EVALUATION OF ANTERIOR CHAMBER ANGLE PARAMETERS POST CATARACT SURGERY USING ANTERIOR SEGMENT OPTICAL COHERENCE TOMOGRAPHY

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ABSTRACT

BACKGROUND

Cataract surgery indirectly alters the anterior chamber configuration. It is not known whether the type of surgery or the type of intraocular lens (IOL) material influences this postoperative change. The objectives of this study were to compare the anterior chamber angle parameters before and after cataract surgery using Anterior Segment Optical Coherence Tomography (AS-OCT) and to determine if the type of surgery or the IOL material influenced this change.

MATERIALS AND METHODS

This was a prospective, observational study done in a tertiary care hospital in North India and included 150 patients who underwent uneventful cataract surgery with IOL implantation from December 2014 to May 2016. Patients were divided into three groups (N=50 eyes each) based on type of surgery and IOL material. The anterior chamber angle parameters (ACA, AOD500, TISA500) were evaluated using AS-OCT one day before and two weeks following cataract surgery. Statistical analysis was done using the paired t-test and student t-test. A P value of < 0.05 was considered significant.

RESULTS

The increase in all nasal and temporal AS-OCT angle parameters was found to be statistically significant in all three groups (P=0.000). There was a positive correlation found between ACA and the other angle parameters (AOD500, TISA500) in both quadrants (P=0.000). Increase in ACA was significantly more in those who underwent small incision cataract surgery (SICS). The type of IOL material (acrylic or PMMA) did not affect postoperative change in angle parameters.

CONCLUSION

There is a significant anterior chamber deepening post cataract surgery irrespective of the type of surgery or the IOL material.

KEYWORDS

Anterior Segment Optical Coherence Tomography; AS-OCT; Anterior chamber angle; Cataract surgery.

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BACKGROUND

Cataract is the most common cause of visual impairment.[1] In India, cataract constitutes half of an estimated nine to twelve million cases of blindness.[2] Cataract surgery is an important health care expenditure[3] but a very cost effective public health intervention.[4] Following cataract surgery, the anterior chamber angle (ACA) widens. The current clinical reference standard for measuring ACA is gonioscopy, but it is invasive and assessments are subjective. AS-OCT is a popular non-contact ACA imaging technique. We quantified the angle changes following cataract surgery using AS-OCT and studied if the type of surgery or IOL material affected this postoperative change.

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MATERIALS AND METHODS

This was a prospective, observational study. The sample size was determined by the number of cases attending the outpatient Department of Ophthalmology of a tertiary care hospital in North India from December 2014 to May 2016. We enrolled 150 consecutive patients who underwent uncomplicated cataract extraction surgery with in-the-bag IOL implantation. They were divided into three groups of 50 eyes each:

Group 1-

Those undergoing phacoemulsification with PMMA lens implantation

Group 2-

Those undergoing phacoemulsification with acrylic lens implantation

Group 3-

Those undergoing small incision cataract surgeries (SICS) with PMMA lens implantation.

The exclusion criteria were-

- Patients with anterior segment pathology other than cataract.
- Patients with prior history of corneal or glaucoma surgery.
- Patients with glaucoma/ ocular hypertension at the time of surgery.
- AS-OCT scans of signal strength less than 6 or where the scleral spur was not clearly identified.
- Operated patients who did not follow up at 2 weeks.

Patients were examined one day prior to cataract surgery and two weeks after surgery. All cases underwent complete ophthalmological examination including presenting visual acuity by Snellen's chart, intraocular pressure (IOP) measurement by Goldmann applanation tonometer and an anterior segment examination which was performed using a slit lamp biomicroscope. Anterior segment scanning was done using Nidek RS-3000 Lite OCT (Nidek, Japan) with its anterior segment adaptor for all eyes under identical ambient lighting conditions with undilated pupils. In each eye, AS-OCT measurements of the anterior chamber angle were performed using radial scans with scan length of 4.0 mm. Each scan was repeated five times and the best image was then considered for the study. Anterior chamber parameters - anterior chamber angle (ACA), angle opening distance at 500 µm anterior to scleral spur (AOD 500) and trabecular-iris space area at 500 µm anterior to scleral spur (TISA 500) - were analysed for both nasal (at 0°) and temporal (at 180°) quadrants. All the measurements were performed by a single observer.

On AS-OCT, the ACA is defined by its arms consisting of the posterior cornea and the opposite iris surface, with the apex located in the angle recess. The AOD represents the distance from the posterior surface of the cornea to the anterior iris, perpendicular to a line drawn along the trabecular meshwork 500 µm anterior to the scleral spur. The TISA is bounded anteriorly by the AOD, posteriorly by a line drawn from the scleral spur perpendicular to the plane of the inner scleral wall to the opposing iris, superiorly by the inner corneoscleral surface and inferiorly by the iris surface.

Cataract extraction surgery (phacoemulsification, SICS) was performed by a single surgeon to avoid bias due to operating technique.

To study the effect of IOL material on postoperative increase in angle parameters, the groups 1 and 2, where patients underwent same surgery but different IOL implantations (i.e., PMMA and acrylic IOLs), were analysed. Similarly, to assess the effect of surgery on postoperative change in angle parameters, comparison was done between groups 1 and 3 wherein group 1 patients underwent phacoemulsification with PMMA IOL implantation and group 3 patients underwent SICS with PMMA implantation.

Statistical Analysis

The data was entered in Microsoft Excel and analysed using SPSS (Statistical Package for Social Sciences) software version 21 (SPSS Inc., Chicago, IL, USA)**.** Statistical analysis for parametric variables was done using the paired t-test and student t-test. Significance level was set at $p<0.05$.

RESULTS

We enrolled 166 patients of which 16 patients were lost to follow up/ had late follow up and 150 patients had complete data on all variables. The mean age of the patients in our study was 59.35 ± 9.38 years (range 25 – 82 years). There were 82 men and 68 women in our study (M: F ratio= 1.2: 1). The age and gender distributions were comparable in all three groups in our study. On overall analysis, the most common type of cataract that was operated upon was nuclear sclerosis (36.7%) followed by posterior subcapsular cataracts (28.7%).

On AS-OCT, all nasal and temporal angle parameters (i. e, ACA, AOD500, TISA500) were found to significantly increase following cataract surgery with IOL implantation in all three groups. (Tables 1 and 2)

AS-OCT Angle Parameter	Quadrant	Group 1 Mean	Group 2 Mean	Group 3 Mean
ACA (degrees)	Nasal Pre-op	26.73 ± 4.90	23.85 ± 6.68	26.69 ± 6.93
	Post-op	36.67 ± 4.99	37.33 ± 6.38	40.04 ± 6.81
	Temporal Pre-op	26.15 ± 5.09	24.59 ± 6.25	26.44 ± 6.95
	Post-op	36.95 ± 4.99	37.17 ± 6.34	39.52 ± 6.79
AOD500 (µ)	Nasal Pre-op	485.04 ± 145.31	426.62 ± 161.80	514.16 ± 169.93
	Post-op	729.96 ± 12.54	682.90 ± 179.18	800.52 ± 200.16
	Temporal Pre-op	479.30 ± 125.32	425.80 ± 141.46	496.54 ± 175.50
	Post-op	753.34 ± 145.31	697.78 ± 190.41	814.28 ± 221.08
TISA500 (mm^2)	Nasal Pre-op	0.18 ± 0.05	0.16 ± 0.06	0.19 ± 0.07
	Post-op	0.28 ± 0.07	0.25 ± 0.07	0.29 ± .09
	Temporal Pre-op	0.18 ± 0.05	0.16 ± 0.05	0.18 ± 0.07
	Post-op	0.28 ± 0.06	0.26 ± 0.08	0.30 ± 0.08

Table 1. Mean Angle Parameters in the Three Groups

*ACA- Anterior chamber angle, AOD500- Angle opening distance at 500µm from scleral spur, TISA500- Trabecular iris space area at 500µm from scleral spur.

Group	AS-OCT Angle Parameter	Difference (post-op mean – pre-op mean)	P value
Group 1	Nasal ACA (degrees)	9.93 ± 3.73	0.000
	Temporal ACA (degrees)	10.80 ± 4.44	0.000
	Nasal AOD (μ)	244.92 ± 122.97	0.000
	Temporal AOD (μ)	274.04 ± 124.93	0.000
	Nasal TISA (mm^2)	0.09 ± 0.05	0.000
	Temporal TISA (mm^2)	0.10 ± 0.06	0.000
Group 2	Nasal ACA (degrees)	13.47 ± 5.64	0.000
	Temporal ACA (degrees)	12.58 ± 5.28	0.000
	Nasal AOD (μ)	256.28 ± 134.46	0.000
	Temporal AOD (μ)	271.98 ± 140.57	0.000
	Nasal TISA (mm^2)	0.09 ± 0.05	0.000
	Temporal TISA (mm^2)	0.10 ± 0.05	0.000
Group 3	Nasal ACA (degrees)	13.35 ± 5.60	0.000
	Temporal ACA (degrees)	13.08 ± 6.50	0.000
	Nasal AOD (μ)	286.36 ± 160.18	0.000
	Temporal AOD (μ)	317.74 ± 206.77	0.000
	Nasal TISA (mm^2)	0.10 ± 0.06	0.000
	Temporal TISA (mm^2)	0.11 ± 0.07	0.000

Table 2. Change in the Mean Angle Parameters in the Three Groups

*ACA- Anterior chamber angle, AOD500- Angle opening distance at 500μm from scleral spur, TISA500- Trabecular iris space area at 500μm from scleral spur

The ACA showed positive correlation with AOD500 in the corresponding quadrants in all three groups. A similar positive correlation was noted between the corresponding ACA and TISA500 values in all three groups. All values were statistically significant (P=0.000). (Table 3)

	Group 1		Group 2		Group 3	
	ACA		ACA		ACA	
	Nasal	Temporal	Nasal	Temporal	Nasal	Temporal
AOD500	0.836	0.831	0.907	0.910	0.926	0.921
TISA500	0.796	0.830	0.853	0.864	0.877	0.879

Table 3. Correlation Coefficients of Preoperative Angle Parameters in the Nasal and Temporal Quadrants in the Three Groups

*ACA- Anterior chamber angle, AOD500- Angle opening distance at 500μm from scleral spur, TISA500- Trabecular iris space area at 500μm from scleral spur.

To study the effect of IOL material on postoperative increase in angle parameters, the groups 1 and 2 were analysed. Statistical significance was tested by applying t-test for independent samples. The difference in the nasal ACA deepening was statistically significant between groups 1 and 2 (P=0.000). However, all other angle parameters, i.e. temporal ACA, nasal and temporal AOD500, nasal and temporal TISA500, did not show any statistically significant differences in the two groups. Hence, the difference in nasal ACA could be an incidental finding. (Table 4)

Angle Parameter	Group 1 Mean Change	Group 2 Mean Change	Mean diff ± SE diff	P value
Nasal ACA	9.93 ± 3.73	13.47 ± 5.64	-3.54 ± 0.96	0.000
Temporal ACA	10.80 ± 4.44	12.58 ± 5.28	-1.78 ± 0.97	0.071
Nasal AOD500	244.92 ± 122.97	256.28 ± 134.46	-11.36 ± 25.77	0.660
Temporal AOD500	274.04 ± 124.93	271.98 ± 140.57	+2.06 ± 26.60	0.938
Nasal TISA500	0.09 ± 0.05	0.09 ± 0.05	0.0036 ± 0.011	0.740
Temporal TISA500	0.10 ± 0.06	0.10 ± 0.05	0.0030 ± 0.011	0.792

Table 4. Effect of IOL Material on Postoperative Change in Angle Parameters

*ACA- Anterior chamber angle, AOD500- Angle opening distance at 500μm from scleral spur, TISA500- Trabecular iris space area at 500μm from scleral spur

To determine the effect of surgery on postoperative change in angle parameters, comparison was done between groups 1 and 3. Statistical significance for surgery type was assessed by applying t-test for independent samples. The differences in the nasal ACA and temporal ACA were statistically significant between group 1 and 3 (P=0.001). However, all other angle parameters, i.e., nasal and temporal AOD500, nasal and temporal TISA500, did not show any statistically significant differences in the two groups. (Table 5)

Angle Parameter	Group 1 Mean Change	Group 3 Mean Change	Mean diff ± SE diff	P value
Nasal ACA	9.93 ± 3.73	13.35 ± 5.60	-3.42 ± 0.95	0.001
Temporal ACA	10.80 ± 4.44	13.08 ± 6.50	-2.27 ± 1.11	0.044
Nasal AOD500	244.92 ± 122.97	286.36 ± 160.18	-41.44 ± 28.56	0.150
Temporal AOD500	274.04 ± 124.93	317.07 ± 206.77	-43.70 ± 34.16	0.204
Nasal TISA500	0.09 ± 0.05	0.10 ± 0.06	-0.0048 ± 0.012	0.688
Temporal TISA500	0.10 ± 0.06	0.11 ± 0.07	-0.0107 ± 0.013	0.425

Table 5. Effect of Surgery Type on Postoperative Change in Angle Parameters

*ACA- Anterior chamber angle, AOD500- Angle opening distance at 500µm from scleral spur, TISA500- Trabecular iris space area at 500µm from scleral spur

DISCUSSION

AS-OCT is based on low coherence interferometry and enables capture of high-resolution images. It allows for rapid image acquisition in a non-contact manner and has low potential for mechanical distortion of the angle structures.[5] There is good inter-session and inter-operator reproducibility as well.[6-8]

The angle parameters considered in our study on AS-OCT were the ACA, AOD500 and TISA500, each measured for both nasal and temporal quadrants. With reference to our study objectives, we found that the angle widths increased after surgery in all three groups. The mean ACA increased by 37.15% in the nasal quadrant and by 41.3% in the temporal quadrant in group 1, 56.48% and 51.16% in the nasal and temporal quadrants respectively in group 2 and 50.02% and 49.47% in the nasal and temporal quadrants respectively in group 3.

Our results are comparable to a study done by Kim et al[5] where AS-OCT was used to assess the change in angle parameters after phacoemulsification surgery with acrylic IOL implantation in 45 Korean subjects, although the postoperative period of evaluation was different in their study (i.e., at the second postoperative day). Kucumen et al also studied 47 eyes of Turkish patients with AS-OCT following phacoemulsification with acrylic IOL implantation.[9] Even though our preoperative AS-OCT angle parameters were comparable to those in their study, the postoperative angle parameters were higher in their study. This may be explained by the fact that their postoperative assessment was done at one month whereas ours was done at two weeks postop.

A retrospective gonioscopic analysis by Cetinkaya et al of the effect of phacoemulsification on the anterior segment anatomy of 112 patients (112 eyes) with cataract and ocular hypertension found that the preoperative iridocorneal angle (ICA) of 2.85 ± 0.75 (Shaffer's grade 2-4) deepened to a significant postoperative mean of 3.46 ± 0.50 (grade 3-4) in the first week and 3.60 ± 0.49 in the first month. However, they found that the postoperative ICA in the second year (2.89 ± .73) was not significant.[10]

Most cataractous lenses are thicker than normal lenses.[11] Kurimoto et al hypothesised that the UBM finding of the backward movement of the iris after cataract removal suggested that the iris shifted away from the anterior wall of the anterior chamber after surgery and thus, deepened the anterior chamber and widened the angle.[12] This would explain why the angle parameters increase after cataract surgery.

In addition to the postoperative change in angle parameters, we also studied the correlation between different angle parameters on AS-OCT. There was a statistically significant positive correlation between ACA and the other angle parameters (AOD500 and TISA500). This finding is similar to the correlation test done by Kim et al where they also found a positive correlation between ACA and the other standardized angle parameters (AOD500, AOD750, TISA500, TISA750).[5]

Further, we analysed if the changes in anterior chamber parameters post-surgery were influenced by the type of surgery, viz, phacoemulsification or SICS. This was done by comparing anterior chamber parameters in groups 1 and 3, where both groups had PMMA IOL implantation but different surgeries. It was found that the type of surgery affected the postoperative increase in both nasal and temporal ACA (P=0.001 and P=0.044 respectively) in a statistically significant manner. Our study showed that the increases in the anterior chamber parameters AOD500 and TISA500 post cataract surgery were similar in both the groups. However, change in nasal and temporal ACA was significantly more in group 3 (SICS) than in group 1. This could be explained by the fact that the cataracts in group 3 (SICS) were more mature than those in group 1 (phacoemulsification) and therefore resulted in greater anterior chamber deepening after surgery.

The deepening of the anterior chamber and widening of the ACA are consequences of the cataract removal and not actuated by the surgeries (SICS and phacoemulsification) themselves. Since both surgeries do not cause any direct physical alteration to the anterior chamber angle structures, we believe this explains why the type of surgery does not

have a statistically significant effect on the change in angle parameters following surgery.

We analysed if the type of IOL material was responsible for the change in angle parameters postoperatively. This was done by comparing the change in angle parameters between groups 1 and 2, where both groups underwent phacoemulsification surgery but different IOL implantations (acrylic or PMMA IOLs). Although there was a statistically significant increase in nasal ACA postoperatively (P=0.000), the other angle parameters, namely, the temporal ACA, the nasal and temporal AOD500, the nasal and temporal TISA500, showed postoperative increase which were not statistically significant. Hence, the change in nasal ACA with IOL material may be an incidental finding.

Behrouz et al believed that the increase in ACD, ACA and anterior chamber volume (ACV) values post cataract surgery occurred because the implanted IOL is thinner compared to the crystalline lens.[13] In cataract surgery, changes in the anterior chamber are affected by the replacement of a cataractous lens with a relatively thinner IOL. This would explain why the type of IOL material does not influence the difference in AC parameters post-surgery. There are not many studies that have compared anterior chamber angle changes following cataract surgery with IOL implantation using AS-OCT. Even though we used the AS-OCT to objectively measure the angle changes in our patients, a potential limitation of this study was its small sample size.

CONCLUSION

There is a significant anterior chamber deepening post cataract surgery irrespective of the type of surgery and IOL material. All the AS-OCT parameters show a significant increase postoperatively and there is a positive correlation between ACA and the other parameters, i.e., AOD500 and TISA500 in their corresponding quadrants as well. Although the postoperative angle parameters increase was significantly more with SICS than with phacoemulsification, it may not be clinically relevant. The type of IOL material did not have any significant effect on the postoperative angle parameters.

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