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Anterior Segment Optical Coherence Tomography Changes after Phacoemulsification

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ABSTRACT
Background: phacoemulsification can cause changes in the anterior segment parameters that could be detected by anterior segment optical coherence tomography.
Purpose: To determine the changes in the anterior segment parameters and intraocular pressure after phacoemulsification (IOP).
Subjects and methods: A prospective, non-randomized study included twenty eyes with visually significant cataract that underwent phacoemulsification with foldable intraocular lens implantation (IOL). Complete ophthalmological examination and anterior segment optical coherence tomography (ASOCT) were performed before surgery and one month postoperatively.
Results: There were statistically significant differences in the anterior segment parameters after cataract surgery. The anterior chamber angle (ACA) at the temporal side before and one month after surgery were 22.58º ± 6.4º , 33.14 º ± 6.48º respectively ($p < 0.001$). The ACA at the nasal side before and one month after surgery were 23.33º ± 6.93º, 34.16º ± 6.99º respectively ($P< 0.001$).
Conclusion: Phacoemulsification with IOL implantation results in significant widening of the ACA proved by quantitative assessment of ASOCT imaging. At the same time it caused small but significant reduction in IOP.
Keywords: Phacoemulsification, anterior chamber angle, anterior segment optical coherence tomography.

INTRODUCTION
Cataract and glaucoma are considered the major causes of visual impairment in the world [(1)]. Phacoemulsification is one of the most frequent surgical techniques used for cataract removal [(2)]. In addition to restore vision, phacoemulsification has been shown to decrease intraocular pressure (IOP) in patients without glaucoma and in patients with glaucoma [(3)]. Because elevated IOP is the main risk factor in the development and progression of glaucoma, phacoemulsification cataract extraction with foldable intraocular lens implantation (IOL) has been implicated to treat both the first and the second leading causes of blindness in the world [(4)].

AIM OF THE WORK
To determine the changes in the anterior segment parameters and IOP following phacoemulsification cataract surgery.

SUBJECTS AND METHODS
A prospective, non-randomized comparative study was carried out at Al-Zahraa university hospital from 5/2016 to 12/2016.

An informed written consent was taken from each participant in the study. The study protocol adhered to the tenets of the Declaration of Helsinki and was approved by the Ethics Board of Al-Azhar University.

A total of twenty eyes with visually significant cataract, as the only cause of visual impairment, were selected from the outpatient clinic.

Exclusion criteria included:

- Eyes with prior penetrating ocular surgery
- Complications related to cataract removal, such as posterior capsular rupture and vitreous loss.
- Eyes with corneal abnormalities such as edema, abrasion or dystrophy, pterygium and other degenerative changes
- Eyes with peripheral anterior synechiae

Complete ophthalmic examination was performed preoperatively and one month postoperatively included the following; uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), IOP measurement by Goldmann applanation tonometry, slit-lamp examination (Haag-Streit, USA), biomicroscopic fundus examination with 90D lens if possible. Images of the anterior segment were obtained using a commercially available OCT device (Nidek 3000). Standard resolution scans captured the temporal and nasal quadrants (nasal-temporal 0˚-180˚) with participants looking straight ahead. All the images were taken with the patients in a sitting position. After several scans were acquired, we selected the best image.

For analysis, the scleral spur (SS) insertion landmark is located where the less reflective ciliary

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muscle contacts the more reflective sclera and angle parameters were automatically measured on the temporal and nasal side.

Angle parameters included

1. ACA (anterior chamber angle)
2. AOD (angle opening distance) 500, 750 [μm] which is defined as the length of a perpendicular line from the trabecular meshwork to the iris at a point (500) (750) μm from the SS.
3. TISA (trabecular iris space area) 500, 750 [μm^2] which is defined as the trapezoidal area with the following boundaries: anteriorly, the AOD 500 (750); posteriorly, a line drawn from the SS perpendicular to the plane of the inner scleral wall to the opposing iris; superiorly, the inner corneo-scleral wall; and inferiorly, the iris surface

All data were analyzed using statistical package for social science (SPSS). Quantitative variables were presented as mean (±standard deviation; SD). P value was interpreted non-significant if >0.05, significant if <0.05 and highly significant if <0.001.

RESULTS

The study comprised twenty eyes (male = 9 and female = 11). Mean age = 57.9 ± 10.9 years.

The intraocular pressures before and one month after surgery were 15.06±3.42and 10.52± 2.32mmHg respectively (P-value < 0.001; highly significant) (Table 1).

Table 1: changes in intraocular pressures (mean± SD) before, a week after, and a month after surgery.

	IOP					
	Range			Mean	±	SD
Pre-operative	10	-	20	15.06	±	3.42
One month post	7	-	15	10.52	±	2.32

The anterior chamber angle (ACA) at temporal side (mean± SD) before and one month after surgery were 22.58º ± 6.4º, 33.14º ± 6.48º respectively, P-value < 0.001 (highly significant) (Fig.1)

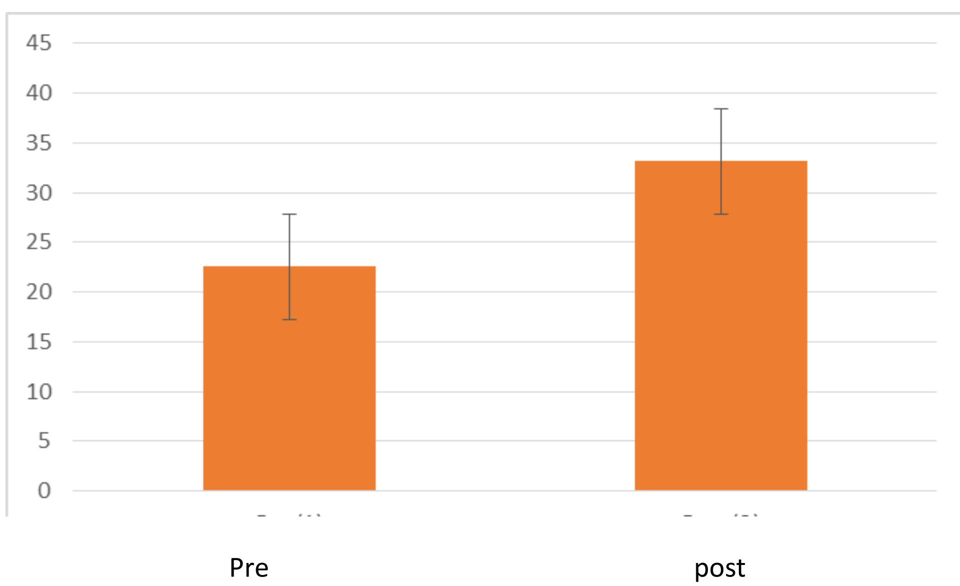

Fig. 1: Changes in anterior chamber angle (ACA) at temporal side before and a month after surgery.

The Anterior chamber angle (ACA) at nasal side before and one month after surgery were 23.33º ± 6.93º, 34.16º ± 6.99º respectively, P value < 0.001(highly significant) (Fig. 2).

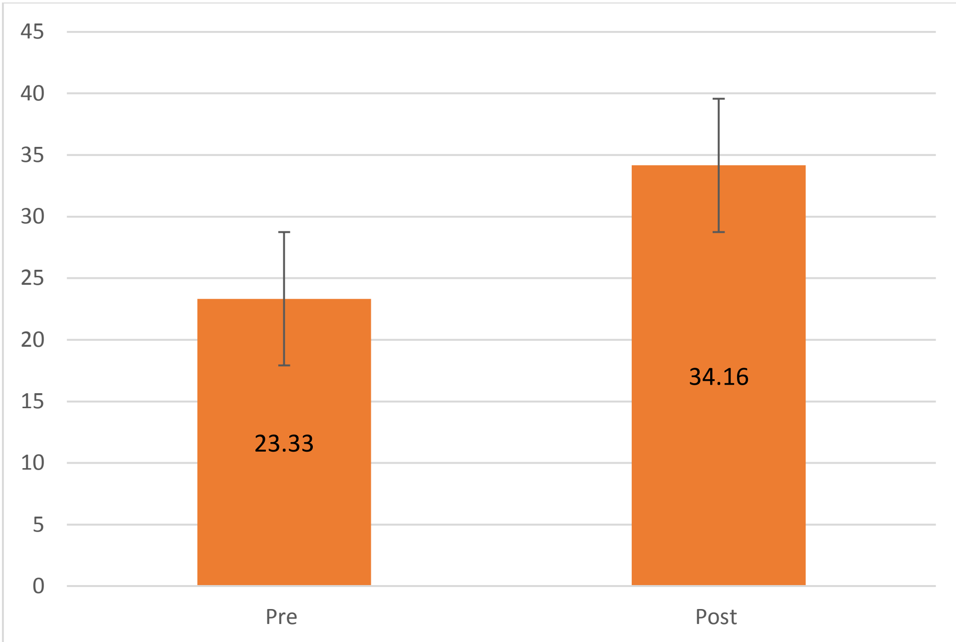

Fig. 2: Changes in anterior chamber angle (ACA) at nasal side before and a month after surgery.

The Trabecular iris spur area (TISA) at temporal side 500 µm from scleral spur before and one month after surgery were 0.20 ±0.12 mm^2, 0.28 ± 0.12 mm^2 respectively P value 0.009 (significant <0.05) (Fig. 3).

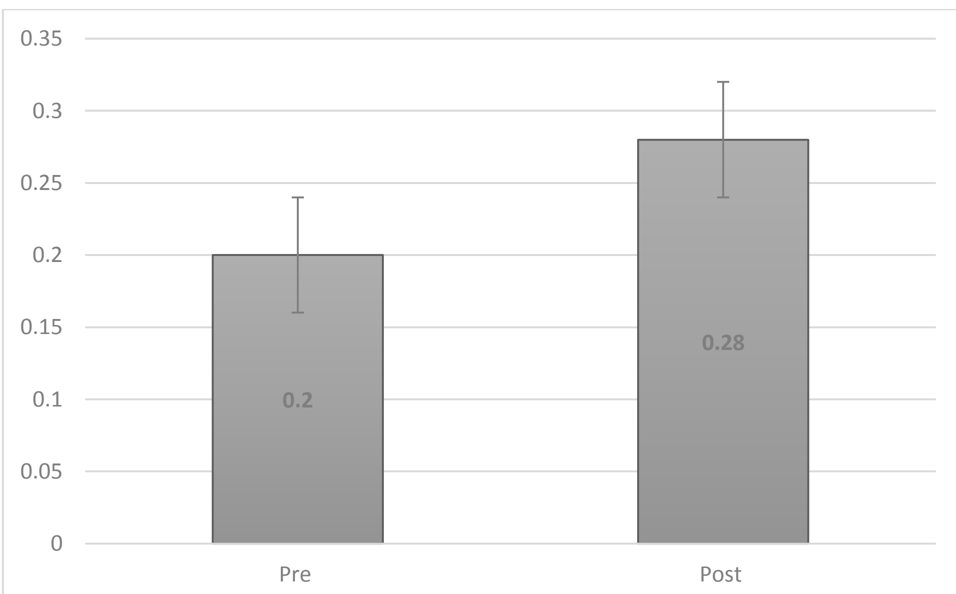

Fig. 3: Changes in Trabecular iris spur area (TISA) at temporal side 500 µm from scleral spur before and one month after surgery.

The Trabecular iris spur area (TISA) at temporal side 750 µm from scleral spur before and one month after surgery were 0.31±0.14 mm^2, 0.48 ± 0.20 mm^2 respectively P value < 0.001(highly significant) (Fig. 4).

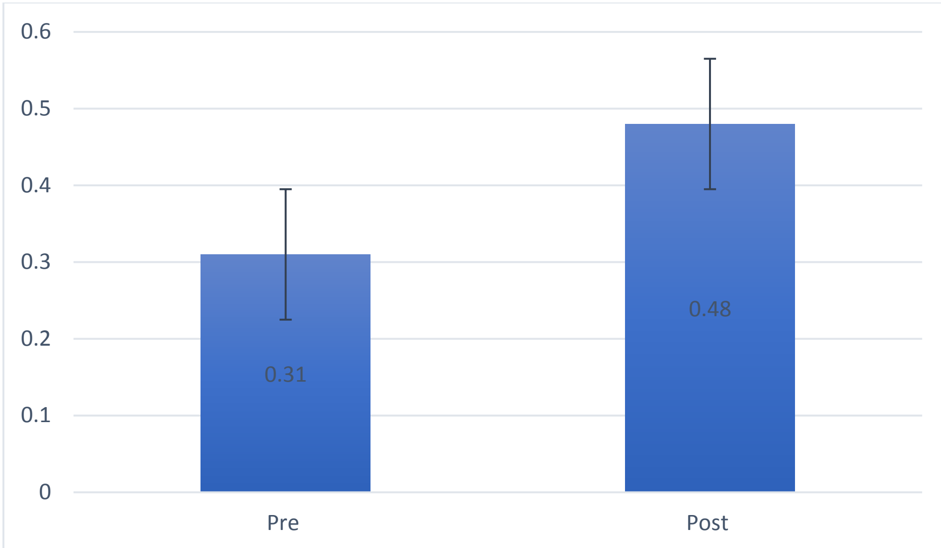

Fig. 4: Changes in TTISA at temporal side 750 µm from scleral spur before and one month after surgery.

The Trabecular iris spur area (TISA) at nasal side 500 µm from scleral spur before and one month after surgery were 0.16 ± 0.06 mm^2, 0.28 ± 0.13 mm^2 respectively P value < 0.001(highly significant) (Fig. 5).

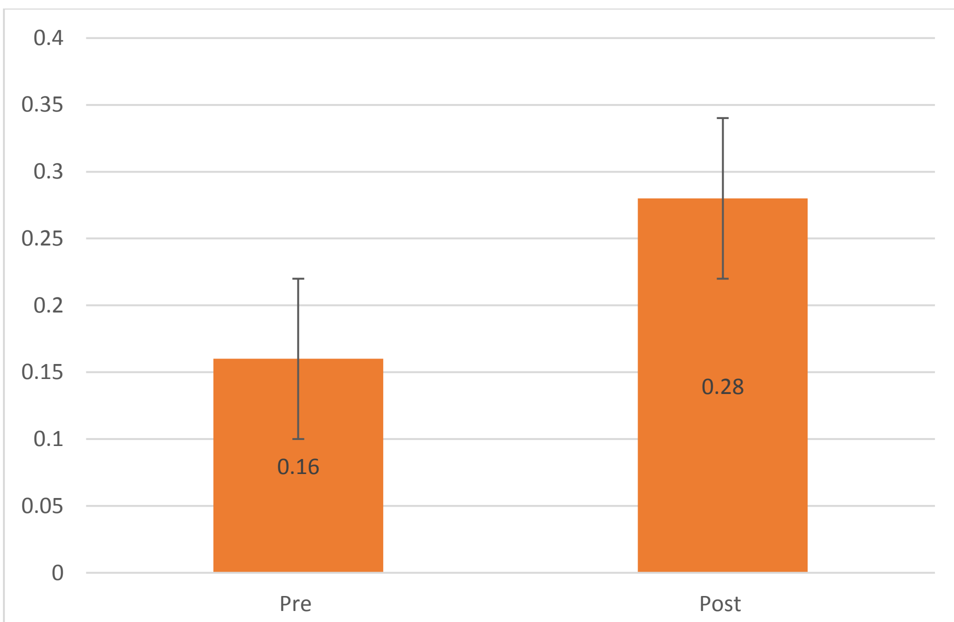

Fig. 5: Changes in TISA at nasal side 500 µm from scleral spur before and one month after surgery.

The Trabecular iris spur area (TISA) at nasal side 750 µm from scleral spur before and one month after surgery were 0.28 ±0.12 mm^2, 0.47 ± 0.17 mm^2 respectively P value < 0.001(highly significant) (Fig. 6).

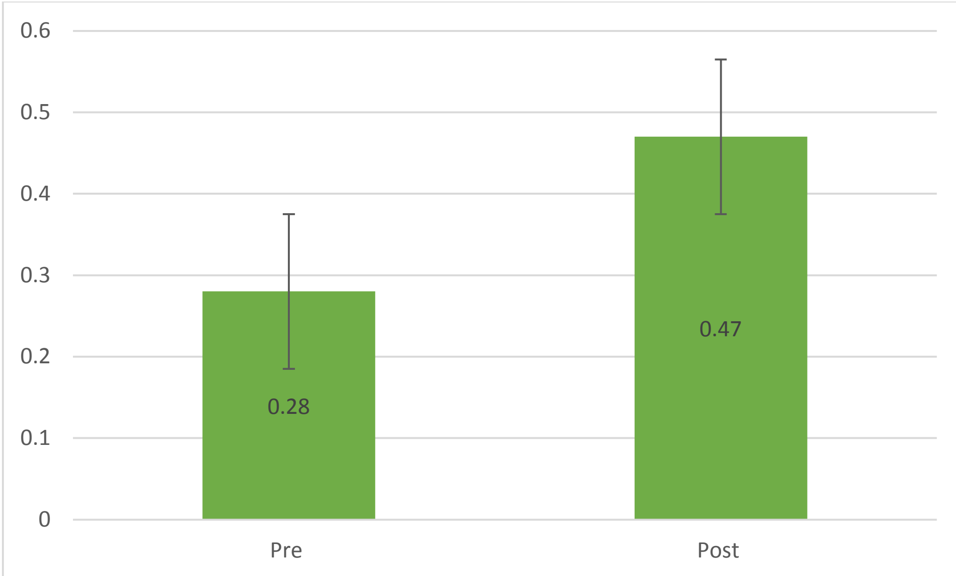

Fig. 6: Changes in TISA at nasal side 750 µm from scleral spur before and one month after surgery.

Angle opening distance (AOD) at temporal side 500 µm from scleral spur before and one month after surgery were 460.15 ±178.97 µm, 720.60 ± 264.78 µm respectively. P value < 0.001(highly significant) (Fig. 7).

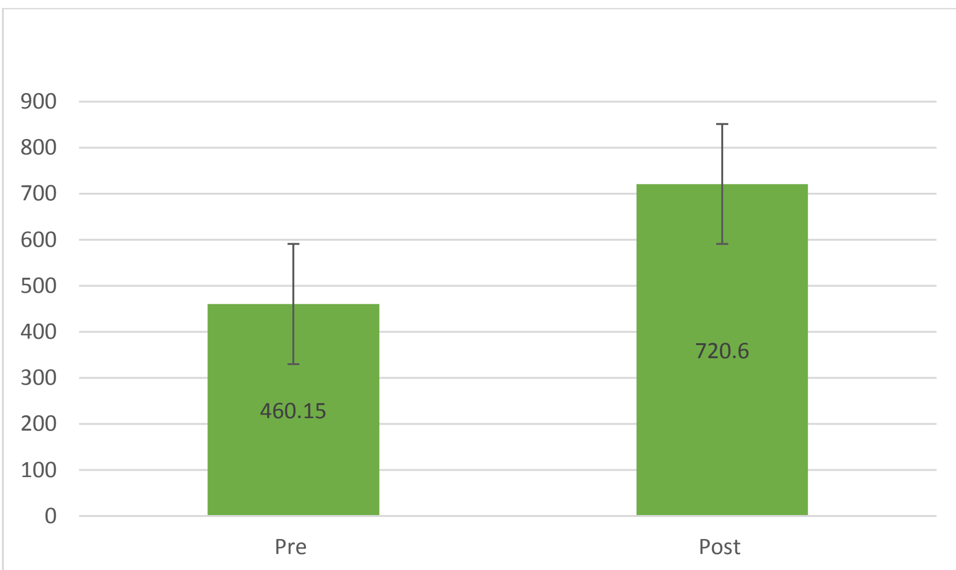

Fig. 7: Changes in AOD at temporal side 500 µm from scleral spur before and one month after surgery.

Angle opening distance (AOD) at temporal side 750 µm from scleral spur before and one month after surgery (mean ± SD) were 560.50 ±223.90 µm, 897.60 ± 303.52 µm respectively. P value < 0.001 (highly significant) (Fig 8).

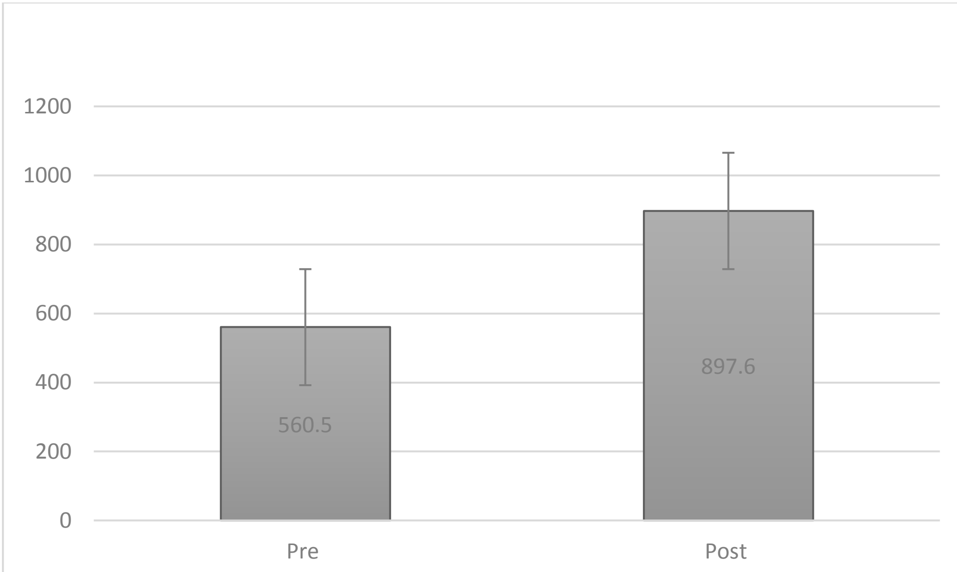

Fig. 8 Changes in AOD at temporal side 750 µm from scleral spur before and one month after surgery

Angle opening distance (AOD) at nasal side 500 µm from scleral spur before and one month after surgery (mean ± SD) were 415.90 ±148.9 µm, 738.60 ± 281.78 µm respectively. P value < 0.001 (highly significant) (Fig. 9).

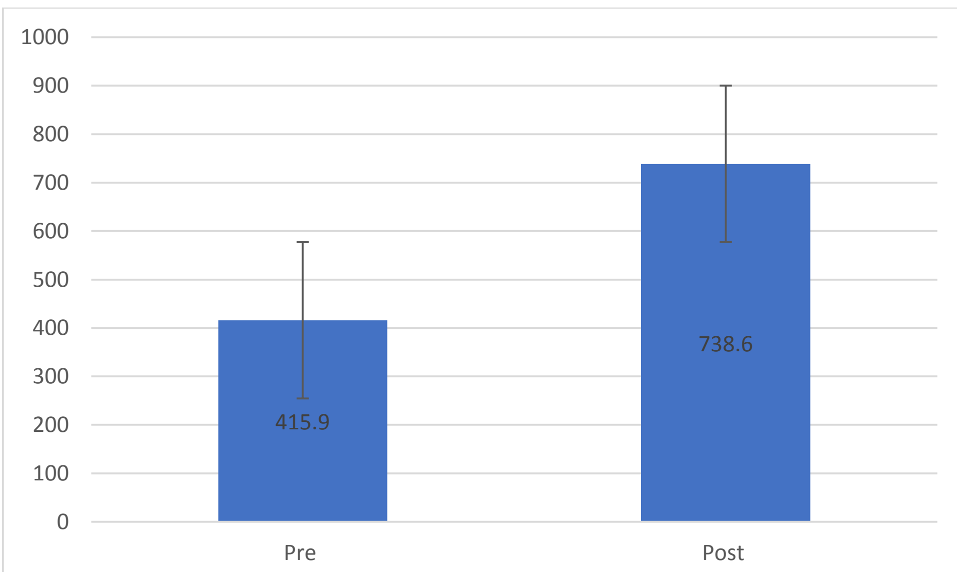

Fig. 9: Changes in AOD at nasal side 500 µm from scleral spur before and one month after surgery

Angle opening distance (AOD) at nasal side 750 µm from scleral spur before and one month after surgery were 536.75 ± 208 µm, 874.35 ± 288.12 µm respectively. P value < 0.001 (highly significant) (Fig. 10).

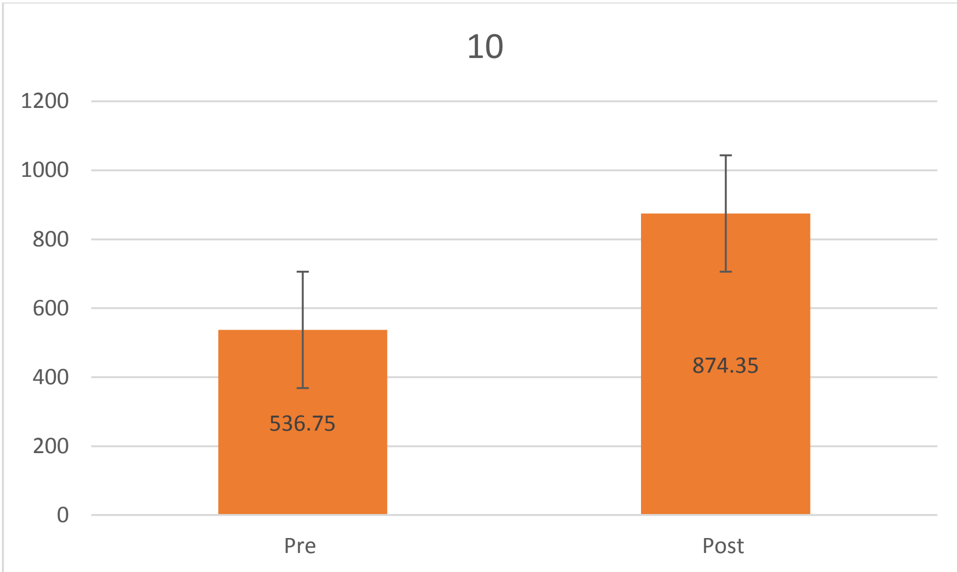

Fig. 10: Changes in AOD at nasal side 750 µm from scleral spur before and one month after surgery.

Figures 11and 12 demonstrate AS-OCT images of the right eye (temporal and nasal) before and one month after surgery.

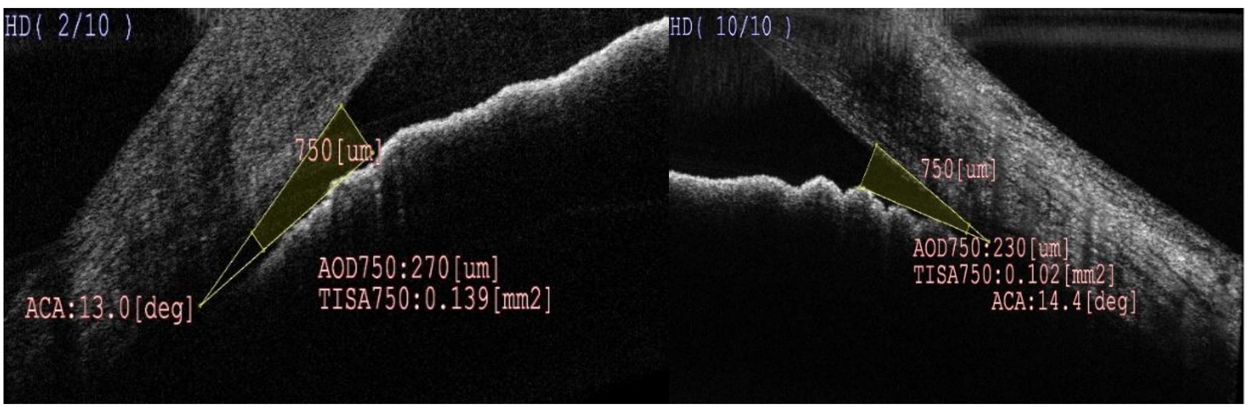

Fig. 11**:** Preoperative AS-OCT of the right eye demonstrate Temporal ACA=13.00 º, AOD 750 =270 µm, TISA 750=o.139 mm^2 and Nasal ACA=14.4 º, AOD 750=230 µm, TISA750= 0.102 mm^2.

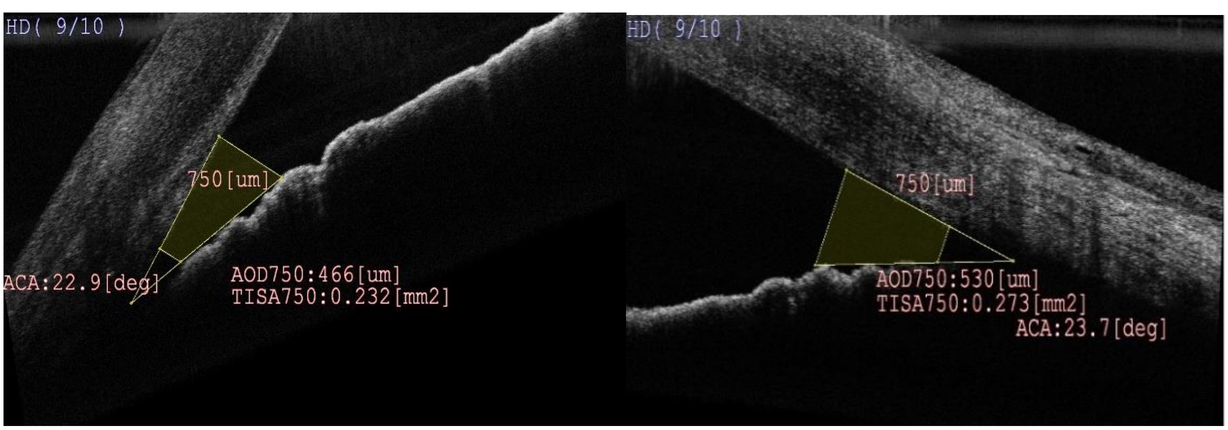

Fig.12: Postoperative AS-OCT of the right eye of the same patient demonstrate Temporal ACA=22.9º, AOD 750 =466 µm, TISA 750=o.232 mm^2 and Nasal ACA=23.7º, AOD 750=530 µm, TISA750= 0.273 mm^2.

DISCUSSION

The results of this study suggest that phacoemulsification with IOL implantation results in widening of the ACA based on quantitative assessment of ASOCT imaging. Furthermore, this result suggests a correlation between IOP reduction and angle widening.

Phacoemulsification cataract surgery with IOL implantation generally results in significant lowering of IOP in patients with glaucoma and in patients without glaucoma. Variations in mean IOP reductions (2- 7mmHg) have been reported in the current study. Wide variation in mean IOP reductions (1.1-13.5mmHg) have been reported in other studies [(5-7)].

Phacoemulsification with IOL implantation seems to reduce IOP more in narrow angle eyes than in open angle eyes. The exact mechanism of this IOP reduction after cataract surgery is still not fully understood. Hypothetically, cataract surgery removes the anatomical cause of narrow angle resulting in deepening of the AC and widening of the ACA. It would be expected that access of aqueous to the filtering portion of the trabecular meshwork will be improved due to widening of the drainage angle [(8)].

Nolan et al. [(9)] investigated the changes in angle configuration after phacoemulsification in 21 patients using AS-OCT and found that the mean AOD500 for the nasal quadrant (in dark conditions) increased from 243 to 457 μm. Their study included 7 eyes with iridotrabecular contact or peripheral anterior synechiae in one or more quadrants and 14 OA (open angle) eyes. However, IOP information was unavailable to correlate with the degree of angle opening.

In the present study, there was a trend toward greater IOP lowering with more ACA widening at both temporal and nasal sides.

Studies have also focused on changes in angle configuration after cataract surgery using either Scheimpflug or ultrasound biomicroscopic images and supported the finding that IOP reduction is greater in angle closure eyes. ***Hayashi et al.*** [(10)] demonstrated by Scheimpflug imaging that the width and depth of the ACA of angle closure glaucoma and OA glaucoma increase significantly after cataract extraction and IOL implantation. They also found that the IOP decreased significantly after surgery and that the amount of reduction in the angle-closure glaucoma group was higher than that in the OA glaucoma and OA groups. However, no association was noted between ACA widening and IOP decrease in their study [(10-12)].

Although angle opening is an apparent mechanism that can partially account for IOP lowering, there are other potential contributory factors, such as ultrasound activation of cytokines, endogenous prostaglandin F2 release, and increase in aqueous outflow by expansion of the trabecular meshwork and lumen of the Schlemm canal [(8)].

Wang et al. [(13).] demonstrated that phacoemulsification ultrasound activates the interleukin 1 facilitating aqueous outflow and reduction in IOP. ***Mathalone et al.*** [(14).]suggested that the endogenous prostaglandin F2 released postoperatively may enhance uveoscleral outflow. Theoretically, postoperative shrinkage of the lens capsule can result in increasing posterior traction on the scleral spur, expanding the trabecular meshwork and lumen of the Schlemm's canal [(14)].

This study has important limitations. The cohorts were relatively small, with only 20 eyes. In addition, a longer follow-up duration would provide more valuable evaluation of the long-term effects of phacoemulsification with IOL implantation in eyes.

In conclusion phacoemulsification with IOL implantation results in widening of the ACA and reduction of IOP.

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