Original Research Article

A comparative analysis of morphometric changes in the angle of anterior chamber after cataract surgery

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ABSTRACT

Background: Cataract surgery brings about certain changes in the angle of anterior chamber and we aimed at understanding the morphometric changes occurring in the angle at the site of incision (SOI) and the site opposite to it (OSOI) after two types of cataract surgeries viz. phacoemulsification and manual small incision cataract surgery (SICS) at two postoperative follow-ups.
Methods: A quasi-experimental study was conducted at AIIMS, Rishikesh and a minimum of 60 patients were enrolled. They were divided into two groups based on the surgery performed, 30 patients had undergone phacoemulsification (group A) and 30 patients had undergone SICS (group B). The patients were evaluated using optical coherence tomography (OCT), the parameters measured were central anterior chamber depth (ACD), anterior chamber angle (ACA), angle opening distance (AOD), and trabecular iris surface area (TISA). The subjects were assessed preoperatively, post-operatively at 1 week and 6 weeks.
Results: The increase in the angle parameters at 1 week and 6 weeks post-operatively was found to be statistically significant in the two groups (p<0.05). The increase in the parameters was also compared between the two surgeries and was found to have no statistical difference.
Conclusions: We were able to conclude that a simple cataract extraction can help treat two most common causes of blindness, cataract and glaucoma and the technique of cataract surgery used does not influence the change brought about in the angle.

Keywords: Morphometric angle parameters, Cataract surgery, ASOCT, Small incision cataract surgery, SICS

INTRODUCTION

Cataract and glaucoma are both common eye disorders in the elderly. Over the past century, the burden of these diseases is increasing and is expected to rise further. There are more than 60 million cases of glaucoma worldwide with a prevalence of 2.65% in people above 40 years of age and is estimated to increase to 80 million by 2020. Hence, the anatomical anomalies of the iridocorneal angle that can cause impeded drainage of aqueous humour and increased intraocular pressure (IOP) is of utmost importance.[1-4]

Several methods are currently available for assessing anterior segment pathology and quantification of angle configuration. Among them gonioscopy is still considered to be the gold standard method but is limited by intra-observer bias.[5] Optical coherence tomography (OCT) is a relatively newer technique to join the league of tools available for detailed anterior segment imaging. It provides cross-sectional imaging of the anterior chamber along with higher spatial resolution simultaneously offering easy and rapid quantification. It does not require any contrast, contact or immersion techniques. It also provides good repeatability and reproducibility with low

intra-observer and inter-observer variation.[6,7] The use of OCT for anterior segment imaging was described for the first time in 2001 where a spectral-domain OCT (SDOCT) with a light source at a wavelength of 1310 nm was used.[8]

Cataract with IOL implantation has found to widen and deepen the anterior chamber by creating more space. During cataract surgery, infusion and aspiration is performed wherein balanced salt solution (BSS) can remove plaque materials from the angle and trabecular meshwork. This water-jet can be strong enough to alter the angle structure. Moreover, previous studies have emphasized that during removal of viscoelastic material, several depositions including pseudoexfoliative material can be removed from the angle which in turn can improve drainage.[9]

In this study, we have assessed the morphometric changes occurring in the angle of anterior chamber after two different types of cataract surgery, i.e. phacoemulsification and manual SICS at 1 week and 6 weeks postoperatively so as to understand postoperative changes after cataract surgery and also to draw a comparison between the two types of cataract surgery. To the best of our knowledge this is the only study to use two postoperative follow-ups for assessing the changes in the angle of anterior chamber.

METHODS

This was a quasi-experimental prospective study conducted at Department of Ophthalmology of All India Institute of Medical Sciences (AIIMS) Rishikesh, India from January 2018 to May 2019. The study was approved by the institutional ethics committee (AIIMS/IEC/18/129) and adhered to tenets of declaration of Helsinki.

A total of 77 patients above the age of 40 years who were undergoing cataract surgery (phacoemulsification and manual SICS) were enrolled in this study. Patients with glaucoma, previous intraocular surgery, or other intraocular pathology were excluded from the study. Those who had systemic illnesses such as diabetes, hypertension, connective tissue disorders, thyroid disorders and malignancies were also excluded. Patients with axial length between less than 21mm and more than 26mm were excluded from the study (verified using lenstar optical biometer (LS 900)). Among the 77 patients enrolled, 12 were lost to follow-up and hence were excluded from the study. Five patients, whose preoperative assessment was done but underwent complicated surgery were also excluded. A total of 60 patients were divided into 2 groups based on the type of cataract surgery they were undergoing – group A consisted of 30 patients who were undergoing phacoemulsification with foldable lens implantation, and group B consisted of 30 patients who were undergoing small incision cataract surgeries (SICS) with PMMA lens implantation.

The type of surgery was decided based on the patient's preference for PMMA lens or a foldable IOL. The grades of cataract operated in both the groups were almost similar. Both group A and B patients had undergone pre-operative routine ophthalmological evaluation including visual acuity, tonometry, slit-lamp biomicroscopy, retinoscopy, keratometry and fundoscopy. All the surgeries were performed by a single surgeon in identical conditions with peribulbar anaesthesia. Group A patients who underwent phacoemulsification with foldable IOL implantation were operated through a 2.75 mm temporal clear corneal incision using Alcon INFINITI®. The corneal incision was not sutured. Group B patients who underwent manual SICS was operated by making a 6 mm frown shaped scleral incision 1.5 mm from the limbus through which a sclera-corneal tunnel was made. No sutures were placed. In all the patients, the IOL was implanted in the bag.

All the patients were subjected to AS-OCT (cirrus HD-OCT 500) preoperatively and postoperatively at 1 week and 6 weeks by the same observer, under identical lighting conditions with undilated pupils. Images of the site of incision (superior) and the site 180 opposite to it (inferior) were captured until the centration and quality were sufficient for analysis. The anterior chamber parameters that were recorded included– central anterior chamber depth (ACD), anterior chamber angle (ACA), angle opening distance anterior to scleral spur at 500 μm and 750 μm (AOD 500, AOD 750), and trabecular-iris space area anterior to scleral spur at 500 μm and 750 μm (TISA 500, TISA 750).

Data analysis

Data was analyzed using statistical package for social sciences (SPSS) version 21, IBM Inc. Descriptive data was reported for each variable. Descriptive statistics such as mean and standard deviation for continuous variables and frequency along with percentages of categorical variables were calculated.

Shapiro Wilk test was used to check which all variables were following normal distribution. Data was found to be normally distributed (p value was more than 0.05). Therefore, bivariate analyses was performed using the parametric tests i.e. independent t test (for comparing two independent groups) and paired t test for comparing two dependent groups. Chi square test was used for frequency analysis. Level of statistical significance was set at p value less than 0.05.

RESULTS

A total of 60 patients were analyzed in the study. 30 had undergone phacoemulsification cataract surgery (group A) and 30 had undergone manual small incision cataract surgery (group B). In group A, there were 13 females and 17 males whose mean age was 61.77 years (standard deviation 11.554 years) while in group B there were 12

females and 18 males whose mean age was 63.13 years (standard deviation 11.895 years).

All the angle parameters showed an increase from preoperative to postoperative 1 week and preoperative to postoperative 6 weeks in both the surgeries. These changes were found to be statistically significant (p<0.05) at the site of incision and also at the site opposite to it. There was an increase from 1 week to 6 weeks however, this change was not statistically significant in both the surgeries (Table 1 and 2).

The parameters appear to show a rise till 1 week and later they appear to have reached a plateau (Figure 1). The parameters to show maximum increase were ACD, TISA and AOD. At the site of incision in group 1 ACD showed an increase of 42.55% while opposite to the site of incision TISA 750 showed an increase of 37.38%. In group 2, AOD 500 had an increase of 76.27% at the site of incision while opposite to the site of incision TISA 750 showed an increase of 50.47%.

After evaluating and comparing the change in the parameters between the two groups, it was found that the two surgeries, phacoemulsification and manual SICS have a similar effect on the angle. There was no statistical significance in the increase of the parameters brought about by the two surgeries (p>0.05) (Table 3 and 4).
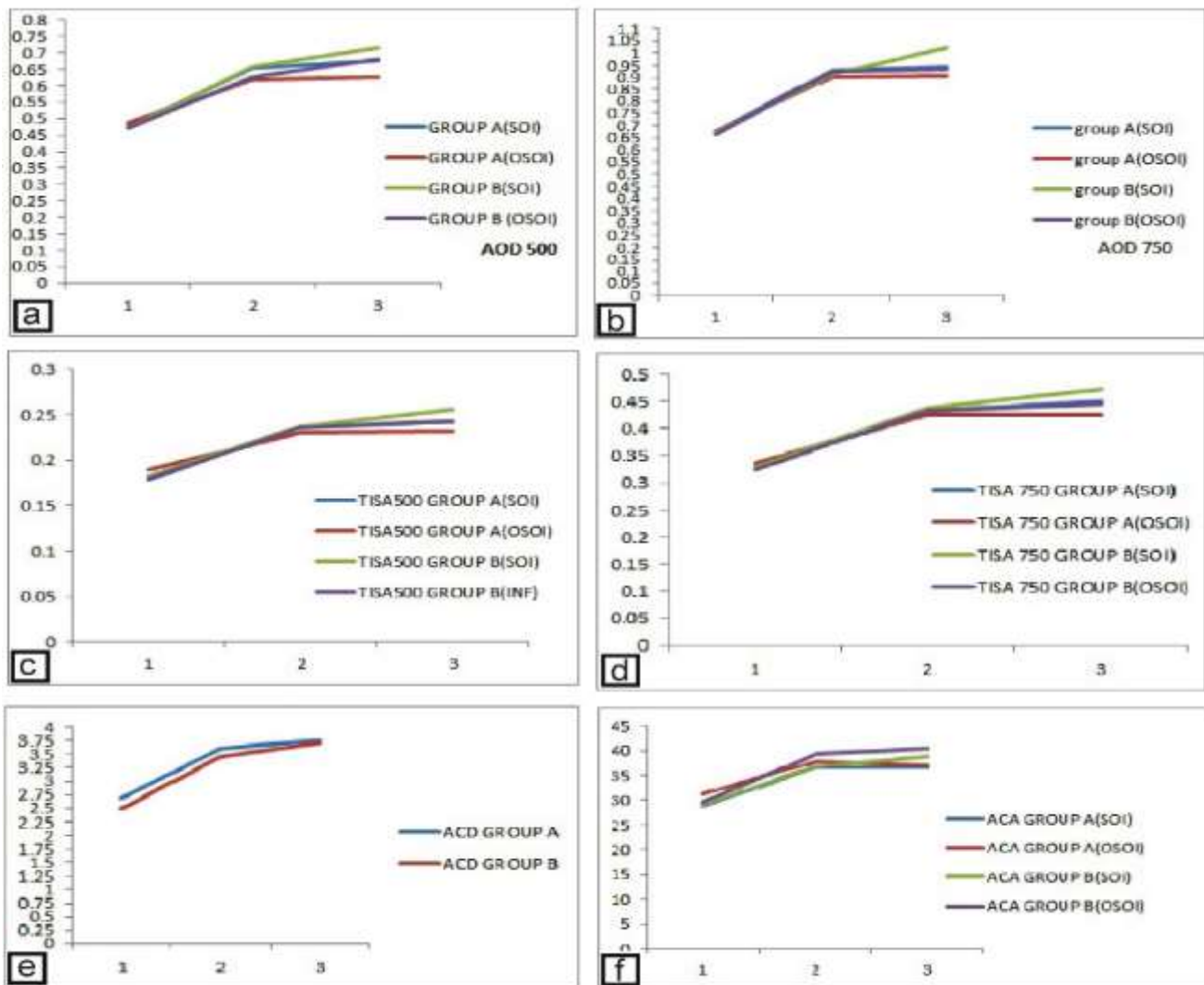

Figure 1: The trend of increase in the OCT parameters at 1 week and 6 weeks in group A and B; a) AOD 500 shows a steady rise up till 1 week as indicated by the slope and after 1 week the increase tends to reach a plateau both at the site of incision (SOI and opposite to the site of incision (OSOI) in, b) AOD 750 shows a steady rise up till 1 week as indicated by the slope and after 1 week the increase tends to reach a plateau, c) TISA 500 shows a steady rise up till 1 week as indicated by the slope and after 1 week the increase tends to reach a plateau at SOI and OSOI, d) TISA 750 shows a steady rise up till 1 week as indicated by the slope and after 1 week the increase tends to reach a plateau at SOI and OSOI, e) central ACD also shows a similar trend as the above parameters with a rising slope till 1 week followed by a plateau between 1 week and 6 weeks, f) ACA also has a similar graph as the above parameters with a slope up till 1 week followed by a plateau both at SOI and OSOI.

Table 1: Group A phacoemulsification - site of incision and opposite to site of incision: showing the comparison between the increase in angle parameters from preoperative (marked as 1), postoperative 1 week (marked as 2) and postoperative 6 weeks (marked as 3) which was found to be statistically significant (p<0.001).

Comparison	Mean	P value	Post hoc pair wise comparison	% change
Site of incision				
AOD 500 (mm)				
Pre-operative	0.477±0.140	<0.001*	1-2*	26.9
1 week	0.652±0.146		1-3*	
6 weeks	0.676±0.140		2-3	
AOD 750 (mm)				
Pre-operative	0.675±0.184	<0.001*	1-2*	28.66
1 week	0.927±0.196		1-3*	
6 weeks	0.943±0.234		2-3	
ACA (°)				
Pre-operative	28.83±8.02	<0.001*	1-2*	21.41
1 week	36.67±7.83		1-3*	
6 weeks	36.83±6.29		2-3	
TISA 500 (mm^2)				
Pre-operative	0.178±0.0470	<0.001*	1-2*	25.29
1 week	0.237±0.046		1-3*	
6 weeks	0.243±0.039		2-3	
TISA 750 (mm^2)				
Pre-operative	0.328±0.082	<0.001*	1-2*	24.05
1 week	0.433±0.085		1-3*	
6 weeks	0.450±0.086		2-3	
ACD (mm)				
Pre-operative	2.69±0.397	<0.001*	1-2*	42.55
1 week	3.60±0.199		1-3*	
6 weeks	3.77±0.251		2-3	
Opposite to site of incision				
AOD 500 (mm)				
Pre-operative	0.488±0.140	<0.001*	1-2*	19.89
1 week	0.617±0.126		1-3*	
6 weeks	0.625±0.123		2-3	
AOD 750 (mm)				
Pre-operative	0.671±0.192	<0.001*	1-2*	15.55
1 week	0.902±0.169		1-3*	
At 6 weeks	0.907±0.161		2-3	
ACA (°)				
Pre-operative	31.4±8.42	<0.001*	1-2*	13.64
1 week	37.9±6.15		1-3*	
At 6 weeks	37.1±5.81		2-3	
TISA 500 (mm^2)				
Pre-operative	0.190±0.044	<0.001*	1-2*	60.5
At 1 week	0.230±0.0384		1-3*	
At 6 weeks	0.231+ 0.0345		2-3	
TISA 750 (mm^2)				
Pre-operative	0.337±0.0818	<0.001*	1-2*	37.38
At 1 week	0.426±0.075		1-3*	
At 6 weeks	0.426±0.067		2-3	

All statistically significant comparisons have been marked with an astrix (*) and the anterior chamber depth (ACD) mentioned is central ACD

Table 2: Group B SICS site of incision and opposite to site of incision: showing the comparison between the increase in angle parameters from preoperative (marked as 1), postoperative 1 week (marked as 2) and postoperative 6 weeks (marked as 3) which was found to be statistically significant (p<0.001).

Comparison	Mean	P value	Post hoc pairwise comparison	% change (preoperative to postoperative 6 weeks)
Site of incision				
AOD 500 (mm)				
Pre-operative	0.472±0.129		1-2*	
At 1 week	0.658±0.158	<0.001*	1-3*	76.27
At 6 weeks	0.715±0.124		2-3	
AOD 750 (mm)				
Pre-operative	0.667±0.176		1-2*	
At 1 week	0.912±0.224	<0.001*	1-3*	29.39
At 6 weeks	1.023±0.209		2-3	
ACA(°)				
Pre-operative	29.07±6.77		1-2*	
At 1 week	36.93±7.1	<0.001*	1-3*	24.23
At 6 weeks	38.83±5.56		2-3	
TISA 500 (mm^2)				
Pre-operative	0.183±0.042		1-2*	
At 1 week	0.237±0.054	<0.001*	1-3*	44.18
At 6 weeks	0.255±0.036		2-3	
TISA 750 (mm^2)				
Pre-operative	0.329±0.076		1-2*	
At 1 week	0.439±0.099	<0.001*	1-3*	23.69
At 6 weeks	0.473±0.067		2-3	
ACD (mm)				
Pre-operative	2.487±0.528		1-2*	
At 1 week	3.458±0.504	<0.001*	1-3*	54.79
At 6 weeks	3.707±0.331		2-3	
Opposite to site of incision				
AOD 500 (mm)				
Pre-operative	0.472±0.14		1-2*	
At 1 week	0.627±0.116	<0.001*	1-3*	22
At 6 weeks	0.681±0.13		2-3	
AOD 750 (mm)				
Pre-operative	0.665±0.196		1-2*	
At 1 week	0.921±0.163	<0.001*	1-3*	17.67
At 6 weeks	0.933±0.158		2-3	
ACA (°)				
Pre-operative	29.73±7.71		1-2*	
At 1 week	39.53±5.947	<0.001*	1-3*	24.52
At 6 weeks	40.37±6.435		2-3	
TISA 500 (mm^2)				
Pre-operative	0.179±0.05		1-2*	
At 1 week	0.236±0.038	<0.001*	1-3*	50.47
At 6 weeks	0.243±0.04		2-3	
TISA 750 (mm^2)				
Pre-operative	0.323±0.089		1-2*	
At 1 week	0.433±0.068	<0.001*	1-3*	29.68
At 6 weeks	0.444±0.076		2-3	

All statistically significant comparisons have been marked with an asterix (*) and ACD mentioned is the central anterior chamber depth

Table 3: Groupwise comparison of mean OCT parameters at the site of incision: the parameters have been compared between the two groups A and B at the site of incision, the increase in parameters in the two groups shows no statistical significant difference (p>0.05). Central ACD has also been compared between the two groups and the increase in ACD also showed no statistically significant difference between the two groups (p>0.05).

Comparison	Preoperative			Postoperative 1 week			Postoperative 6 week		
	Group	Mean	P	Mean		P	Mean		P
AOD 500 mm	A	0.477±+ 0.140	0.88	0.65±0.146		0.88	0.677±0141		0.27
	B	0.472±0.129		0.65±0.158			0.715±0.124		
AOD 750 mm	A	0.676±0.185	0.86	0.92±0.196		0.79	0.943±0.234		0.17
	B	0.667±0.176		0.91±0.224			1.02±0.209		
ACA (°)	A	28.8±8.02	0.90	36.7±7.83		0.89	36.8±6.29		0.19
	B	29.1±6.77		36.9±7.10			38.8±5.56		
TISA 500 mm²	A	0.178±0.047	0.71	0.237±0.046		1.0	0.243±0.037		0.22
	B	0.182±0.42		0.237±0.054			0.255±0.036		
TISA 750 mm²	A	0.329±0.082	0.99	0.432±0.085		0.80	0.449±0.086		0.25
	B	0.329±0.076		0.44±0.099			0.47±0.067		
ACD mm	A	2.69±0.398	0.09	3.61±0.199		0.04	3.76±0.251		0.44
	B	2.49±0.528		3.46±0.504			3.70±0.332		

Table 4: Groupwise comparison of mean OCT parameters –opposite to the site of incision: the parameters have been compared between the two groups A and B at the site of incision, the increase in parameters in the two groups shows no statistical significant difference (p>0.05). Central ACD has also been compared between the two groups and the increase in ACD also showed no statistically significant difference between the two groups (p>0.05).

Comparison	Group	Preoperative			Postoperative 1 week			Postoperative 6 week		
		Mean		P	Mean	SD	P	Mean	SD	P
AOD 500 (mm)	A	0.488±0.140		0.67	0.617±0.126		0.75	0.92±0.123		0.09
	B	0.472±0.140			0.627±0.116			0.92±0.129		
AOD 750 (mm)	A	0.671±0.192		0.90	0.902±0.169		0.65	0.541±0.161		0.54
	B	0.665±0.196			0.921±0.163			0.543±0.158		
ACA (°)	A	31.40±8.42		0.43	37.9±6.15		0.30	30.04±5.81		0.04
	B	29.73±7.71			39.53±5.95			31.04±6.44		
TISA (mm²)	A	0.190±0.044		0.37	0.230±0.038		0.55	0.243±0.035		0.23
	B	0.179±0.049			0.236±0.038			0.233±0.040		
TISA (mm²)	A	0.336±0.082		0.55	0.426±0.075		0.73	0.345±0.067		0.34
	B	0.323±0.089			0.433±0.068			0.343±0.076		
ACD (mm)	A	2.69±0.397		0.09	3.61±0.199		0.41	3.77±0.251		0.44
	B	2.49±0.528			3.46±0.504			3.71±0.332		

DISCUSSION

AS-OCT is light system based low coherence interferometry that enables rapid acquisition of high-resolution images in a non-contact manner. It has a very low potential for mechanical distortion of the angle structures making it idea for quantitative data analysis. The assessment of the angle by an OCT machine has been described as morphometric analysis of the angle parameters that is a semi-automatic method of evaluation of the angle of anterior chamber.[6,8,10-16]

With reference to our study objectives, we found that the angle parameters increased after surgery in both the groups. The mean ACA increased by 21.41% at the site of incision and by 13.64 % in the opposite site in group A (phacoemulsification), and in group B (SICS) 24.23% and 24.52% at the site of incision and the site opposite to it, respectively. These parameters showed an increase from preoperative values to postoperative 1 week and preoperative values to postoperative 6 weeks, which is likely to be attributed by the space created in the anterior chamber after cataract extraction. However, the increase from postoperative 1 week to 6 weeks was not statistically significant. We hypothesize that this may be because between 1 to 6 weeks the angle parameters were approaching stabilization and hence only minimal increase was present from 1 week to 6 weeks. The results are comparable to the study done by Kim et al who used an AS-OCT to assess the change in angle parameters after phacoemulsification, although the postoperative evaluation was done on the second postoperative day.[17]

The change in the angle parameters between group A and B was also compared. The increase in angle parameters in

both the groups was similar (no statistical significance) suggesting that in this aspect no surgery is superior to the other. This result was similar to the study conducted by Varghese on 150 eyes. However, in their study the increase in ACA was more in the SICS group in their study as compared to the phacoemulsification group. This could be explained by the fact that in their study cataracts operated with SICS were more mature (intumescent) than the other group.[18] While in our study the type of cataracts enrolled in both the groups were almost similar resulting in statistically similar deepening and widening of the anterior chamber. Both the surgeries (SICS and phacoemulsification) as such do not cause any direct physical alteration to the anterior chamber angle structures. Hence, this could be the reason that the type of surgery does not have a statistically significant effect on the changes occurring in angle parameters following cataract surgery.

Advanced cataracts are found to be associated with increased reactive oxygen species (ROS) in anterior chamber. These ROS can damage the cells of trabecular meshwork and Schlemm's canal by oxidative stress and they have also shown to increase the resistance of trabecular meshwork outflow due to high levels of hydrogen peroxide and it is possible that cataract extraction can bring down the levels of ROS in anterior chamber. Therefore, cataract extraction may be an effective adjuvant treatment for glaucoma.[19,20]

In this study quantification of angle parameters was also done and it was found that the parameter to show maximum increase at the site of incision in group B (SICS) was AOD 500 with an increase of 76.27% while at the opposite site of incision TISA 500 showed an increase of 50.47%. In group A (phacoemulsification) parameters to show maximum increase were AOD 750 (28.66%) and TISA 500 (60.5%) at the site of incision and at the site opposite to the site of incision respectively. However, it was not possible to determine which parameter is superior. Kim et al were able to demonstrate a high degree of correlation among all the angle parameters suggesting that these parameters are highly associated with each other and it was not possible in their study also to determine which parameter is superior. Hence, results from studies using different angle measurement techniques are likely have similar meanings.[17]

In this study, we were able to establish a positive effect of cataract surgery on the angle of anterior chamber which is independent of the type of cataract surgery and this effect peaks for sometime after surgery and then reaches a plateau. We were also able to establish that this effect is brought about in two quadrants that is, both at the site of incision and the site opposite to it. However, we were not able to describe which parameter (ACA, ACD, AOD and TISA) is superior to the others. Hence, a long term study might give us some insight about inter-parameter superiority and duration based variability of individual parameter.

By evaluating the angle parameters at 1 week and 6 weeks postoperatively, we were able to assess the nature of increase in the morphometric parameters i.e. they increase steadily up till 1 week and then stabilize. However, we are not able to comment whether this increase persists as it is or there is a slight decline in the long term, a study evaluating this change for an even greater postoperative period may be required to comment upon the long term status of the angle after cataract surgery.

Our study was not without limitations. We conducted a study in non-glaucomatous patients, outcome can be better evaluated in glaucomatous patients and IOP fluctuations can better be monitored in such patients. The duration of the study was only up till 6 weeks a longer duration can help evaluate the long term effects on the angles and also the angle parameters we chose are semi-automatic. There is a chance of error if the calliper is not placed correctly. Morphometric analysis requires placement of a 'calliper' on the sclera spur. However, the scleral spur is not visible in approximately 20% of cases which makes it difficult to place the calliper in such cases. Moreover, it is very difficult to locate the spur in the superior quadrant and inferior quadrants as they are covered by the eyelids.[15,16,21-23] Koprowski et al studied a new method of angle measurement, angle opening minimum (AOM) which is the shortest distance between all the points of the cornea and selected range of the iris. This method is free of the disadvantages described in the known methods as it is calculated automatically rather than being semi-automated. However, this method is yet to be incorporated in the OCT machines.[16]

CONCLUSION

Cataract surgery is a safe and cost effective treatment option and it should be considered in a patient who has both glaucoma and cataract. In patients with hard cataract and presenting to an ophthalmologist with glaucoma, simple cataract surgery may provide significant control. Anterior chamber optical coherence tomography is emerging as a valuable diagnostic tool that can provide valuable morphometric analysis of the anterior chamber.

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