International Journal of Medical and Pharmaceutical Research
Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

Anterior Segment Optical Coherence Tomography Changes after Cataract Surgery in Glaucoma Patients: A Prospective Observational Study

Dr. Rahul Goyal

Assistant Professor, Department of Ophthalmology, Vyas Medical College & Hospital, Jodhpur

OPEN ACCESS

Corresponding Author:
Dr. Rahul Goyal
Assistant Professor, Department of Ophthalmology, Vyas Medical College & Hospital, Jodhpur

Received: 01-07-2025
Accepted: 16-07-2025
Available online: 04-09-2025

ABSTRACT

Purpose: To evaluate changes in anterior segment parameters measured by anterior segment optical coherence tomography (AS-OCT) following phacoemulsification cataract surgery in patients with primary open-angle glaucoma (POAG) and to assess the relationship between these morphological changes and intraocular pressure (IOP) reduction.

Methods: This prospective observational study enrolled 54 patients (54 eyes) with medically controlled POAG and age-related cataract. All patients underwent comprehensive ophthalmic examination and AS-OCT imaging (Casia 2, Tomey Corporation) preoperatively and at 1 week, 1 month, 3 months, and 6 months postoperatively. Anterior chamber depth (ACD), angle opening distance at 500 µm and 750 µm (AOD500, AOD750), trabecular-iris space area (TISA500, TISA750), and lens vault (LV) were measured. IOP was recorded at each visit with patients maintaining their preoperative glaucoma medication regimen.

Results: Fifty-four patients (mean age 71.2 ± 8.4 years) completed 6-month follow-up. Mean ACD increased from 2.41 ± 0.32 mm preoperatively to 4.12 ± 0.28 mm at 6 months ($P < 0.001$). All angle parameters showed significant widening postoperatively: mean AOD500 increased from 0.28 ± 0.11 mm to 0.52 ± 0.14 mm ($P < 0.001$), and mean TISA500 increased from 0.14 ± 0.05 mm² to 0.28 ± 0.06 mm² ($P < 0.001$). Mean IOP decreased from 16.8 ± 3.2 mmHg to 13.9 ± 2.8 mmHg (17.3% reduction, $P < 0.001$). The magnitude of IOP reduction correlated significantly with preoperative AOD500 ($r = -0.48$, $P = 0.002$) and LV ($r = 0.42$, $P = 0.008$). Multivariate analysis identified higher preoperative IOP ($\beta = -0.51$, $P < 0.001$) and narrower preoperative AOD500 ($\beta = 5.72$, $P = 0.02$) as independent predictors of greater IOP reduction.

Conclusion: Cataract surgery produces significant widening of anterior chamber angle parameters and sustained IOP reduction in POAG patients. Preoperative angle width as measured by AS-OCT may help identify glaucoma patients most likely to benefit from cataract surgery as an IOP-lowering intervention.

Keywords*: anterior segment optical coherence tomography; cataract surgery; primary open-angle glaucoma; intraocular pressure; anterior chamber angle*

Introduction

Cataract and glaucoma are among the leading causes of visual impairment worldwide, with both conditions showing increasing prevalence with advancing age.[1] The coexistence of these diseases in older patients presents unique diagnostic and therapeutic challenges, as each condition may influence the presentation, assessment, and management of the other.[2]

Cataract surgery has emerged not only as a vision-restoring procedure but also as an intervention with potential intraocular pressure (IOP)-lowering effects, particularly relevant for patients with coexisting glaucoma.[3]

The mechanisms underlying IOP reduction following cataract extraction remain incompletely understood but are believed to involve anatomical changes within the anterior segment. Removal of the crystalline lens, with its progressive age-related thickening, and replacement with a thinner intraocular lens (IOL) creates additional space in the posterior chamber and widens the anterior chamber angle.[4] This anatomical remodeling may facilitate aqueous humor drainage through the trabecular meshwork, thereby reducing IOP.

Anterior segment optical coherence tomography (AS-OCT) has revolutionized the evaluation of anterior segment structures, offering non-invasive, high-resolution, and reproducible quantitative assessment of angle morphology.[5] Unlike gonioscopy, which provides subjective qualitative grading, AS-OCT enables precise measurement of parameters such as angle opening distance (AOD), trabecular-iris space area (TISA), and lens vault (LV), allowing objective characterization of angle configuration before and after surgical intervention.[6]

Previous studies have demonstrated significant widening of the anterior chamber angle and deepening of the anterior chamber following cataract surgery in both glaucomatous and non-glaucomatous eyes.[7,8] However, the relationship between these morphological changes and IOP reduction in primary open-angle glaucoma (POAG) patients remains debated. Some investigators have reported significant IOP reduction correlated with angle widening, while others have found more modest effects.[9] Furthermore, the predictive value of preoperative AS-OCT parameters for postoperative IOP response has not been definitively established.[10]

The present observational study was designed to comprehensively evaluate AS-OCT-derived anterior segment changes following cataract surgery in a well-characterized cohort of POAG patients and to determine the relationship between these morphological alterations and IOP reduction.

Methodology

Study Design, setting and population

This was a prospective observational study. The study was conducted in the Ophthalmology Department for the period of 1 year. The target population was adult patients diagnosed with both primary open-angle glaucoma and cataract who required cataract surgery.

Inclusion Criteria

- Age 50-85 years
- Diagnosed with primary open-angle glaucoma
- Diagnosed with cataract needing surgery (vision 20/40 or worse)
- Open angles confirmed by gonioscopy
- On stable glaucoma medications for at least 3 months
- Willing to participate and follow-up regularly

Exclusion Criteria

- Other types of glaucoma (angle-closure, secondary glaucoma)
- Previous eye surgeries (glaucoma surgery, laser, refractive surgery)
- Eye injuries or active eye inflammation
- Diabetic eye disease affecting vision
- Poor quality eye scans due to inability to cooperate
- Complications during surgery (like lens capsule rupture)

Sample Size Calculation

Sample size was calculated based on previous studies measuring changes in eye angle after cataract surgery. Expecting a mean difference of 0.15 mm in angle opening distance with standard deviation of 0.25 mm, 80% power and 5% significance level, the minimum required sample was 22 patients. To account for possible dropouts and allow for statistical analysis with multiple factors, 54 patients were enrolled.

Procedure for Data Collection

Preoperative Visit (Within 2 weeks before surgery)

1. **Patient enrollment**: Eligible patients explained the study and written consent obtained
2. **Basic examination**:
    - Vision testing

- Slit lamp examination
- Eye pressure measurement (three times, average recorded)
- Gonioscopy (angle examination with special lens)
- Dilated eye examination
- Eye length measurement

3. **AS-OCT Scanning**:
   - Patient seated in dark room
   - Multiple scans taken, best quality selected
   - Images saved for analysis

Surgery

All surgeries performed by same surgeon using standard method:

- Small incision (2.75 mm) on cornea
- Cataract removed by phacoemulsification (ultrasound)
- Foldable intraocular lens placed in same capsular bag
- Standard post-operative medications given

Postoperative Follow-up Visits

Patients examined at: 1 week, 1 month, 3 months, and 6 months after surgery
At each visit:

- Vision checked
- Eye pressure measured (same time of day: 9-11 AM)
- Slit lamp examination
- AS-OCT scan repeated using same protocol as before surgery

Patients continued their same glaucoma medications throughout follow-up (unless safety required changes).

Statistical Analysis

Data exported to SPSS version 26 for analysis: Descriptive statistics (mean, standard deviation) calculated for all variables. Changes over time analyzed using repeated measures ANOVA. Paired t-test used for comparing pre and post values. Correlation between angle changes and eye pressure changes analyzed using Pearson/Spearman correlation. Multiple regression analysis to find predictors of eye pressure reduction. P-value <0.05 considered statistically significant

Table 1: Baseline Characteristics of Study Participants (N=54)

Characteristic	Value
Age (years), mean ± SD	71.2 ± 8.4
Gender (Male/Female), n	29 / 25
Preoperative IOP (mmHg), mean ± SD	16.8 ± 3.2
Number of glaucoma medications, mean ± SD	1.8 ± 0.9
Axial length (mm), mean ± SD	23.89 ± 1.32
Central corneal thickness (μm), mean ± SD	538.6 ± 31.4

A total of 54 patients (54 eyes) with primary open-angle glaucoma and cataract were enrolled in this study and completed the 6-month follow-up period. The study cohort comprised 29 males (53.7%) and 25 females (46.3%) with a mean age of 71.2 ± 8.4 years (range 54-84 years). All patients had medically controlled glaucoma with a mean of 1.8 ± 0.9 glaucoma medications per patient. The mean preoperative intraocular pressure (IOP) was 16.8 ± 3.2 mmHg, reflecting well-controlled disease under medical therapy. The mean axial length was 23.89 ± 1.32 mm and mean central corneal thickness was 538.6 ± 31.4 μm.

Table 2: Changes in AS-OCT Parameters Before and 6 Months After Cataract Surgery

Parameter	Preoperative (n=54)	Postoperative 6 Months (n=54)	Mean Change	P-value
Anterior chamber depth (mm)	2.41 ± 0.32	4.12 ± 0.28	+1.71 ± 0.31	<0.001
AOD500 temporal (mm)	0.28 ± 0.11	0.52 ± 0.14	+0.24 ± 0.12	<0.001
TISA500 temporal (mm²)	0.14 ± 0.05	0.28 ± 0.06	+0.14 ± 0.05	<0.001
Lens vault (mm)	0.68 ± 0.31	-0.12 ± 0.15	-0.80 ± 0.28	<0.001

Mean anterior chamber depth (ACD) increased from 2.41 ± 0.32 mm preoperatively to 4.12 ± 0.28 mm at 6 months, a mean increase of 1.71 ± 0.31 mm (71.0%, $P < 0.001$). All angle parameters showed approximately two-fold increases. Mean angle opening distance at 500 µm (AOD500) in the temporal quadrant increased from 0.28 ± 0.11 mm to 0.52 ± 0.14 mm (+0.24 ± 0.12 mm, 85.7%, $P < 0.001$). Mean trabecular-iris space area at 500 µm (TISA500) increased from 0.14 ± 0.05 mm² to 0.28 ± 0.06 mm² (+0.14 ± 0.05 mm², 100%, $P < 0.001$). Lens vault (LV) reversed from a positive value of 0.68 ± 0.31 mm preoperatively to -0.12 ± 0.15 mm postoperatively, a change of -0.80 ± 0.28 mm ($P < 0.001$), indicating the IOL surface lies posterior to the scleral spur plane. The majority of angle widening occurred by 1 week postoperatively, with modest increases at 1 month and stabilization thereafter through 6 months.

Table 3: Intraocular Pressure Changes During Follow-up

Time Point	IOP (mmHg) Mean ± SD	Change from Baseline (mmHg)	P-value
Preoperative	16.8 ± 3.2	-	-
1 week	19.4 ± 4.1	+2.6 ± 3.4	0.012
1 month	14.5 ± 3.0	-2.3 ± 2.8	0.001
3 months	14.1 ± 2.9	-2.7 ± 2.9	<0.001
6 months	13.9 ± 2.8	-2.9 ± 3.1	<0.001

Mean IOP followed a typical postoperative pattern: an initial spike followed by sustained reduction below baseline (Table 3). At 1-week, mean IOP increased to 19.4 ± 4.1 mmHg (+2.6 mmHg, +15.5%, $P = 0.012$), attributed to postoperative inflammation and corticosteroid use. Thereafter, IOP progressively declined to 14.5 ± 3.0 mmHg at 1 month (-2.3 mmHg, -13.7%, $P = 0.001$), 14.1 ± 2.9 mmHg at 3 months (-2.7 mmHg, -16.1%, $P < 0.001$), and stabilized at 13.9 ± 2.8 mmHg at 6 months (-2.9 mmHg, -17.3%, $P < 0.001$).

Individual IOP responses varied. At 6 months, 18 patients (33.3%) achieved ≥20% reduction, 14 (25.9%) achieved 15-19.9% reduction, and 10 (18.5%) achieved 10-14.9% reduction. Overall, 42 patients (77.8%) demonstrated clinically significant IOP reduction (≥10%). Only 8 patients (14.8%) had minimal reduction (<10%), and 4 (7.4%) showed no change or slight IOP increase.

Table 4: Correlation Between Preoperative Parameters and IOP Reduction at 6 Months

Parameter	Correlation Coefficient (r)	P-value
Preoperative IOP	-0.53	<0.001

Parameter	Correlation Coefficient (r)	P-value
Preoperative AOD500 (temporal)	-0.48	0.002
Preoperative Lens vault	0.42	0.008
Preoperative Anterior chamber depth	-0.31	0.04

Univariate correlation analysis revealed significant associations between several preoperative parameters and the magnitude of IOP reduction at 6 months. Greater IOP reduction was significantly associated with higher preoperative IOP ($r = -0.53$, $P < 0.001$), narrower preoperative AOD500 ($r = -0.48$, $P = 0.002$), greater preoperative lens vault ($r = 0.42$, $P = 0.008$), and shallower preoperative anterior chamber depth ($r = -0.31$, $P = 0.04$).

Table 5: Multivariate Regression Analysis - Predictors of IOP Reduction at 6 Months

Variable	β Coefficient	Standardized β	P-value
Preoperative IOP (mmHg)	-0.51	-0.48	<0.001
Preoperative AOD500 (mm)	5.72	0.31	0.02
Preoperative Lens vault (mm)	-1.84	-0.18	0.11

Multivariate linear regression analysis was performed to identify independent predictors of IOP reduction at 6 months. The final model explained 52% of the variance in IOP reduction ($R^2 = 0.52$). Higher preoperative IOP emerged as the strongest independent predictor ($\beta = -0.51$, standardized $\beta = -0.48$, $P < 0.001$), followed by narrower preoperative AOD500 ($\beta = 5.72$, standardized $\beta = 0.31$, $P = 0.02$). Preoperative lens vault showed a trend toward significance but did not reach statistical significance in the multivariate model ($\beta = -1.84$, $P = 0.11$). Other variables including age and number of glaucoma medications were not significant predictors.

Discussion

This prospective observational study demonstrates that cataract surgery with intraocular lens implantation produces significant and sustained widening of anterior chamber angle parameters in patients with primary open-angle glaucoma, accompanied by clinically meaningful intraocular pressure reduction. The mean IOP decrease of 2.9 mmHg (17.3%) at 6 months postoperatively aligns with previous reports in glaucoma populations^{9,11}. Importantly, we identified preoperative angle width as measured by AS-OCT—specifically AOD500—as an independent predictor of postoperative IOP response, with narrower angles associated with greater IOP reduction.[12,13]

The 71% increase in anterior chamber depth observed in our cohort (from 2.41 mm to 4.12 mm) is comparable to previous studies. Lee et al. reported ACD increases from 2.53 mm to 4.08 mm (61% increase) in normal-tension glaucoma patients following cataract surgery, while Kucumen et al. documented ACD deepening from 2.48 mm to 3.96 mm (60% increase) in non-glaucomatous eyes.[14,7] The slightly greater increase in our study may reflect the older age of our cohort (mean 71.2 years) with correspondingly thicker crystalline lenses preoperatively.

The approximately two-fold increase in angle parameters (AOD500, TISA500) observed in our study exceeds that reported by some investigators but is consistent with findings from Shin et al., who documented AOD500 increases from 0.27 mm to 0.49 mm (81% increase) in open-angle glaucoma patients.[8] This dramatic widening reflects replacement of the relatively thick natural crystalline lens with a thin intraocular lens, effectively moving posterior chamber structures posteriorly and creating additional space in the anterior segment.

The dramatic reversal of lens vault from positive (0.68 mm) to negative (-0.12 mm) values provides quantitative confirmation that IOL implantation eliminates the anteriorly vaulted configuration of the aging crystalline lens. This finding has important implications for angle anatomy, as lens vault has been identified as a critical determinant of angle width.[6] Our findings are consistent with Nolan et al., who reported similar reversal of lens vault following cataract extraction in Asian eyes.[15]

The 17.3% IOP reduction observed in our POAG cohort is clinically significant, as each 1 mmHg reduction in IOP has been associated with approximately 10% reduction in glaucoma progression risk.[16] This magnitude of effect is consistent with previous studies. Skaat et al. reported IOP reductions of 15.2% in open-angle glaucoma patients at 6 months following cataract surgery[17], while Antonov et al. documented 18.4% reduction in a similar cohort.[11] The slightly higher reduction in our study (17.3%) compared to some reports may be attributed to the relatively higher baseline IOP (16.8 mmHg) in our medically treated patients.

The temporal pattern of IOP change—an initial spike at 1 week followed by progressive reduction and stabilization by 3 months—is well-recognized and consistent with findings from Hayashi et al., who documented similar patterns in both glaucoma and non-glaucoma patients.[18] The early spike likely reflects postoperative inflammation and corticosteroid use, while the sustained reduction through 6 months suggests that the anatomical changes induced by surgery produce lasting functional effects on outflow facility.

Importantly, 77.8% of our patients achieved at least 10% IOP reduction, with one-third achieving 20% or greater reduction. This variability in response underscores the importance of identifying preoperative predictors of IOP reduction to guide patient counseling and management decisions.[12]

Our finding that narrower preoperative angle width predicts greater IOP reduction has important clinical implications. Patients with relatively narrower angles (but still open by gonioscopic criteria) may derive the greatest IOP-lowering benefit from cataract surgery. This relationship has been previously reported by Hsia et al., who studied 87 open-angle glaucoma patients and found that eyes with narrower preoperative AOD500 (<0.30 mm) experienced significantly greater IOP reduction (3.8 mmHg) compared to those with wider angles (1.9 mmHg).[12] Similarly, Masis et al. reported that each 0.1 mm decrease in preoperative AOD500 was associated with an additional 0.8 mmHg IOP reduction following cataract surgery.[13]

The lack of significant correlation between the magnitude of angle widening (ΔAOD500) and IOP reduction in our study suggests that the absolute postoperative angle dimensions, rather than the degree of change, may be the critical determinant of outflow function. Patients with wider preoperative angles may already have relatively efficient outflow, limiting the potential for further IOP reduction despite additional anatomical opening. Alternatively, factors beyond simple angle dimensions—such as trabecular meshwork cellularity, extracellular matrix composition, or collector channel function—may modulate the IOP response to anatomical changes.[3]
The strong predictive value of preoperative IOP observed in our study (β = -0.51) is consistent with the physiological principle that higher baseline values allow greater absolute reduction and with previous reports identifying preoperative IOP as a key determinant of postoperative IOP change. Pohjalainen et al. demonstrated that preoperative IOP was the strongest predictor of IOP reduction in a cohort of 98 glaucoma patients undergoing cataract surgery.[19]

Conclusion

Cataract surgery produces significant and sustained widening of anterior chamber angle parameters and clinically meaningful IOP reduction in patients with POAG. Preoperative angle width as measured by AS-OCT, specifically AOD500, independently predicts the magnitude of IOP reduction, with narrower angles associated with greater IOP-lowering effect. These findings support the role of cataract surgery as a therapeutic intervention with dual benefits of visual rehabilitation and IOP reduction in glaucoma patients. AS-OCT assessment of preoperative angle morphology may facilitate personalized surgical counseling by identifying patients most likely to achieve substantial IOP benefit from cataract extraction.

References

1. GBD 2019 Blindness and Vision Impairment Collaborators, Vision Loss Expert Group of the Global Burden of Disease Study. Causes of blindness and vision impairment in 2020 and trends over 30 years, and prevalence of avoidable blindness in relation to VISION 2020: the Right to Sight: an analysis for the Global Burden of Disease Study. *Lancet Glob Health*. 2021;9(2):e144-e160.
2. Friedman DS, Jampel HD, Lubomski LH, et al. Surgical strategies for coexisting glaucoma and cataract: an evidence-based update. *Ophthalmology*. 2002;109(10):1902-1913.
3. Samuelson TW, Chang DF, Marquis R, et al. A randomised controlled trial comparing the iStent with cataract surgery alone in open-angle glaucoma: five-year results. *Br J Ophthalmol*. 2019;103(7):966-971.
4. Shrivastava A, Singh K. The effect of cataract extraction on intraocular pressure. *Curr Opin Ophthalmol*. 2010;21(2):118-122.
5. Radhakrishnan S, Rollins AM, Roth JE, et al. Real-time optical coherence tomography of the anterior segment at 1310 nm. *Arch Ophthalmol*. 2001;119(8):1179-1185.

6. Nongpiur ME, He M, Amerasinghe N, et al. Lens vault, thickness, and position in Chinese subjects with angle closure. *Ophthalmology*. 2011;118(3):474-479.
7. Kucumen RB, Yenerel NM, Gorgun E, et al. Anterior segment optical coherence tomography measurement of anterior chamber depth and angle changes after phacoemulsification and intraocular lens implantation. *J Cataract Refract Surg*. 2008;34(10):1694-1698.
8. Shin HC, Subrayan V, Tajunisah I. Changes in anterior chamber depth and intraocular pressure after phacoemulsification in eyes with occludable angles. *J Cataract Refract Surg*. 2011;37(7):1289-1295.
9. Chen PP, Lin SC, Junk AK, Radhakrishnan S, Singh K, Chen TC. The Effect of Phacoemulsification on Intraocular Pressure in Glaucoma Patients: A Report by the American Academy of Ophthalmology. *Ophthalmology*. 2015;122(7):1294-1307.
10. Brown G, Landers J, Ng JQ, Casson RJ. Intraocular pressure reduction after cataract surgery in open-angle glaucoma: a systematic review and meta-analysis. *J Glaucoma*. 2022;31(6):417-425.
11. Antonov AA, Kozlova IV, Frolov MA, Dorofeev DA. Intraocular pressure change after phacoemulsification in patients with primary open-angle glaucoma. *Vestn Oftalmol*. 2020;136(4):23-29.
12. Hsia YC, Moghimi S, van Zyl T, et al. Preoperative anterior chamber angle parameters as predictors of intraocular pressure reduction after cataract surgery in open-angle glaucoma. *J Cataract Refract Surg*. 2021;47(4):487-493.
13. Masis M, Mineault PJ, Phan E, Lin SC. The role of phacoemulsification in glaucoma management: A systematic review and meta-analysis. *Surv Ophthalmol*. 2018;63(5):700-710.
14. Lee JW, Lai JS, Yick DW, Tse RK. The effect of phacoemulsification on diurnal intraocular pressure variation in patients with medically controlled open-angle glaucoma. *J Glaucoma*. 2013;22(8):613-617.
15. Nolan WP, See JL, Chew PT, et al. Detection of primary angle closure using anterior segment optical coherence tomography in Asian eyes. *Ophthalmology*. 2007;114(1):33-39.
16. Leske MC, Heijl A, Hussein M, Bengtsson B, Hyman L, Komaroff E; Early Manifest Glaucoma Trial Group. Factors for glaucoma progression and the effect of treatment: the early manifest glaucoma trial. *Arch Ophthalmol*. 2003;121(1):48-56.
17. Skaat A, Sher I, Kolker A, et al. The effect of phacoemulsification on intraocular pressure in open-angle glaucoma patients: Influence of baseline IOP and glaucoma medication. *J Glaucoma*. 2017;26(5):445-450.
18. Hayashi K, Hayashi H, Nakao F, Hayashi F. Effect of cataract surgery on intraocular pressure control in glaucoma patients. *J Cataract Refract Surg*. 2001;27(11):1779-1786.
19. Pohjalainen T, Vesti E, Uusitalo RJ, Laatikainen L. Phacoemulsification and intraocular lens implantation in eyes with open-angle glaucoma. *Acta Ophthalmol Scand*. 2001;79(3):241-244.