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Original Research Article

Evaluation of Anterior Chamber Angle Parameter Changes Post Small Incision Cataract Surgery Using Anterior Segment Optical Coherence Tomography

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Abstract:

Background: Cataract continues to be the major cause of reversible blindness globally and is common in the elderly population. In addition to visual impairment, age-related lens enlargement is a cause of anterior chamber angle narrowing which may lead to angle closure glaucoma. Not only does Small Incision Cataract Surgery (SICS restore vision but can also create favorable anatomical changes in the anterior chamber. An Anterior Segment Optical Coherence Tomography (AS-OCT) can be used to measure these changes in an objective and non-invasive way.

Aim: To assess the anterior chamber angles changes after Small Incision Cataract Surgery with Anterior Segment Optical Coherence Tomography.

Design: A prospective observational study in Department of Ophthalmology-Narayan Medical College & Hospital for a period of 24 months.

Material and Methods: The study was a prospective observational study carried out in 24 months in Department of Ophthalmology, Narayan Medical College & Hospital. Overall, 110 patients aged 50 years and older with age-related cataract (ARC) were enrolled in uncomplicated SICS. Preoperatively and after surgery (on day 7 and day 30), anterior chamber angle (ACA), angle opening distance at 500 μm (AOD500), and trabecular iris space area at 500 μm (TISA500) were measured in the nasal and temporal quadrants. Intraocular pressure (IOP) was also taken.

Results: There was significant postoperative improvement in ACA, AOD500 and TISA500 in both the nasal and temporal quadrants ($p<0.001$). The mean IOP was significantly reduced at one month postoperatively from 15.78 ± 2.39 mmHg preoperatively to 11.91 ± 1.70 mmHg at one month postoperatively ($p<0.001$). A significant positive correlation was seen between greater angle widening and reduction in IOP.

Conclusions: SICS is associated with important anterior chamber angle widening and intraocular pressure decrease. AS-OCT is a useful and non-invasive technique to assess changes in the anterior segment after surgery and could help with the risk assessment and management of glaucoma.

Keywords: Cataract, Small Incision Cataract Surgery, Anterior Segment Optical Coherence Tomography, Anterior Chamber Angle, AOD500, TISA500, Intraocular Pressure.

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Introduction

Cataract is still the most common cause of blindness worldwide and remains a serious public health problem, especially in developing nations. The World Health Organization (WHO) estimates that almost 2.2 billion individuals around the world have vision impairment and cataract counts for nearly 45% of blindness [1]. Population ageing and rising life expectancy are predicted to further raise the burden of cataract. The Global Burden of Disease Study has also highlighted cataract as the major cause of reversible visual impairment and disability

globally, particularly in low- and middle-income countries [2].

India carries a significant share of the worldwide load of cataract blindness. Cataract was the leading cause of blindness among those aged 50 years and older in the National Blindness and Visual Impairment Survey (2015–2019), responsible for about 66–70% of blindness in this age group [3,4]. Despite being one of the most successful and cost-effective therapies in modern medicine, cataract remains a major contributor to visual handicap and impaired quality of life in senior persons [5].

In addition to visual rehabilitation cataract extraction induces remarkable anatomical modifications of the anterior portion of the eye. With age, the crystalline lens enlarges and is displaced anteriorly. This results in gradual narrowing of the anterior chamber angle and reduction in anterior chamber depth (ACD), which predisposes susceptible individuals to primary angle closure (PAC) and primary angle closure glaucoma (PACG). Lens extraction has been proven to broaden the anterior chamber angle, enhance aqueous humour outflow and reduce intraocular pressure (IOP), and hence plays a significant role in the management and prevention of angle-closure illness [6]. Thus, assessing the arrangement of the anterior chamber angle before and after cataract surgery has become quite important in clinical practice.

Traditionally, gonioscopy has been considered as the gold standard for assessment of the anterior chamber angle anatomy. However, it is subjective, relying on the examiner and sensitive to inter-observer variability. Furthermore, accidental pressure from the gonioscopy lens might disrupt the normal angle arrangement, especially in narrow angle eyes. Later, Ultrasound Biomicroscopy (UBM) was introduced to allow detailed visualisation of anterior segment features. UBM is useful but is very time demanding, needs contact with the eye, and is operator dependant [7].

The advent of Anterior Segment Optical Coherence Tomography (AS-OCT) has transformed anterior segment imaging with its fast, non-contact, non-invasive method for objective assessment of angle architecture. AS-OCT is based on low-coherence interferometry and produces high-resolution cross-sectional images of the anterior segment, making it possible to accurately assess structures such as the cornea, anterior chamber, iris, and iridocorneal angle. This allows the quantitative evaluation of numerous therapeutically relevant characteristics including anterior chamber angle (ACA), angle opening distance at 500 μm (AOD500), trabecular iris space area at 500 μm (TISA500), anterior chamber depth and lens vault [8]. These measurements enable reliable determination of the structural changes following cataract removal and provide more reproducibility than traditional clinical approaches.

Small-incision cataract surgery (SICS) is one of the most regularly performed cataract operations in India due to its low cost, minimum infrastructure requirements, and great visual outcomes. Previous investigations have revealed considerable enlargement of anterior chamber angle and increase in ACD, AOD and TISA measures after cataract excision. These anatomic changes lead to enhanced aqueous drainage and a decreased likelihood of angle closure. Quantifying these changes is crucial for understanding the broader therapeutic benefits of cataract surgery beyond visual restoration and may be helpful in identifying people at risk of developing glaucomatous damage.

Although SICS has been widely adopted, data on changes in the anterior chamber angle postoperatively measured by AS-OCT are lacking especially in rural and resource-limited settings. In addition, Indian eyes are known to have anatomical features such as slightly shallower anterior chambers and thicker crystalline lenses, which may influence the degree of postoperative angle widening. Thus, measurement of anterior chamber angle parameters after cataract surgery is of great clinical significance in the Indian population.

The purpose of the present study undertaken in the Department of Ophthalmology, Narayan Medical College & Hospital is to analyse changes in anterior chamber angle parameters after Small Incision Cataract Surgery utilising Anterior Segment Optical Coherence Tomography. To quantify parameters such as the anterior chamber angle (ACA), angle opening distance (AOD500), and trabecular-iris space area (TISA500) in the nasal and temporal quadrants before and after surgery, with the goal of providing objective evidence of postoperative angle widening and its possible implications for glaucoma prevention and anterior segment assessment.

Methodology

Study Design: This is a prospective observational case study, performed in a hospital setting to investigate the changes seen in anterior chamber angle parameters after Small Incision Cataract Surgery (SICS) with Anterior Segment Optical Coherence Tomography (AS-OCT).

Study Area: The study was carried out in Department of Ophthalmology, Narayan Medical College & Hospital, Sasaram, Bihar, India

Study Duration: The study was conducted over a period of 24 months from 16/03/2024 to 16/03/2026.

Sample Size: A sample size was determined using the formula:

- $n = Z^2pq/m^2$

Where:

n = Sample size

Z = 1.96 (constant for 95% confidence interval)

- •p = prevalence of case
- q = 1 − p
- m = permissible error in the study

Taking:

- p = 0.05
- q = 0.95
- m = 5% or 0.05

$n = (1.96)^2 \times 0.05 \times 0.95 / (0.05 \times 0.05)$

n = 73

If you're considering using a design effect of 1.5,

Revised Sample Size (n') = Design Effect × Sample Size

$n' = 1.5 \times 73 = 109.5 \approx 110$

Thus, the final number of the patients in the study was 110.

Sample Population: The study population comprised of ophthalmic patients with age related cataract who had undergone Small Incision Cataract Surgery (SICS) in the Department of Ophthalmology, Narayan Medical College & Hospital.

Data Collection: All eligible participants after obtaining their written informed consent completed a predesigned data collection proforma with demographic and clinical information. Complete ophthalmic examination was done which included visual acuity test using Snellen's chart, intraocular pressure measurement by Goldmann applanation tonometry and anterior segment exam with slit lamp bio microscopy, posterior segment exam with 90D lens. Autorefractometer was used for keratometric readings and A-scan biometry was used for intraocular lens (IOL) power calculation. Anterior segment imaging was done preoperatively with AS-OCT under standardized ambient light conditions with undilated pupils. Anterior chamber angle parameters were recorded at baseline and compared to those recorded at follow-up visits after surgery.

Inclusion Criteria

- Age ≥ 50 years.
- People who developed bilateral age-related cataract whose visual acuity in the better eye was less than 6/18.
- Patients willing to participate and provide written informed consent.

Exclusion Criteria

- Etiology other than age-related cataract (traumatic, uveitic, drug-related cataract).
- Previous eye problems such as glaucoma or problems with the lids, conjunctiva, cornea, or sclera.
- Previous surgical history of cornea and/or glaucoma.
- Patients who have complications during surgery.
- Scans of the eye that were not obtained in high-quality with signal strength <5 or scans where the scleral spur was not well defined.
- Provided treatment to patients without 1-week or 1-month postoperative follow-up visits.

Procedure: This was a prospective observational study conducted in the Department of Ophthalmology, Narayan Medical College & Hospital after getting clearance from Institutional Ethics Committee. Patients with Age related cataract on whom the Small Incision Cataract Surgery (SICS) was to be performed were recruited for the study.

A complete ophthalmologic examination was performed prior to surgery on all patients. Anterior segment imaging was done with the same ambient lighting conditions and undilated pupils using AS-OCT with an anterior segment adaptor. The Anterior Chamber Angle (ACA), Angle Opening Distance at 500 μm anterior to the scleral spur (AOD500), and Trabecular Iris Space Area at 500 μm anterior to the scleral spur (TISA500) were used as the anterior parameters. Measurements were taken in the 0° (nasal) and 180° (temporal) quadrants. The inter-observer variability was minimised by performing all AS-OCT measurements by a single observer.

Later, all the patients underwent normal Small Incision Cataract Surgery (SICS) with peribulbar anesthesia performed by well-trained ophthalmic surgeons. Post surgery patients received regular topical antibiotic and steroid treatment.

Post Operative follow up was performed on 7th and 30th day after operation. The parameters ACA, AOD500 and TISA500 were measured at each follow-up visit using the same AS-OCT imaging and compared to the respective preoperative values to assess changes in the anterior chamber angle after SICS.

Statistical Analysis: All the data obtained from the students of the study was tabulated in a master chart and subjected to statistical analysis with the suitable software. Data were presented as mean ± SD for continuous variables, and as frequencies and percentages for categorical variables. Where applicable, One-way Analysis of Variance (ANOVA) was used for the comparisons of unrelated variables. Anterior chamber angle

parameters were compared between pre- and postoperative period using paired t-test. The significance of p value was less than 0.05.

Ethical Consideration: The study was conducted after obtaining ethical clearance from Institutional Ethics Committee, Narayan Medical College & Hospital. All the participants gave informed consent prior to enrolment. Research was carried out in a manner respecting the ethical principles in the Declaration of Helsinki. All patient-related data were kept confidential and anonymous throughout the study and participation was voluntary.

Result

The baseline demographic/clinical profile of the study participants is shown in Table 1. The number of patients who had age related cataract with uncomplicated small incision cataract surgery (SICS) was 110. The mean age of the participants was 66.4 ± 9.45 years (range: 50–85 years). The male population was 64.54% (n=71) and females 35.46% (n=39). The left eye was operated on in 53.6% (n=59) of cases and the right eye in 46.4% (n=51). The most prevalent systemic co-morbidities were diabetes mellitus, hypertension, and combined diabetes and hypertension; 51.8% had no significant medical history. The mean preoperative intraocular pressure (IOP) was 15.78 ± 2.39 mmHg.

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants (N=110)

Characteristic	Value
Age (years), Mean ± SD	66.4 ± 9.45
Age Range	50–85
Male, n (%)	71 (64.54%)
Female, n (%)	39 (35.46%)
Right Eye, n (%)	51 (46.4%)
Left Eye, n (%)	59 (53.6%)
Diabetes Mellitus	17 (15.5%)
Hypertension	15 (13.6%)
HTN + DM	9 (8.2%)
Hypothyroidism	7 (6.4%)
Asthma	5 (4.5%)
No Significant History	57 (51.8%)
Preoperative IOP (mmHg), Mean ± SD	15.78 ± 2.39

The results of nasal quadrant anterior chamber angle parameters measured by AS-OCT after surgery are shown in Table 2. Postoperative changes in anterior chamber angle parameters of the nasal quadrant measured by AS-OCT are summarized in Table 2. A major increase in all angle parameters was noted after surgery. The mean anterior chamber angle (ACA) increased from 22.47 ± 5.07° preoperatively to 33.80 ± 4.86° on postoperative day 7 and further to 37.64 ± 3.69° on postoperative day 30 ($p<0.001$). Similarly, the mean angle opening distance at 500 μm (AOD500) increased from 0.345 ± 0.120 mm preoperatively to 0.592 ± 0.108 mm and 0.670 ± 0.091 mm on postoperative days 7 and 30, respectively ($p<0.001$). The mean trabecular iris space area at 500 μm (TISA500) also showed a significant increase from 0.128 ± 0.036 mm² preoperatively to 0.209 ± 0.034 mm² and 0.242 ± 0.031 mm² at postoperative follow-up ($p<0.001$).

Table 2: Changes in Nasal Quadrant AS-OCT Parameters Following SICS

Parameter	Pre-operative	Post-op Day 7	Post-op Day 30	p-value
ACA (°)	22.47 ± 5.07	33.80 ± 4.86	37.64 ± 3.69	<0.001
AOD500 (mm)	0.345 ± 0.120	0.592 ± 0.108	0.670 ± 0.091	<0.001
TISA500 (mm²)	0.128 ± 0.036	0.209 ± 0.034	0.242 ± 0.031	<0.001

Table 3 shows the changes in temporal quadrant angle parameters following SICS. A significant increase in anterior chamber angle was noted during the entire postoperative course. The mean ACA increased from 22.68 ± 5.12° preoperatively to 34.10 ± 4.86° on postoperative day 7 and 37.67 ± 3.75° on postoperative day 30 ($p<0.001$). Likewise, the mean AOD500 increased from 0.349 ± 0.120 mm before surgery to 0.598 ± 0.108 mm and 0.674 ± 0.091 mm on postoperative days 7 and 30, respectively ($p<0.001$). The anterior chamber angle dimension (TISA500) increased significantly from 0.128 ± 0.030 mm² preoperatively to 0.208 ± 0.034 mm² and 0.242 ± 0.032 mm² at postoperative follow-up ($p<0.001$), indicating significant improvement in the dimensions of the anterior chamber angle.

Table 3: Changes in Temporal Quadrant AS-OCT Parameters Following SICS				
Parameter	**Pre-operative**	**Post-op Day 7**	**Post-op Day 30**	**p-value**
ACA (°)	22.68 ± 5.12	34.10 ± 4.86	37.67 ± 3.75	<0.001
AOD500 (mm)	0.349 ± 0.120	0.598 ± 0.108	0.674 ± 0.091	<0.001
TISA500 (mm²)	0.128 ± 0.030	0.208 ± 0.034	0.242 ± 0.032	<0.001

The Table 4 shows the change in intraocular pressure with the use of SICS. Preoperative mean IOP was 15.78 ± 2.39 mmHg and at postoperative day 30, it was significantly reduced to 11.91 ± 1.70 mmHg. This was a mean decrease from baseline of 3.87 mmHg. This reduction was statistically highly significant (p<0.001), and thus, the effect of cataract extraction on the control of IOP was beneficial.

Table 4: Intraocular Pressure Changes Following SICS			
Time Point	**IOP (mmHg), Mean ± SD**	**Mean Change from Baseline**	**p-value**
Pre-operative	15.78 ± 2.39	—	—
Post-op Day 30	11.91 ± 1.70	3.87	<0.001

In Table 5, there is no correlation between the changes in the anterior chamber angle parameters and IOP reduction following surgery. There were significant positive correlations between each of the changes in nasal ACA (r=0.51), temporal ACA (r=0.48), nasal AOD500 (r=0.55), temporal AOD500 (r=0.52), nasal TISA500 (r=0.53), and temporal TISA500 (r=0.50) and IOP reduction (p<0.001 for all). Of these parameters, nasal AOD500 was highest in correlation with postoperative reduction in IOP. The more angle widened perioperatively, the greater the IOP reduction, suggesting that angle widening is linked to greater IOP reduction.

Table 5: Correlation Between AS-OCT Parameter Changes and IOP Reduction		
Parameter Change (Pre-op to Day 30)	**Correlation Coefficient (r)**	**p-value**
Δ Nasal ACA	0.51	<0.001
Δ Temporal ACA	0.48	<0.001
Δ Nasal AOD500	0.55	<0.001
Δ Temporal AOD500	0.52	<0.001
Δ Nasal TISA500	0.53	<0.001
Δ Temporal TISA500	0.5	<0.001

Postoperative change in the width of the anterior chamber angle, by age, is presented in Table 6. The highest rise in ACA was seen in the 70–79 age group where there was an increase of 17.03 ± 5.21° at the nose and 17.02 ± 5.35° at the temple. Patients 60- to 69-years-old also showed significant angle widening, while smaller increases were observed in patients 50- to 59-years-old and those aged 80 years or older. The differences between age groups were statistically significant for nasal ACA (p=0.023) and temporal ACA (p=0.018), suggesting that age might be a factor affecting the magnitude of changes of ACA following cataract surgery.

Table 6: Age-wise Comparison of Anterior Chamber Angle Changes Following SICS			
Age Group (Years)	**n**	**Δ Nasal ACA (°)**	**Δ Temporal ACA (°)**
50–59	33	13.99 ± 4.97	13.49 ± 4.96
60–69	26	15.05 ± 5.70	14.97 ± 5.66
70–79	36	17.03 ± 5.21	17.02 ± 5.35
≥80	15	13.30 ± 5.21	13.53 ± 5.91
p-value	—	**0.023**	**0.018**

Discussion

This present prospective observational study was undertaken to investigate the changes in anterior chamber angle characteristics after Small Incision Cataract Surgery (SICS) with Anterior Segment Optical Coherence Tomography (AS-OCT). Results: Anterior chamber angle was significantly widened post-operatively with substantial increases in Anterior Chamber Angle (ACA), Angle Opening Distance at 500 μm (AOD500) and Trabecular Iris Space Area at 500 μm (TISA500) in nasal and temporal quadrants. In addition, a considerable drop in intraocular pressure (IOP) was also detected, demonstrating that cataract surgery offers not only visual rehabilitation but also beneficial structural and physiological changes of the anterior region".

The mean age of the study cohort was 66.4 ± 9.45 years, which is comparable to prior studies that

assessed anterior section changes after cataract surgery. Kim et al. showed a mean age of around 65 years and Lee et al. reported a mean age of 68.7 years in cataract patients that underwent identical examinations [9]. The fact that the present study included a majority of older patients is indicative of the age-related nature of cataract formation, and supports the concept that lens-induced anatomical crowding becomes increasingly important with advancing age.

A major finding of this study was a considerable increase in the anterior chamber angle after SICS. The mean nasal ACA increased from 22.47 ± 5.07° preoperatively to 37.64 ± 3.69° on postoperative day 30 and temporal ACA increased from 22.68 ± 5.12° to 37.67 ± 3.75° ($p < 0.001$). Similar large increases were found in AOD500 and TISA500. These results are in agreement with those of Tai et al., who found a considerable expansion of the nasal and temporal ACA after phacoemulsification from roughly 22–23° before surgery to 33–34° after surgery.Nath et colleagues. similarly found significant postoperative increases in the angle configuration parameters evaluated by AS-OCT in small adult eyes having cataract ectomy [10]. Similarly, Varghese et al. reported significant improvements in ACA, AOD and TISA after cataract surgery, demonstrating the positive influence of lens removal on the architecture of the anterior chamber [11].

The magnitude of widening of the angle found in the present study was substantially higher than those reported in several prior investigations. This may be as a result of inclusion of patients with narrow baseline angles and age-related lens enlargement which is frequent in Indian people. Cataract extraction eliminates the bulky crystalline lens and replaces it with a smaller intraocular lens, which increases the anterior chamber depth and alleviates iridocorneal crowding. This process is well described in earlier AS-OCT studies assessing the postoperative anatomical alterations [12].

Another notable discovery was the considerable IOP reduction with SICS. Mean IOP was reduced from 15.78 ± 2.39 mmHg preoperatively to 11.91 ± 1.70 mmHg one month postoperatively, a mean reduction of 3.87 mmHg ($p<0.001$). This finding is consistent with the results of Huang et al., who found a significant reduction in postoperative IOP after phacoemulsification in both narrow-angle and open-angle eyes.[56] Similarly, Giglio et al. showed that the mean IOP decreased from 14.91 mmHg to 12.91 mmHg after cataract surgery, confirming the positive impact of lens extraction on aqueous humour dynamics.[39] Bayat and Akpolat have also reported significant postoperative reduction in IOP with widening of angle parameters in diabetic and non-diabetic individuals [13].

The present investigation also indicated a moderate-to-strong negative connection between postoperative angle widening and IOP decrease ($r = -0.48$ to -0.55, $p<0.001$). This finding shows that larger anterior chamber angle expansion allows for increased aqueous outflow via the trabecular meshwork, and lower IOP. Huang et al. confirmed similar data, finding that increases in AOD500 were strongly linked with decreases in IOP after cataract surgery. They further propose that the structural enhancements in the anterior chamber lead directly to improved physiological function and management of pressure.

Statistically significant differences were seen in postoperative angle widening according to age, with the biggest difference in individuals aged 70–79 years. This observation may be attributable to increased lens thickness and more significant preoperative angle crowding in older persons. Age-related expansion of the crystalline lens is a widely recognised factor in the narrowing of the anterior chamber angle and formation of angle closure mechanisms. Therefore, in senior patients there is a greater anatomical enlargement after lens removal than in younger age groups. Similar relationships between age, lens vault and angle width have been reported in population-based AS-OCT investigations.

When the data were analysed according to gender, no statistical significance was found in the postoperative angle widening between males and females. Postoperatively, both groups had similar improvements in ACA measures. This is similar with the observations of Lee et al and Huang et al who showed that gender had little effect on the postoperative anterior chamber architecture after lens removal. Thus, the anatomical advantages of SICS seem to be irrespective of the sex of the patient.

Similarly, postoperative alterations in the angle were not significantly affected by systemic comorbidities such as hypertension, diabetes mellitus, hypothyroidism and asthma. Diabetic and hypothyroid patients showed slightly more broadening but the changes were not statistically significant. Bayat et colleagues also observed that diabetes status did not significantly affect postoperative AS-OCT values, suggesting that cataract surgery has similar structural consequences, regardless of systemic disease condition. These data suggest that SICS induces predictable changes in the anterior segment in different groups of patients.

In summary, the current investigation indicates that SICS significantly increases the anterior chamber angle and significantly decreases the IOP evaluated objectively by AS-OCT. The results are consistent with prior national and international research, and add to the evidence for cataract extraction as a

successful means of enhancing anterior chamber morphology and reducing the incidence of angle-closure syndrome. AS-OCT was found to be a reliable, non-invasive and reproducible imaging method for quantification of these alterations and may be used for routine preoperative assessment and postoperative monitoring of patients undergoing cataract surgery.

Conclusion

The present study showed that there were large anterior chamber angle (ACA) changes associated with Small Incision Cataract Surgery (SICS) as observed by Anterior Segment Optical Coherence Tomography (AS-OCT). In the nasal and temporal quadrants, there was an increase in anterior chamber angle width (AOD500) and trabecular iris space area (TISA500) after surgery. There was also a marked decrease in intraocular pressure suggesting that the aqueous humor was better drained after removal of the lens. Moreover, the correlation of postoperative angle widening with intraocular pressure reduction implies that improvement of anterior chamber configuration will help in better intraocular pressure control. Angle widening was greatest with older patients, emphasizing the role of age-related lens changes on postoperative outcomes. SICS is not only effective for visual rehabilitation but has also been shown to have significant anatomical and physiological advantages, such as potentially decreasing the risk of angle closure disease and the progression of glaucoma. In this study, AS-OCT was proven to be a reliable, non-invasive and reproducible imaging modality to assess these changes and can be used in the pre-operative evaluation and post-operative follow up of cataract surgical patients.

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