pathology; and any intraoperative complication.

Surgical Procedure and Follow-up
All patients underwent clear corneal incision phacoemulsification by an experienced surgeon under peribulbar anaesthesia. The pupil was dilated with phenylephrine 5% w/v and tropicamide 0.8% w/v. A 1 mm temporal paracentesis and a 2.2 mm clear corneal incision were made, followed by a 5–5.5 mm continuous curvilinear capsulorhexis, hydrodissection, direct chop phacoemulsification, irrigation and aspiration, and implantation of a single-piece hydrophilic acrylic IOL in the capsular bag. Intracameral moxifloxacin was given at completion.

Follow-up was conducted at 1, 4 and 12 weeks. Each visit included IOP measurement by Goldmann applanation tonometry, ACD and CCT measurement by optical biometry, and BCVA recording. Statistical analysis was performed using appropriate tests of significance; p < 0.05 was considered significant.

OBSERVATIONS AND RESULTS
Sixty-two eyes of 62 patients underwent phacoemulsification. Clinical and demographic characteristics are summarized in Table 1. The PXF group was significantly older (68.65 ± 3.94 vs 60.00 ± 6.38 years; p < 0.01), reflecting the age-related nature of PEXS. The PXF group also had a significantly shallower preoperative ACD and a thicker CCT than controls.

Table 1: Clinical Characteristics of the Study Population

Parameter	PXF Group	Control Group	P-value
Number of patients	31	31	-
Right eye / Left eye	14 / 17	15 / 16	-

Male / Female	14 / 17	18 / 13	-
Mean age ± SD (years)	68.65 ± 3.94	60.00 ± 6.38	< 0.01
Mean ACD ± SD (mm)	2.99 ± 0.31	3.24 ± 0.26	0.00
Mean CCT ± SD (µm)	549.96 ± 11.63	529.29 ± 12.55	0.00
Mean Pre-op IOP ± SD (mmHg)	14.48 ± 1.88	12.88 ± 1.77	0.00
Mean Post-op IOP ± SD (mmHg)	10.81 ± 0.54	11.25 ± 1.03	0.03

Demographic and Ocular Biometric Parameters of Both Groups.

A chi-squared test confirmed that sex distribution did not differ significantly between PXF and control groups ($\chi^2 = 1.033$, df = 1, p = 0.31), indicating that sex was not a source of bias. As expected for an age-related disorder, the PXF group was significantly older than controls (68.65 ± 3.94 vs 60.00 ± 6.38 years; Welch's t = 6.42, p < 0.001). This age difference is intrinsic to pseudoexfoliation and is consistent with previously published cohorts (Fig 1 & Fig 2) .

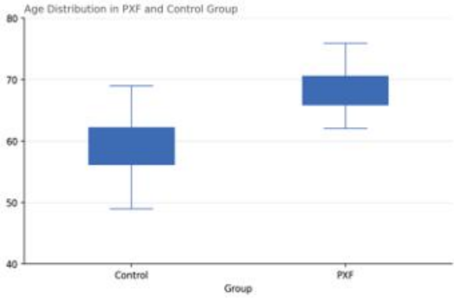

Fig 1. Age Distribution in PXF and Control Group

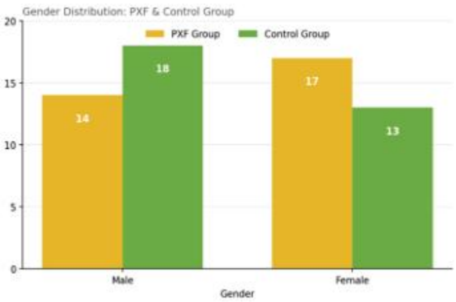

Fig 2. Gender Distribution in PXF and Control Group

1. Intraocular Pressure Changes

The mean preoperative IOP was significantly higher in the PXF group (14.48 ± 1.88 mmHg) than in the control group (12.88 ± 1.77 mmHg; p = 0.00). At 12 weeks postoperatively, the mean IOP decreased to 10.81 ± 0.54 mmHg in the PXF group and 11.25 ± 1.03 mmHg in the control group (p = 0.03). Phacoemulsification produced a sustained reduction in IOP in both groups, but the magnitude of reduction was significantly greater in the PXF group (Table 2 & Fig 3).

Table 2: Intraocular Pressure Changes in PXF and Control Groups

Mean IOP ± SD (mmHg)	PXF Group	Control Group	P-value
Pre-op	14.48 ± 1.88	12.88 ± 1.77	0.00
Post-op Week 1	12.32 ± 1.58	12.08 ± 1.08	0.49
Post-op Week 4	11.60 ± 1.05	11.52 ± 0.87	0.73
Post-op Week 12	10.81 ± 0.54	11.25 ± 1.03	0.03

Mean IOP values at each time point.

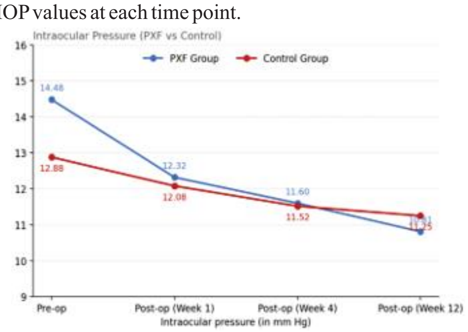

Fig 3. Trend Comparison of IOP in PXF vs Control Group

2. IOP Difference (IOP-Diff) and IOP-Diff Ratio

The IOP-Diff (change between pre- and postoperative IOP) and the IOP-Diff ratio (IOP-Diff/Pre-op IOP) were calculated to control for baseline IOP. The mean IOP-Diff at 12 weeks was -3.68 mmHg in the PXF group versus -1.63 mmHg in controls, and the mean IOP-Diff ratio at 12 weeks was -0.24 versus -0.11 (p < 0.01 for both). The absolute values of both indices were significantly greater in the PXF group at every time point (Table 3 & Fig 4-5).

Table 3: IOP-Diff and IOP-Diff Ratio Comparison

Time point	IOP-Diff PXF (mmHg)	IOP-Diff Control (mmHg)	IOP-Diff Ratio PXF	IOP-Diff Ratio Control
Week 1	-2.16	-0.81	-0.14	-0.05
Week 4	-2.88	-1.37	-0.19	-0.09
Week 12	-3.68	-1.63	-0.24	-0.11

IOP-Diff (mmHg) and IOP-Diff ratio at each follow-up visit.

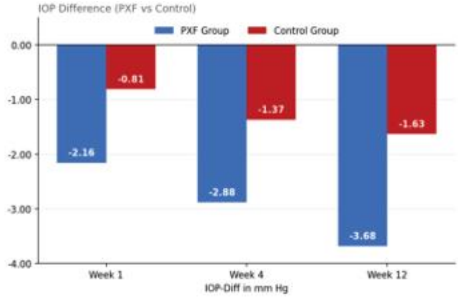

Fig 4. Trend Comparison of IOP-Diff in PXF vs Control Group

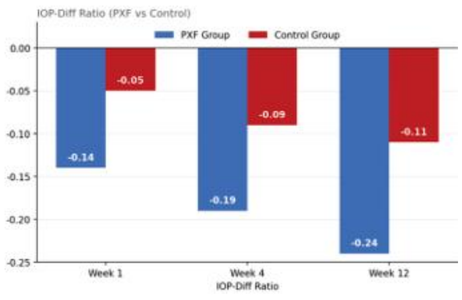

Fig 5. Trend Comparison of IOP-Diff Ratio in PXF vs Control

3. Effect of Preoperative IOP on Postoperative IOP Change

A strong positive correlation was observed between preoperative IOP and the absolute postoperative IOP change (r = +0.96 PXF, r = +0.87 control; p < 0.01). A similar correlation was found with relative IOP change (r = +0.93 PXF, r = +0.84 control; p < 0.01). Higher preoperative IOP was thus associated with a greater IOP-lowering effect after phacoemulsification.

4. Anterior Chamber Depth and Central Corneal Thickness

Postoperative ACD increased significantly in both groups, with a greater change in the PXF group (Table 4). CCT remained essentially unchanged throughout follow-up (PXF: 549.96 ± 11.63 to 549.62 ± 11.71 µm; control: 529.29 ± 12.55 to 528.83 ± 10.37 µm; p < 0.01between groups at all time points) (Table 5 & Fig 6), indicating no sustained corneal oedema.

Table 4: Anterior Chamber Depth Changes

Mean ACD ± SD (mm)	PXF Group	Control Group	P-value
Pre-op	2.99 ± 0.31	3.24 ± 0.26	0.00
Post-op Week 1	3.05 ± 0.29	3.25 ± 0.32	0.01
Post-op Week 4	3.22 ± 0.34	3.33 ± 0.17	0.11
Post-op Week 12	3.57 ± 0.20	3.38 ± 0.19	0.00

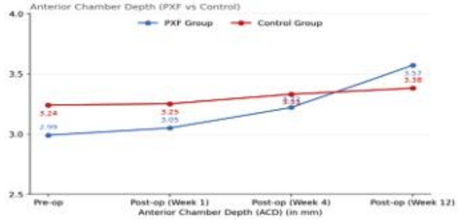

Fig 6. Trend comparison of ACD in PXF vs Control group

Table 5: Central Corneal Thickness Changes

Mean CCT ± SD (µm)	PXF Group	Control Group	P-value
Pre-op	549.96 ± 11.63	529.29 ± 12.55	0.00
Post-op Week 1	548.07 ± 10.66	528.69 ± 11.01	0.00
Post-op Week 4	547.67 ± 11.91	526.31 ± 10.74	0.00
Post-op Week 12	549.62 ± 11.71	528.83 ± 10.37	0.00

Mean CCT at each time point.

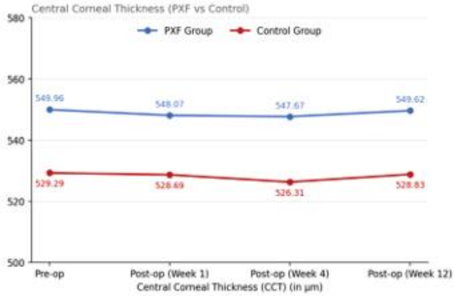

Fig 7. Trend Comparison of CCT in PXF vs Control Group

DISCUSSION

The principal finding of this study is that phacoemulsification produced a significantly greater reduction in IOP in PXF eyes than in healthy eyes, both in absolute terms (IOP-Diff) and as a proportion of baseline IOP (IOP-Diff ratio), and that this effect was sustained over 12 weeks.

Several mechanisms may explain the enhanced IOP-lowering effect in PXF eyes: mechanical washout of pseudoexfoliative material and pigment from the trabecular meshwork during phacoemulsification; relief of mechanical compression of the meshwork following replacement of the bulky cataractous lens by a thin foldable IOL; and biochemical changes in the anterior segment that improve aqueous outflow facility. The strong correlation between preoperative IOP and the magnitude of IOP reduction ($r = +0.96$ in PXF eyes) indicates that PXF eyes with higher baseline IOP derive the greatest benefit from cataract surgery.

The greater postoperative deepening of the anterior chamber in the PXF group reflects their shallower preoperative chamber and likely contributes to the greater IOP reduction by relieving anatomical crowding of the angle. CCT remained stable in both groups, indicating that modern small-incision phacoemulsification does not produce sustained corneal decompensation. The use of the IOP-Diff ratio, rather than absolute IOP-Diff alone, permits a fair intergroup comparison despite differing baseline IOP values — a methodological strength of this study.

CONCLUSION

Phacoemulsification produced a significant and sustained IOP reduction in both groups, but the IOP reduction, IOP-Diff and IOP-Diff ratio were all significantly greater in pseudoexfoliation eyes. A strong positive correlation was observed between preoperative IOP and postoperative IOP reduction. Phacoemulsification may therefore be considered a valuable IOP-lowering procedure in cataract patients with coexisting pseudoexfoliation syndrome, in addition to its primary visual rehabilitation benefit.

Limitations

This was a single-centre study with a short follow-up of 12 weeks; longer-term data are needed to confirm the durability of the IOP-lowering effect. Glaucomatous patients were excluded, so the findings apply primarily to non-glaucomatous PXF eyes.

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