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Original Research Article

A COMPARATIVE STUDY OF ANTERIOR CHAMBER ANGLE CHANGES IN CATARACT PATIENTS IN PRE-OPERATIVE PERIOD AND POST-OPERATIVE PERIOD USING SPECTRAL DOMAIN ANTERIOR SEGMENT OPTICAL COHERENCE TOMOGRAPHY

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ABSTRACT

Background: Cataract is one of the most common causes of visual impairment and is associated with anatomical changes in the anterior segment of the eye. Cataract extraction with intraocular lens (IOL) implantation can significantly alter anterior chamber configuration. Spectral-domain anterior segment optical coherence tomography (SD-AS-OCT) provides a non-invasive and reproducible method for quantitative assessment of anterior chamber angle parameters. The aim and objective is to compare pre- and post-operative anterior chamber changes after SICS and phacoemulsification by measuring ACA, AOD500, ACD, and TISA500 using Spectral-Domain AS-OCT.

Materials and Methods: A hospital-based longitudinal observational study was conducted among 48 patients aged 40–65 years with age-related cataract undergoing SICS or phacoemulsification with IOL implantation at the Department of Ophthalmology, College of Medicine and Sagore Dutta Hospital, Kolkata, over 18 months.

Results: Among 48 participants, IOP decreased from 19.54 mmHg pre-operatively to 15.96 mmHg at 1 month. ACA, AOD500, TISA500 and ACD progressively increased after surgery, demonstrating widening of the anterior chamber angle, expansion of the trabecular-iris space, and deepening of the anterior chamber.

Conclusion: Cataract extraction with IOL implantation significantly modifies anterior chamber anatomy, resulting in deepening of the anterior chamber and widening of the anterior chamber angle. SD-AS-OCT is a useful, non-invasive imaging modality for objectively evaluating these anatomical changes and may provide valuable information regarding postoperative anterior segment configuration and angle-related risk.

Keywords: Cataract, Anterior Chamber Angle, Spectral-Domain AS-OCT, Intraocular Lens, Anterior Chamber Depth.

INTRODUCTION

Cataract is the leading cause of vision loss in the world. The World Health Organization has estimated that more than 20 million people are blind due to cataract and that the condition causes 51% blindness worldwide. Cataract is also the leading cause of visual impairment, with 33% of the world's population experiencing decreased vision because of this disorder; only refractive error has a greater impact in this regard. Globally, over 10 million cataract operations are performed each year.[1]

Cataract extraction by Small Incision Cataract Surgery and Phacoemulsification may cause changes in the anterior chamber angles. Cataract surgery indirectly alters anterior chamber configuration. It is not known whether the type of surgery or the type of intraocular lens material influences this postoperative change.[2] Increased aqueous outflow is thought to be an important effect of cataract surgery with posterior chamber intraocular lens implantation, resulting in a reduction in intraocular pressure. This reduction may be due to changes in anterior segment parameters.[3] Glaucoma and cataract commonly occur in similar age groups and may coexist. Drugs such as pilocarpine, used in glaucoma treatment, can accelerate cataract formation. With age, lens volume increases, leading to narrowing of the anterior chamber and iridocorneal angle, thereby increasing resistance to aqueous outflow and inducing IOP elevation.[4] Examination of angle elements using gonioscopy is accepted as the gold standard; however, it is subjective and influenced by examiner experience. Several studies have demonstrated the effect of phacoemulsification on narrow-angle glaucoma. After phacoemulsification, the degree of the iridocorneal angle increases. AS-OCT can be used to evaluate these changes and examine the correlation between iris thickness (IT) and angle-opening distance (AOD) at 500 µm and 750 µm (AOD500 and AOD750). AS-OCT is a non-invasive, non-contact technique that provides cross-sectional imaging of the anterior segment at a resolution of 6–25 µm with real-time two-dimensional imaging. Three-dimensional imaging is also available in newer models. It does not require local anesthesia. Its main disadvantage is absorption of the wavelength by iris pigments, which prevents visualization behind the iris and may limit identification of causes of secondary angle closure such as plateau iris, ciliary body tumors, lens subluxation, or ciliary effusion. Its major advantage is that it is quick and simple to perform.[5] Anterior segment cross-sectional imaging is essential for evaluating anterior chamber configuration using quantitative parameters. Anterior Segment Optical Coherence Tomography (AS-OCT) is a non-invasive and non-contact imaging technique for the anterior segment.[6] Anterior segment OCT was first described in 1994 by Izatt et al. using an 830 nm wavelength. This wavelength is suboptimal for angle imaging because of limited penetration through scattering tissues such as the sclera. Subsequently, 1310 nm OCT was developed, providing better scleral penetration and real-time imaging at 8 frames per second.[7] The present study uses Spectralis OCT (Heidelberg Engineering) with an external add-on lens for anterior segment imaging. Its optical source is a Super Luminescent Diode (SLD), and the technology uses both cSLO (Confocal Scanning Laser Ophthalmoscope) and low-coherence interferometry, producing images at a wavelength of 820 nm. The present study will measure Anterior Chamber Angle (ACA), Angle Opening Distance (AOD500), Anterior Chamber Depth (ACD), and Trabecular Iris Space Area (TISA500). The use of AS-OCT in routine clinical practice significantly lags behind Posterior Segment OCT; therefore, further research is required to demonstrate and validate the benefits of OCT-based methods in the management of anterior segment diseases. Cataract refers to clouding or opacification of the lens, which progressively impairs visual acuity and may lead to blindness. Other symptoms include impaired visual contrast, increased glare sensitivity, impaired color perception, and changes in refractive power. Nuclear sclerosis may be associated with progressive myopia. Cataract develops slowly, is painless, and is considered the most common reversible cause of blindness worldwide, affecting approximately 95 million people. Age-related cataract is the most common type, while congenital, connatal, and secondary cataracts are other forms.[1] Cataract prevalence increases markedly with age, rising from 3.9% at 55–64 years to 92.6% at 80 years and above.[6–8] Other risk factors include smoking,[8] myopia,[9] intraocular infection or inflammation, metabolic diseases, drugs, ionizing radiation, genetic predisposition,[10] and ocular trauma. In Germany, age-related cataract is the most common type of lens opacification.[11]

MATERIALS AND METHODS

Study type: A Hospital based observational study.
Study design: Longitudinal study
Place of study- This study was conducted in the Department of Ophthalmology, College of Medicine and Sagore Dutta Hospital, Kolkata, West Bengal.
Study period- The study period was 18 months after getting approval from IEC.
Study population- Includes age group from 40-65 years reporting to the Department of Ophthalmology having cataract.
Sample size- A total of 48 Patients with age-related cataract undergoing Small Incision Cataract Surgery (SICS) or phacoemulsification with intraocular lens implantation.
Inclusion Criteria:

- All individuals from 40-65 years of age having cataract willing to take part in the study.

Exclusion Criteria:

- Unwilling patients.
- Patients with significant ophthalmic comorbidities detrimental to final visual outcomes.
- Patients with a history of previous intraocular surgery.

Study Variable:

- Anterior Chamber Angle (ACA)
- Angle Opening Distance (AOD500)
- Trabecular Iris Space Area (TISA500)
- Anterior Chamber Depth (ACD)
- Intraocular Pressure (IOP)

Statistical Analysis

Data was entered in ExcelTM then checked for consistency. Data was analyzed in Jamovi (Free open Software). Continuous variables was expressed in Mean ± SD or Median ± IQR, depending upon their distribution. Difference of findings before and after surgery was tested for statistical significance using proper test depending upon the distribution of the data.

RESULTS

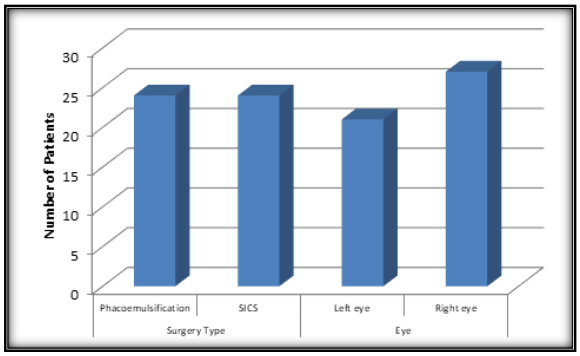


Figure 1: Distribution of Study Participants According to Surgery Type and Eye

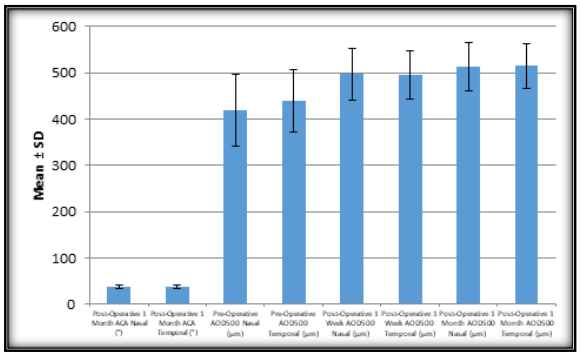


Figure 2: Distribution of Mean Anterior Chamber Angle and Angle Opening Distance Parameters Among Study Participants

Age and Gender-wise Distribution of Study Participants

Results:

Among the 48 study participants, the highest proportion belonged to the 51–60 years age group, with 22 cases (45.80%), followed by those aged ≤50 years, with 14 cases (29.20%). The ≥70 years age group comprised 12 cases (25.00%). The age-wise distribution was statistically significant (p = 0.03318). Regarding gender, 24 participants (50.00%) were female and 24 (50.00%) were male, with no statistically significant difference (p = 1.000).

Interpretation:

The study population was predominantly represented by participants aged 51–60 years. An equal distribution of male and female participants was observed. The age distribution was statistically significant, whereas the gender distribution was not statistically significant.

Surgery Type and Eye-wise Distribution of Study Participants

Results:

Among the 48 study participants, 24 (50.00%) underwent phacoemulsification and 24 (50.00%) underwent SICS, resulting in an equal distribution between the two surgical procedures (p = 1.000). Regarding the operated eye, 27 participants (56.30%) underwent surgery on the right eye, whereas 21 (43.80%) underwent surgery on the left eye. The difference in eye-wise distribution was not statistically significant (p = 0.22246).

Interpretation:

The study included an equal number of participants undergoing phacoemulsification and SICS. A slight predominance of right-eye surgeries was observed; however, the difference between right and left eyes was not statistically significant.

Distribution of Mean Age, IOP, and Anterior Chamber Angle Parameters

Results:

The mean age of the 48 study participants was 55.17 ± 6.24 years, with a range of 44–67 years and a median of 55.50 years. The mean pre-operative IOP was 19.54 ± 1.50 mmHg, which decreased to 17.46 ± 1.47 mmHg at 1 week and further to 15.96 ± 1.27 mmHg at 1 month post-operatively. The mean pre-operative ACA was 30.65 ± 5.31° nasally and 30.10 ± 4.47° temporally. At 1 week post-operatively, the ACA increased to 36.60 ± 4.91° nasally and 36.13 ± 4.23° temporally.

Interpretation:

A progressive reduction in IOP was observed following cataract surgery, from 19.54 mmHg pre-operatively to 15.96 mmHg at 1 month. Simultaneously, the anterior chamber angle widened in both nasal and temporal quadrants during the early post-operative period, indicating improvement in anterior chamber configuration following surgery.

Distribution of Mean Anterior Chamber Angle and Angle Opening Distance Parameters

Results:

The mean post-operative 1-month ACA was 37.63 ± 4.50° nasally and 36.81 ± 4.16° temporally. The mean pre-operative AOD500 was 419.35 ± 77.33 µm nasally and 439.02 ± 66.81 µm temporally. At 1 week post-operatively, the mean AOD500 increased to 496.96 ± 55.55 µm nasally and 494.56 ± 51.69 µm temporally. At 1 month, it further increased to 512.77 ± 52.81 µm nasally and 514.71 ± 49.11 µm temporally.

Interpretation:

The findings demonstrate a progressive widening of the anterior chamber angle and increase in AOD500 following cataract surgery. The increase was evident at 1 week and became more pronounced at 1 month, suggesting that cataract extraction resulted in sustained improvement in anterior chamber angle dimensions.

Distribution of Mean Trabecular Iris Space Area (TISA500) Parameters

Results:

The mean pre-operative TISA500 was 0.3010 ± 0.0870 mm² nasally and 0.2963 ± 0.0889 mm² temporally. At 1 week post-operatively, the mean TISA500 increased to 0.3467 ± 0.0870 mm² nasally and 0.3438 ± 0.0934 mm² temporally. At 1 month, the mean TISA500 further increased to 0.3642 ± 0.0848 mm² nasally and 0.3619 ± 0.0944 mm² temporally.

Interpretation:

A progressive increase in TISA500 was observed following cataract surgery in both nasal and temporal quadrants. The increase from pre-operative values to 1 month post-operatively indicates expansion of the trabecular iris space and consequent widening of the anterior chamber angle.

Distribution of Mean Anterior Chamber Depth (ACD)

Results:

The mean pre-operative ACD was 2.7165 ± 0.3306 mm, with a range of 2.00–3.25 mm and a median of 2.85 mm. At 1 week after surgery, the mean ACD increased to 3.3410 ± 0.4280 mm, with a median of 3.245 mm. At 1 month post-operatively, the mean ACD further increased to 3.5598 ± 0.4601 mm, with values ranging from 2.44–4.55 mm and a median of 3.495 mm.

Interpretation:

Cataract surgery was associated with a progressive deepening of the anterior chamber. The mean ACD increased from 2.7165 mm pre-operatively to 3.3410 mm at 1 week and 3.5598 mm at 1 month, indicating a sustained improvement in anterior chamber depth following cataract extraction.

Table 1: Distribution of Study Participants According to Age Group and Gender

		Frequency	Percent	p-value
Age Group	≤50 years	14	29.20%	0.03318
	51–60 years	22	45.80%	
	≥70 years	12	25.00%	
Gender	Female	24	50.00%	1
	Male	24	50.00%	

Table 2: Distribution of Study Participants According to Surgery Type and Eye

		Frequency	Percent	p-value
Surgery Type	Phacoemulsification	24	50.00%	1
	SICS	24	50.00%	
Eye	Left eye	21	43.80%	0.22246
	Right eye	27	56.30%	

Table 3: Distribution of Mean Age, IOP, and Anterior Chamber Angle Parameters among Study Participants

	Mean	SD	Minimum	Maximum	Median
Age (years)	55.17	6.24	44	67	55.5
Pre-Operative IOP (mmHg)	19.54	1.5	18	22	20
Post-Operative 1 Week IOP (mmHg)	17.46	1.47	16	20	18
Post-Operative 1 Month IOP (mmHg)	15.96	1.27	14	18	16
Pre-Operative ACA Nasal (°)	30.65	5.31	23	44	30.5
Pre-Operative ACA Temporal (°)	30.1	4.47	23	40	30
Post-Operative 1 Week ACA Nasal (°)	36.6	4.91	27	44	38
Post-Operative 1 Week ACA Temporal (°)	36.13	4.23	28	43	37

Table 4: Distribution of Mean Anterior Chamber Angle and Angle Opening Distance Parameters Among Study Participants

	Mean	SD	Minimum	Maximum	Median
Post-Operative 1 Month ACA Nasal (°)	37.63	4.5	29	44	39
Post-Operative 1 Month ACA Temporal (°)	36.81	4.16	29	44	38
Pre-Operative AOD500 Nasal (µm)	419.35	77.33	310	588	410
Pre-Operative AOD500 Temporal (µm)	439.02	66.81	301	590	436.5
Post-Operative 1 Week AOD500 Nasal (µm)	496.96	55.55	413	671	478.5
Post-Operative 1 Week AOD500 Temporal (µm)	494.56	51.69	427	662	480.5
Post-Operative 1 Month AOD500 Nasal (µm)	512.77	52.81	451	676	502
Post-Operative 1 Month AOD500 Temporal (µm)	514.71	49.11	453	665	506

Table 5: Distribution of Mean Trabecular Iris Space Area (TISA500) Parameters Among Study Participants

	Mean	SD	Minimum	Maximum	Median
Pre-Operative TISA500 Nasal (mm²)	0.301	0.087	0.14	0.49	0.275
Pre-Operative TISA500 Temporal (mm²)	0.2963	0.0889	0.14	0.5	0.27
Post-Operative 1 Week TISA500 Nasal (mm²)	0.3467	0.087	0.19	0.56	0.31
Post-Operative 1 Week TISA500 Temporal (mm²)	0.3438	0.0934	0.21	0.61	0.33
Post-Operative 1 Month TISA500 Nasal (mm²)	0.3642	0.0848	0.22	0.58	0.345
Post-Operative 1 Month TISA500 Temporal (mm²)	0.3619	0.0944	0.22	0.63	0.345

Table 6: Distribution of Mean Anterior Chamber Depth (ACD) Among Study Participants

	Mean	SD	Minimum	Maximum	Median
Pre-Operative ACD (mm)	2.7165	0.3306	2	3.25	2.85
Post-Operative 1 Week ACD (mm)	3.341	0.428	2.36	4.15	3.245
Post-Operative 1 Month ACD (mm)	3.5598	0.4601	2.44	4.55	3.495

DISCUSSION

The present study evaluated changes in anterior segment parameters before and after cataract surgery using Spectral Domain Anterior Segment Optical Coherence Tomography (AS-OCT) among 48 eyes. The mean age of the participants was 55.17 ± 6.24 years, with the largest proportion belonging to the 51–60 years age group (45.80%). Equal representation of males and females was observed, while phacoemulsification and small-incision cataract surgery each accounted for 50.0% of the procedures. Akil H et al. evaluated anterior chamber angle parameters before and after cataract surgery using AS-OCT and reported significant postoperative increases in ACA, AOD500 and TISA500, demonstrating that cataract extraction produces measurable anatomical changes in the anterior chamber.[12] A major finding of the present study was the progressive reduction in intraocular pressure (IOP) following cataract surgery. The mean pre-operative IOP was 19.54 ± 1.50 mmHg, decreasing to 17.46 ± 1.47 mmHg at 1 week and further to 15.96 ± 1.27 mmHg at 1 month. The reduction in IOP was accompanied by widening of the anterior chamber angle and deepening of the anterior chamber. Siak J et al. demonstrated that cataract surgery can produce significant anatomical changes in the anterior chamber angle together with alterations in IOP, supporting the relationship between postoperative anatomical remodeling and aqueous humor dynamics.[13] The present study demonstrated marked widening of the anterior chamber angle (ACA) after cataract surgery. The mean nasal ACA increased from 30.65 ± 5.31° pre-operatively to 36.60 ± 4.91° at 1 week and 37.63 ± 4.50° at 1 month. Similarly, the temporal ACA increased from 30.10 ± 4.47° pre-operatively to 36.13 ± 4.23° at 1 week and 36.81 ± 4.16° at 1 month. Toro MD et al. reported statistically significant increases in both nasal and temporal angle parameters following cataract surgery, with significant positive correlations between ACA, AOD500 and TISA500.[14] The widening of the ACA can be explained by removal of the bulky crystalline lens. Following cataract extraction and posterior chamber IOL implantation, the iris-lens diaphragm moves posteriorly, increasing the available anterior chamber space. Yu ZY et al. demonstrated that quantitative anterior chamber angle measurements obtained using AS-OCT are reliable and show good correlation with other imaging modalities, supporting the use of AOD500 and TISA500 as objective indicators of angle configuration.[15] A substantial increase was also observed in AOD500. The mean pre-operative nasal AOD500 was 419.35 ± 77.33 µm, increasing to 496.96 ± 55.55 µm at 1 week and 512.77 ± 52.81 µm at 1 month. Temporally, AOD500 increased from 439.02 ± 66.81 µm pre-operatively to 494.56 ± 51.69 µm at 1 week and 514.71 ± 49.11 µm at 1 month. Ibrahim MM et al. reported significant increases in AOD500 following phacoemulsification, irrespective of pre-existing angle status, indicating that lens extraction produces substantial widening of the anterior chamber angle.[16] The increase in AOD500 observed in the present study indicates greater separation between the trabecular meshwork and iris following cataract extraction. This enlargement of the angle may improve aqueous humor access to the trabecular meshwork and thereby contribute to postoperative IOP reduction. Bayat and Akpolat reported that both AOD500 and TISA500 increased significantly one month after cataract surgery, while IOP decreased significantly in both diabetic and non-diabetic patients.[17] The TISA500 measurements also demonstrated progressive postoperative enlargement. Nasal TISA500 increased from 0.3010 ± 0.0870 mm² pre-operatively to 0.3467 ± 0.0870 mm² at 1 week and 0.3642 ± 0.0848 mm² at 1 month. Temporally, it increased from 0.2963 ± 0.0889 mm² to 0.3438 ± 0.0934 mm² at 1 week and 0.3619 ± 0.0944 mm² at 1 month. Shabana N et al. demonstrated that AS-OCT-derived AOD500 and TISA500 measurements show good agreement with ultrasound biomicroscopy measurements, supporting their usefulness for quantitative evaluation of anterior chamber angle morphology.[18] Parajuli S demonstrated that the increase in TISA500 complements the findings for AOD500. While AOD500 provides a linear assessment of angle opening, TISA500 represents the area of the trabecular-iris space. Therefore, simultaneous increases in both parameters indicate generalized expansion of the anterior chamber angle. Recent comparative evidence has also shown that cataract extraction produces greater widening of multiple anterior chamber angle parameters, including AOD500 and TISA500, than alternative angle-opening procedures.[19] Another important finding was the progressive deepening of the anterior chamber. The mean pre-operative ACD was 2.7165 ± 0.3306 mm, increasing to 3.3410 ± 0.4280 mm at 1 week and 3.5598 ± 0.4601 mm at 1 month. This represents an increase of approximately 0.62 mm at 1 week and 0.84 mm at 1 month compared with baseline. Siyan Li et al. recently demonstrated significant postoperative changes in anterior chamber angle parameters following lens surgery using swept-source AS-OCT, further supporting the concept of persistent postoperative anterior segment remodelling.[20]

CONCLUSION

The present study demonstrated clear postoperative changes in anterior segment parameters following cataract surgery. There was a progressive reduction in intraocular pressure along with widening of the anterior chamber angle in both nasal and temporal quadrants. AOD500 and TISA500 also increased progressively, indicating expansion of the trabecular-iris space. Anterior chamber depth increased after surgery, demonstrating deepening of the anterior chamber. These findings suggest that cataract extraction produces favorable anatomical changes in the anterior segment and may improve aqueous humor outflow. Spectral Domain AS-OCT provided a non-invasive, objective, and quantitative method for evaluating these postoperative changes and may be useful in routine clinical assessment.

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