ORIGINAL RESEARCH

Anterior Segment Optical Coherence Tomography Changes after Cataract Surgery in Glaucoma Patients

[1]Brijesh Singh, [2]Meenu Babber, [3]Ravi Ranjan, [4]Mafat Lal, [5]Granth Kumar, [6]Alok Pratap Singh

[1]Associate Professor, [2]Professor and Head, [3]Professor, [4]Junior Resident, Department of Ophthalmology, Uttar Pradesh University of Medical Sciences, Saifai, Etawah, Uttar Pradesh, India
[5]Professor, Department of Medicine, Uttar Pradesh University of Medical Sciences, Saifai, Etawah, Uttar Pradesh, India
[6]Assistant Professor, Department of Ophthalmology, Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow, Uttar Pradesh, India

Corresponding author
Mafat Lal
Junior Resident, Department of Ophthalmology, Uttar Pradesh University of Medical Sciences, Saifai, Etawah, Uttar Pradesh, India
Email: drmafatyadav15@gmail.com

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ABSTRACT

Objective: This study aimed to measure anterior chamber depth (ACD) and anterior chamber angle (ACA) using optical coherence tomography before and after cataract surgery in glaucoma patients. **Methodology:** This prospective, cross-sectional study employed purposive sampling and included 25 eyes of patients with primary open-angle glaucoma and grade I & II cataract, as well as 15 eyes of patients with pseudoexfoliation glaucoma. Group A comprised patients with primary open-angle glaucoma and grade II, III cataract, while Group B included patients with secondary glaucoma and grade 2 and 3 cataracts. **Results:** In Group A, the majority (52.0%) of patients were aged 40-50 years, while in Group B, the majority (53.3%) were aged 51-60 years. The difference in the distribution of studied patients between the groups was statistically insignificant ($p > 0.05$). The mean ACA pre-operative, post-operative after 1 week, and post-operative after 4 weeks in Group A were 35.93±2.74, 43.33±5.21, and 48.27±5.46, respectively. The differences were statistically insignificant ($p > 0.05$). Additionally, in Group A, the mean central corneal thickness (CCT) pre-operative, post-operative after 1 week, and post-operative after 4 weeks were 532.80±48.77, 562.12±44.60, and 544.76±42.05, respectively, with statistically insignificant differences ($p > 0.05$). **Conclusion:** In eyes with primary open-angle glaucoma (POAG) and pseudoexfoliation glaucoma (PXG), intraocular pressure (IOP) and anterior segment parameters, including ACD, ACA, and CCT, may alter after cataract surgery. These changes may vary between PXG- and POAG-affected eyes.

Keywords*:* anterior chamber depth, anterior chamber angle, optical coherence tomography, glaucoma, cataract surgery

INTRODUCTION

Glaucoma stands as the leading cause of irreversible blindness globally, with the World Health Organization ranking it as the second most common cause of blindness worldwide after cataract [1]. In 2006, the estimated global burden of glaucoma was 60 million, projected to increase to 79.6 million by 2020, with nearly half of the cases occurring in Asia [1]. The global prevalence of glaucoma is approximately 3.54%.[1]

By 2020, India is expected to surpass the United States in having the second-largest population with glaucoma. The estimated prevalence of glaucoma cases in India is reported to be 11.9 million [1]. However, the prevalence of glaucoma varies across different populations and subgroups, ranging from 2.3% to 4.7%. Primary open-angle glaucoma (POAG) accounts for about three-quarters (74%) of all glaucoma cases. While intraocular pressure (IOP) is a recognized factor in the development and progression of open-angle glaucoma, ocular and systemic factors such as age, demographic characteristics, and genetic and vascular causes also play significant roles.[2]

Studies by Varma et al. have revealed that a notable proportion of patients referred as "open-angle glaucoma" were later found to have closed angles. Furthermore, over 12% of cataract surgery referrals, whether by ophthalmologists or optometrists,

involved patients with closed angles or pre-existing primary angle-closure suspect (PACS).[3]

Glaucoma and cataracts often afflict similar age groups, and their occurrence in combination is not uncommon. It has been established that certain medications used in glaucoma treatment, such as pilocarpine, can accelerate cataract formation.[4]

Anterior segment optical coherence tomography (AS-OCT) is a non-invasive, non-contact method that allows in vivo visualization of tissues, offering crucial insights into the pathophysiology of diseases. Although gonioscopy and ultrasound biomicroscopy have traditionally been used to evaluate angle widening after cataract surgery, AS-OCT, using a long-wavelength (1310nm) light, provides high-resolution images and enables rapid and easy quantitative analysis of various structures.[5]

AS-OCT excels due to its non-contact nature, offering 360-degree, objective angle measurements and central corneal thickness measurements. However, gonioscopy allows for clearer observation of angle structures, additional features such as synechiae, pseudoexfoliation, and neovascularization. While AS-OCT may overestimate angle closure, particularly in superior and inferior quadrants, gonioscopy allows for clearer observation of iris configuration and insertion features.[6]

METHODOLOGY

The study, conducted with institutional ethical committee approval, was a prospective interventional clinical investigation aiming to observe anterior segment optical coherence tomography (AS-OCT) changes after cataract surgery in glaucoma patients. The study comprised two groups: Group A included patients with Primary Open-Angle Glaucoma (POAG) and grade II, III cataract, while Group B involved patients with secondary glaucoma (pseudoexfoliation glaucoma) and grade 2 and 3 cataracts. The study was conducted in the Outpatient Department of Ophthalmology at UPUMS, SAIFAI, spanning from January 1st, 2021, to June 30 th, 2022.

All patients underwent routine ophthalmic examinations, including assessments of visual acuity, Goldmann tonometry, slit-lamp biomicroscopy, and funduscopy. Refractive errors were determined through manifest refraction. Following a detailed ocular and systemic history, a comprehensive ocular examination, including visual acuity and AS-OCT, was performed to evaluate anterior chamber depth (ACD), anterior chamber angle (ACA), and central corneal thickness (CCT). Cataract surgery was conducted via Small Incision Cataract Surgery (SICS) and Phacoemulsification. In the postoperative period, patients received topical ciplox-dexamethasone six times a day for four weeks. The iridocorneal angle was assessed using a 3-mirror lens. Patients with early to moderate-level disease were evaluated in the glaucoma department based on Retinal Nerve Fiber Layer (RNFL) and visual field findings.

The study encompassed the analysis of patient age, sex, preoperative findings such as Intraocular Pressure (IOP) change, and postoperative visual acuity. All measurements were recorded at least twice at different times by the same individual. Data were analyzed using the Statistical Package for Social Sciences, version 23 (SPSS Inc., Chicago, IL). Results for continuous variables were presented as mean ± standard deviation (SD), while categorical variables were expressed as numbers (percentages). P-values were calculated with independent samples t-test and cross-tabulation using Student t-test. Values of $p < 0.0001$ were considered significant.

RESULTS

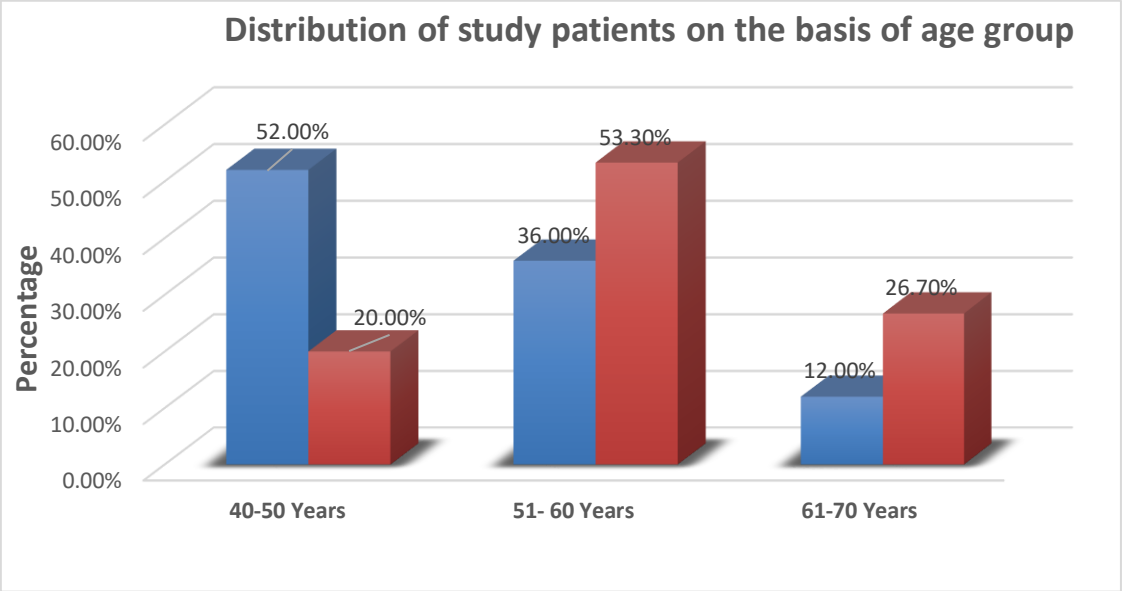
The mean age of the studied patients in Group A (Primary Open-Angle Glaucoma) was 51.84±7.47 years, while in Group B (Pseudoexfoliative Glaucoma) it was 56.87±7.50 years. In Group A, the majority (52.0%) of patients belonged to the 40-50 years age group, and in Group B, the majority (53.3%) were in the 51-60 years age group (Table 1)(Graph 1). In Groups A and B, 56.0% and 66.7% of the investigated patients were males.

Table 1: Distribution of studied patients based on age group

Age	Group		P value
	Prim Open Angle Glaucoma Group-A (n=25)	Pseudo Exfoliative Glaucoma Group-B (n=15)	
40-50 Years	13 (52.0%)	3 (20.0%)	0.122*
51- 60 Years	9 (36.0%)	8 (53.3%)	
61-70 Years	3 (12.0%)	4 (26.7%)	
Age (Mean±SD)	51.84±7.47	56.87±7.50	**0.047**#

*Chi Square test; #Independent Sample t test;

Graph 1: Distribution of studied patients based on age group



The distribution of the studied patients based on vital examination revealed that the mean Systolic Blood Pressure (SBP) was highest in both groups, i.e., 125.44±9.81 in Group A and 125.87±8.93 in Group B (Table 2).

Table 2: Distribution of studied patients based onvital examination cases

Vital	Group		P value*
	Prim Open Angle Glaucoma Group-A (n=25)	Pseudo Exfoliative Glaucoma Group-B (n=15)	
HR (Per Min)	80.88±8.68	80.93±9.44	0.986
SBP (mmHg)	125.44±9.81	125.87±8.93	0.891
DBP (mmHg)	77.84±4.36	78.13±3.74	0.829

Independent Sample t test

A comparison between the groups based on intraocular pressure (IOP) revealed that the majority (64.0%) of patients in Group-A belonged to the Right eye Intraoperative Mobile Subconjunctival (IMSC) group, while 36.0% belonged to the Left eye IMSC group (Table 3).

Table 3: Distribution of studied patients based on anterior chamber examination findings

Anterior Chamber		Group-A (n=25)	Group-B (n=15)	P value
Right Eye	**IMSC**	16 (64.0%)	8 (53.3%)	0.505
Left Eye	**IMSC**	9(36.0%)	7 (46.7%)	0.567

Chi Square test

The comparison of Best Corrected Visual Acuity (BCVA) pre- and post-operatively for Groups A and B showed that the mean value of BCVA for the pre-operative left eye was highest in both groups, and the difference between the groups was statistically insignificant ($p > 0.05$). The mean in the post-operative left eye was highest in both Groups A and B (Table 4).

Table 4: Distribution of studied patients based on BCVA pre and post-operative

BCVA (log MAR)		Group-A(n=25)	Group-B (n=15)	P value
Pre-operative	**Right**	0.67±0.27	0.63±0.15	0.613
	Left	0.70±0.25	0.67±0.17	0.674
Post-operative	**Right**	0.14±0.10	0.15±0.11	0.847
	Left	0.06±0.09	0.07±0.09	0.730

The comparison between Groups A and B based on IOP showed that the mean IOP of Group-B was maximum in all parameters, and the difference was statistically significant ($p = 0.029$) (Table 5).

Table 5: Distribution of studied patients based on IOP in various follow ups

IOP (mmHg)		Group-A (n=25)	Group-B (n=15)	P value
Pre-operative	**Right**	23.88±2.13	28.53±4.10	**<0.001**
	Left	23.92±2.16	28.53±3.58	**<0.001**
Post- operative after 1 week	**Right**	10.48±1.78	12.13±2.42	**0.018**
	Left	10.28±1.77	12.60±1.68	**<0.001**
Post- operative after 4 weeks	**Right**	12.72±2.41	14.87±3.14	**0.020**
	Left	12.72±2.41	15.53±3.31	**0.009**

Independent Sample t test

The comparison between Groups A and B based on Anterior Chamber Depth (ACD) showed that the mean ACD of Group-B was maximum in all parameters, and the difference was statistically insignificant ($p > 0.05$) (Table 6).

Table 6: Distribution of studied patients based on ACD in various follow ups

ACD(µm)	Prim Open Angle Glaucoma Group-A (n=25)	Pseudo Exfoliative Glaucoma Group-B (n=15)	P value
Pre-operative	2327.32±216.91	2382.60±305.95	0.508
Post- operative after 1 week	2447.52±220.67	2539.07±347.61	0.313
Post- operative after 4 weeks	2669.60±265.76	2680.33±383.52	0.917

Independent Sample t test

The distribution of research subjects is presented in Table 7 based on pre- and post-operative results for several cases of ACD, ACA, and CCT. The mean value of ACD was highest in all cases, followed by CCT, respectively. Based on pre- and post-operative Cirrus HD OCT findings in several cases, the mean of the examined patients was statistically significant in each case ($p < 0.05$).

Table 7: Distribution of studied patients based on Pre and post-operative Cirrus HD OCT findings of several cases

		Mean	Std. Deviation	P value
ACD	**Pre- operative**	2348.05	251.58	**<0.001**
	Post- operative after 1 week	2481.85	274.51	
	Post- operative after 4 weeks	2673.62	310.31	
ACA	**Pre- operative**	35.80	3.74	**<0.001**
	Post- operative after 1 week	42.22	5.24	
	Post- operative after 4 weeks	46.75	5.97	
CCT	**Pre- operative**	526.70	45.374	**<0.001**
	Post- operative after 1 week	556.27	37.81	
	Post- operative after 4 weeks	543.40	35.10	

Paired Samples Statistics

Distribution of studied patients based on Pre and post-operative ACD, ACA, and CCT findings of several cases in Group A is presented in Table 8. The mean value of ACD was highest in all cases followed by CCT, respectively. The mean of studied patients based on Pre and post-operative Cirrus HD OCT findings of several cases in Group A was statistically significant in all cases ($p < 0.05$).

Table 8: Distribution of studied patients based on Pre and post-operative Cirrus HD OCT findings in group A cases

		Mean	Std. Deviation	P value
ACD	**Pre- operative**	2327.32	216.91	**<0.001**
	Post- operative after 1 week	2447.52	220.67	
	Post- operative after 4 weeks	2669.60	265.76	
ACA	**Pre- operative**	35.72	4.287	**<0.001**
	Post- operative after 1 week	41.56	5.261	
	Post- operative after 4 weeks	45.84	6.18	
CCT	**Pre- operative**	532.80	48.77	**<0.001**
	Post- operative after 1 week	562.12	44.60	
	Post- operative after 4 weeks	544.76	42.05	

Paired Samples Statistics

The distribution of studied patients based on Pre and post-operative ACD, ACA, and CCT findings of several cases in Group B is presented in Table 9. The mean value of ACD was highest in all cases followed

by CCT, respectively. The mean of studied patients based on Pre and post-operative Cirrus HD OCT findings of several cases in Group B was statistically significant in all cases ($p < 0.05$).

Table no 13: Distribution of studied patients based on Pre and post-operative Cirrus HD OCT findings in group B cases

		Mean	Std. Deviation	P value
ACD	**Pre- operative**	2382.60	305.95	**<0.001**
	Post- operative after 1 week	2539.07	347.61	
	Post- operative after 4 weeks	2680.33	383.52	
ACA	**Pre- operative**	35.93	2.74	**<0.001**
	Post- operative after 1 week	43.33	5.21	
	Post- operative after 4 weeks	48.26	5.46	
CCT	**Pre- operative**	516.53	38.49	**<0.001**
	Post- operative after 1 week	546.53	20.26	
	Post- operative after 4 weeks	541.13	19.80	

Paired Samples Statistics

DISCUSSION

Cataract surgery stands out as the most prevalent surgical procedure globally, particularly as individuals age, often accompanied by the development of cataracts or glaucoma. Simultaneous occurrences of cataracts and glaucoma pose challenges, but cataract surgery has generally shown favorable outcomes for glaucoma patients. The removal of cataract-related media opacification not only improves visual clarity but also aids in monitoring optic neuropathy progression, including changes in cup/disc ratio and visual field.[7-9]

Anterior segment optical coherence tomography (AS-OCT) serves as a reliable method for evaluating the anterior chamber angle. Siak J et al. discovered that, following phacoemulsification, intraocular pressure (IOP) reduction was similar between angle-closure glaucoma (ACG) and open-angle glaucoma (OAG) groups, but AS-OCT revealed a more open anterior chamber angle in OAG compared to ACG. In our study, the majority of cases were in the age range of 40 to 60 years, with a male predominance.[10-12]

Our findings align with studies by Kim YC et al. and Eligin U et al., demonstrating that cataract surgeries impact on age, preoperative and postoperative best-corrected visual acuity (BCVA), and other parameters was consistent across different glaucoma groups. The study observed no significant differences in blood pressure, heart rate, or eye laterality between groups.[13-17]

Regarding IOP, our study and others, such as Kim YC et al., reported significantly higher postoperative IOP values in pseudoexfoliative glaucoma (PXG) groups compared to other glaucoma types. Elgin U et al. further highlighted that both POAG and PXG groups experienced a significant decrease in IOP after cataract surgery, with a more pronounced reduction in PXG.[18-20]

Anterior chamber depth (ACD), anterior chamber angle (ACA), and central corneal thickness (CCT) were analyzed preoperatively and postoperatively, showing no significant differences between groups. Vu AT et al. reported a notable increase in ACD postoperatively, consistent with our findings. The effects of cataract surgery on these parameters were more pronounced in closed-angle glaucoma than open-angle glaucoma.[21-24]

Differences in preoperative ACD between PXG and POAG patients were noted, reflecting PXG patients' shallower anterior chambers. The postoperative increase in ACD was more substantial in PXG patients. Studies by Dooley I et al. and Uçakhan OO et al. evaluated similar changes in anterior chamber parameters and IOP levels postoperatively, supporting our observations.[25-27]

CONCLUSION

Our findings underscore the importance of considering anterior segment parameters in predicting refractive outcomes post-cataract surgery. We recommend that surgeons incorporate preoperative lens vault (LV) assessments when planning cataract surgery for glaucoma patients. To our knowledge, there is a lack of literature comparing how cataract surgery impacts anterior segment parameters evaluated by optical biometry in patients with primary open-angle glaucoma (POAG) and pseudoexfoliative glaucoma (PXG). The notable postoperative increase in anterior chamber depth (ACD) values in PXG patients may be attributed to ciliary zonular laxity in these individuals. Changes in intraocular pressure (IOP) and anterior segment parameters, including ACD, anterior chamber angle (ACA), and central corneal thickness (CCT), may occur after cataract surgery in eyes with POAG and PXG. These changes may differ between PXG- and POAG-affected eyes.

LIMITATIONS OF THE STUDY

- A larger sample size is needed to validate our findings. Additionally, as all patients were North Indian, it remains uncertain whether similar associations would be observed in other regional groups.
- Various other factors could influence refractive outcomes after cataract surgery. The study has a relatively short follow-up duration.

RECOMMENDATIONS FOR FUTURE STUDIES

- Future research should aim to include a larger number of patients, encompass a broader spectrum of glaucoma types, and employ different imaging techniques such as anterior segment optical coherence tomography (AS-OCT).

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