Anterior chamber angle and intraocular pressure changes following scleral buckling for rhegmatogenous retinal detachment

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Purpose: To investigate and report the changes in the anterior chamber angle using anterior segment optical coherence tomography (AS-OCT) and associated intraocular changes following different scleral buckling configurations for repair of rhegmatogenous retinal detachments (RRD).

Methods: 28 eyes of 28 patients with a mean age of 36.93 ± 13.49 were enrolled for the study among patients scheduled for rhegmatogenous retinal detachment surgery. In 14 eyes, a 360 degrees encircling buckle was used (encircling group) and in 14 eyes segmental circumferential buckle was used (segmental group). Preoperatively, AS-OCT was used to assess 3 parameters: anterior chamber angle (ACA), angle opening distance (AOD) and trabecular-iris space area (TISA). Those parameters were reassessed 1 week, 1 month and 3 months postoperatively. Corresponding IOP values were also recorded.

Results : In the encircling group, IOP was noted to be uncontrolled despite medications in 50% of patients with mean IOP 24.2±1.12 mmHg at 1 week . The mean ACA at site 0 changed significantly from 31.56 ± 10.35 degree preoperatively to 20.29 ± 8.92, 22.36 ± 9.35 and 25.28 ± 10.6 at postoperative 1 week, 1 month and 3 months respectively (p value < 0.001).In the segmental group, *IOP was noted to be uncontrolled despite medications in 21.5% of patients with mean IOP 22.1±0.76 mmHg.* the mean ACA at site 0 changed significantly from 33.03 ± 8.73 degree preoperatively to 31.79 ± 8.49, 32.32 ± 8.62 and 32.73 ± 8.74 at postoperative 1 week , 1 month and 3 months respectively (p value =0.015).

Conclusion: Scleral buckling induces AC angle narrowing with elevation of IOP in the early postoperative period. These changes are more reported with the encircling than the segmental buckles. Also, these changes can be effiently monitored and quantified using AS-OCT.

Index Terms: Anterior chamber angle, intraocular pressure, scleral buckling, rhegmatogenous retinal detachment

(RRD), may help to isolate the preoperative susceptible cases for intraocular pressure (IOP) variations , explain cause of postoperative IOP changes and find a way to optimize postoperative management of thes e changes. The study was a prospective cohort of for whom SB surgery was operated at the department of ophthalmology, Zagazig University, Egypt between April 2019 and October 2019. The patients were divided into two groups depending on the extent of scleral buckle used. Group one (encircling group) included patients with RRD indicated for encircling (360°) scleral buckle. Group two (segmental group) included patients with RRD indicated for segmental circumferential (less than 360°) scleral buckle. The research was directed to correlate the changes in AC angle parameters with the IOP values preoperatively, 1 week, 1 month and 3 months following SB surgery. These parameters included anterior chamber angle (ACA) , angle opening distance (AOD) and trabecular-iris space area (TISA) .The study revealed that Scleral buckling (either encircling or segmental circumferential) induced anterior chamber angle narrowing that can cause postoperative IOP elevation. In the encircling group, the mean ACA at site 0 changed significantly from 31.56 ± 10.35 degree preoperatively to 20.29 ± 8.92, 22.36 ± 9.35 and 25.28 ± 10.6 at postoperative 1 week, 1 month and 3 months respectively (p value < 0.001). In the segmental group , the mean ACA at site 0 changed significantly from 33.03 ± 8.73 degree preoperatively to 31.79 ± 8.49, 32.32 ± 8.62 and 32.73 ± 8.74 at postoperative 1 week , 1 month and 3 months respectively (p value =0.015).

Index Terms* —*Anterior chamber angle, intraocular pressure, scleral buckling, rhegmatogenous retinal detachment

Ⅰ- INTRODUCTION

Rhegmatogenous retinal detachments (RRD) surgical management techniques include pneumatic retinopexy, scleral buckling (SB) and pars plana vitrectomy, either alone or in combination [1]. For vitro-retinal surgeons, SB surgery remains the procedure of choice in uncomplicated RRD especially in young, phakic and myopic patients with inferior breaks [2] as it saves the crystalline lens in comparison to the high incidence of cataract developing after pars plana vitrectomy [3]. The extra ocular and less invasive nature of SB contribute to the low morbidity, better visual acuity and lower incidence of intraoperative and postoperative complications [4]. Earlier reports revealed changes in the eye ball geometry following SB surgery in the form of changes in axial length, corneal curvature and refractive state in addition to anterior chamber (AC) shallowness especially in the early postoperative period [5-8]. Other papers [9] confirmed the early occurrence of ciliary body edema in all cases following SB procedures that may induce changes in AC angle. Although possible intraocular pressure (IOP) elevation after SB surgery is well known [10], the changes in AC angle need more documentation especially with the advent of anterior segment optical coherence tomography (AS-OCT) that was employed in this study to analyze the AC angle with objective parameters depending on high resolution cross sectional images of the AC angle. These parameters include anterior chamber angle (ACA), angle opening distance 500 (AOD500) and trabecular iris space area500 (TISA500) [11].

Ⅱ- METHODS

This prospective cohort study included 28 eyes of patients diagnosed to have primary RRD recruited from the outpatient clinic at the department of ophthalmology, Zagazig University, Egypt between April 2019 and October 2019.The inclusion criteria were phakic patients aged 15-50 years. Eyes with preexisting AC angle abnormalities, diagnosed with glaucoma or undergone previous cataract surgery were excluded. Patients undergoing combined pars plana vitrectomy and SB or performing radial SB were not included. Any case undergoing anterior or posterior segment procedures during the follow up period was also excluded. The retina must remain attached during the whole follow up period. The other eye, which served as a control for all measurements, was excluded if it had previous intraocular surgery or developed RRD during the follow up period. A written consent was obtained from all patients and the study was approved by the Ethics Committee of the Zagazig University Hospital. Preoperative evaluation encompassed thorough medical history (age, sex and previous operations), visual acuity, IOP measurement (under mydriasis) with Goldmann applanation tonometer, slit lamp biomicroscopy and posterior segment examination using both indirect ophthalmoscope with indentation of sclera and three mirror gonio-fundus lens. Proliferative vitroretinopthy PVR grading [12] was detected in addition to site and number of retinal breaks. IOLMaster (Carl Zies) was used to measure the axial length (AL) and anterior chamber depth (ACD).Imaging of the anterior chamber angle using AS-OCT system (NIDEK OCT RS 3ooo advance device) was performed at the site of the angle corresponding to the site of retinal break (site 0) and at a site 180˚ opposite to it (site 180). Three images were taken for each site and one was chosen depending on quality of the image for analysis by the built-in software. AC angle parameters were then obtained after identifying the scleral spur. ACA measures angle between posterior corneal surface and iris surface. AOD500 specifies distance between iris and a point 500 µm away from scleral spur on posterior corneal surface. TISA500 demonstrates area circumscribed within AOD500 line, posterior corneal surface, line drawn from scleral spur in parallel with AOD line, and iris surface (fig 1).

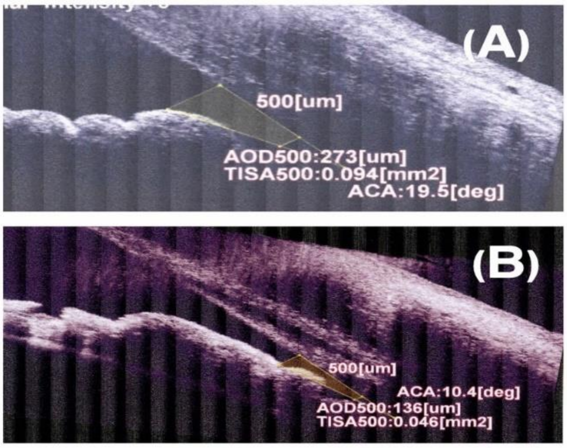

Figure 1. illustrates AC –OCT of the AC angle preoperative(A) and 1w postopertative(B).

All measurements were obtained after instillation of short acting mydriatic (tropicamide 0.5%; Alexandria co. pharmaceuticals, Egypt). In all the operated eyes , an exoplant was used ; either a 360˚ #240 band incorporated with a segement of a #287 tire or a circumferential silicone sponge(oval sponge style # 506 Labtician Ophthalmics Inc., Oakville, Canada) extending between 90˚ and 180˚ beneath the recti muscles. The buckles were fixed to the sclera by 5/0 polyester sutures.

. The following variables were noted regarding the SB procedure: whether an encircling or segmental buckle was used , whether sub retinal fluid was drained or not ,whether AC paracentesis was performed or not , number of cryo applications , whether intravitreal air was injected or not and whether the case received mannitol 20%(Allmed Middle east ,Egypt) or acetazolamide 250 mg tablets(CID, Egypt) postoperatively. The patients were divided into two groups depending on the extent of scleral buckle used. Group one (encircling group) included patients with RRD indicated for encircling (360˚) scleral buckle. Group two (segmental group) included patients with RRD indicated for segmental circumferential (less than 360˚) scleral buckle. Postoperative treatment consisted of topical antibiotic eye drops (moxifloxacin hydrochlorite0.5% ; orchidia pharmaceutical ind. Egypt) 5 times daily for two weeks , topical steroid drops(prednisone acetate ; jamjoom pharma ,Egypt) 5 times daily for three weeks and topical short acting mydriatic 3 times daily for three weeks. Postoperative follow up included evaluation of visual acuity, confirmation of retinal reattachment in all quadrants and measurement of axial length and AC depth using IOL Master. IOP was measured (under mydriasis) using Goldmann applanation tonometer 1week, 1month and 3 months postoperatively. Imaging of the anterior chamber angle using AS-OCT was performed specifying angle parameters 1week, 1month and 3 months postoperatively. These measurements were obtained under the use of short acting mydriatic. Ultrasound Bio-Microscopy (UBM) was used for further evaluation of cases with post-operative shallow AC or post-operative elevation of IOP(fig.2).

Figure 2. UBM of the AC angle postoperatively shows supraciliary effusion , bowing of iris and narrowing of AC angle

Results were tabulated on Microsoft Excel spreadsheets that was revised for any possible keyboard errors. Data were analyzed using a data base software program, Statistical Package for Social Science (SPSS) (Version 20.0. Armonk, NY: IBM Corp). Chi square (X2) test , Fisher's exact test , Independent t-test (t) , Mann-Whitney U test , Paired t-test , Repeated Measures ANOVA with post Hoc and Friedman Test for Repeated-Measures with post Hoc were used for analysis . Pearson correlation (r) was used to assess the degree of correlation. P value < 0.05 was considered statistically significant**.**

III- RESULTS

The mean age of the patients included in the study was 36.93 ± 13.49. There were 19 males and 9 females patients. Analysis included 28 eyes treated successfully by SB and their 28 fellow eyes that served as controls. Table I summarizes preoperative, intraoperative and postoperative characteristics of the study population.

TABLE I. DISTRIBUTION OF THE STUDIED PARTICIPANTS TO PREOPERATIVE, INTRAOPERATIVE AND POSTOPERATIVE CHARACTERISTICS (N=28).

characteristics	n= 28	
	No.	%
• Sex -male -female	 19 9	 67.9 32.1
• Operated eyes -right -left	 15 13	 53.6 46.4
• Extent of SB per degree -180 -270 -360	 11 3 14	 39.3 10.7 50
• Drainage of sub retinal fluid -yes -no	 13 15	 46.4 53.6
• Number of cryo application -1 -2 -3 -4	 5 6 13 4	 17.9 21.4 46.4 14.3
• Paracentesis -yes -no	 6 22	 21.4 78.6

• Intraoperative gas injection -yes -no	 3 25	 10.7 89.3
• PVR grading -no -grade A -grade B	21 4 3	75 14.3 10.7
• Postoperative mannitol or acetazolamide -yes -no	 12 16	 42.9 57.1

Table ‖ and table ⅠV show the changes in AC angle parameters among the encircling group and the segmental group respectively where all parameters including ACA 0 , ACA 180 , AOD 0 , AOD 180 , TISA 0 and TISA 180 decreased during the follow up period in the encircling group while , in the segmental group, ACA 0 , TISA 0 and TISA 180 showed significant decrease after 1w only but ACA 180 , AOD 0 and AOD 180 did not show any significant change .

TABLE ‖. CHANGE IN ACA, AOD, AND TISA PREOPERATIVE, 1 WEEK, 1MONTH, AND 3 MONTH AMONG THE ENCIRCLING GROUP (N=14).

Variables	pre	1 w	1 m	3 m	P4	P5	P6	Total P
ACA 0 (degrees) Mean ± SD	31.56 ± 10.35	20.29 ± 8.92	22.36 ± 9.35	25.28 ± 10.6	**0.001***	**<0.001****	**<0.001****	**b<0.001****
		P1:<0.001**	**P2:<0.001****	**P3:<0.001****				
ACA180 (degrees) Mean ± SD	30.50 ± 9.66	19.41 ± 9.37	21.56 ± 9.96	26.01 ± 9.37	**<0.001****	**<0.001****	**<0.001****	**b<0.001**
		P1:<0.001**	**P2:<0.001****	**P3:0.001***				
AOD0 (micro m) Mean ± SD	601 ± 215.7	386.7± 157.5	425± 198.2	505.9± 202.2	**<0.001****	0.064	**<0.001****	**b<0.001****
		P1:<0.001**	**P2: 0.002***	**P3: 0.033***				
AOD180 (micro m) Mean ± SD	594.4 ± 222.2	359.2 ± 172.4	402.3 ± 177.6	502.1 ± 208.9	**0.005***	**<0.001****	**0.002***	**b<0.001 ****
		P1:<0.001 **	**P2:<0.001****	**P3: 0.004***				
TISA 0(mm square) Mean ± SD	0.220 ± 0.08	0.148 ± 0.06	0.165 ± 0.08	0.186 ± 0.08	0.097	0.072	0.338	**b<0.001****
		P1:<0.001**	**P2: 0.01***	**P3:** 0.15				
TISA180(mm square) Mean ± SD	0.206 ± 0.10	0.134 ± 0.06	0.158 ± 0.07	0.257 ± 0.22	0.085	**0.031***	0.160	**b<0.001****
		P1: <0.001**	**P2:** 0.065	**P3:** 0.436				

[a] **Repeated Measures ANOVA with post Hoc**
[b] **Friedman Test for Repeated-Measures with post Hoc**
P1: pre/1w, P2: pre/1m, P3: pre/3m, P4: 1w/1m, P5: 1w/3m, P6: 1m/3m

Table Ⅲ shows that 50% of patients in the encircling group presented after 1w with uncontrolled IOP despite receiving medications. This percent decreased to 14.2% after 1m and at 3m , all IOPs were controlled.

TABLE Ⅲ: CLASSIFICATION OF PATIENTS ACCORDING TO IOP CONTROL IN THE ENCIRCLING GROUP(N=14).

	Group 1					
	uncotrolled IOP with medications (IOP>21)		controlled IOP with medications (IOP≤21)		controlled IOP without medications (IOP≤21)	
	No %	Mean	No %	Mean	No %	Mean
1w	7(50%)	24.2 ±1.2	4(28.5%)	18.1 ±0.85	3(21.5%)	15.6 ±1.5
1m	2(14.2%)	21.75 ±0.35	2(14.2%)	18 ±0.7	10(71.6%)	15.77 ±0.9
3m	0.0 (00%)	-	1(7.1%)	21.5	13(92.9%)	15.6 ±0.3

Table Ⅱ shows the changes in AC angle parameters among the encircling group where all parameters decreased during the follow up period.

TABLE ⅠV. CHANGES IN ACA, AOD, AND TISA PREOPERATIVE, 1 WEEK, 1MONTH, AND 3 MONTH AMONG THE SEGMENTAL GROUP (N=14).

Variables	pre	1 w	1 m	3 m	P4	P5	P6	Tot. P
ACA 0 (degrees) Mean ± SD	33.03 ± 8.73	31.79 ± 8.49	32.32 ± 8.62	32.73 ± 8.74	**0.033***	0.073	0.198	[a]**0.015***
		P1: 0.029*	**P2:** 0.140	**P3:** 0.114				
ACA180 (degrees) Mean ± SD	32.20 ± 9.38	31.07 ± 9.33	31.45 ± 9.26	32 ± 9.35	**0.033***	**0.048***	0.068	[a]**0.003***
		P1: 0.094	**P2:** 0.141	**P3:** 0.436				
AOD0 (micro m) Mean ± SD	677.4 ± 246.2	604.4± 185.8	621± 191.2	644.1± 204.1	**0.022***	**0.011***	**0.013***	[b]**0.004***
		P1: 0.082	**P2:** 0.108	**P3:** 0.111				
AOD180 (micro m) Mean ± SD	626.6 ± 231.2	598.6 ± 226.4	596.3 ± 202.5	640.6 ± 239.3	**0.016***	**0.004***	**0.024***	[b]**0.001***
		P1: 0.099	**P2:** 0.414	**P3:** 0.328				
TISA 0(mm square) Mean ± SD	0.254 ± 0.09	0.219 ± 0.07	0.233 ± 0.07	0.233 ± 0.07	**0.009***	0.055*	0.115	[b]**0.01***
		P1: 0.041*	**P2:** 0.311	**P3:** 0.552				
TISA180(mm square)	0.250 ± 0.09	0.222 ± 0.07	0.232 ± 0.08	0.239 ± 0.08	**0.003***	**<0.001****	**0.022***	[b]**<0.001****

Mean ± SD		**P1: 0.006***	**P2:** 0.059	**P3:** 0.476				

[a] Repeated Measures ANOVA with post Hoc
[b] Friedman Test for Repeated-Measures with post Hoc
P1: pre/1w, P2: pre/1m, P3: pre/3m, P4: 1w/1m, P5: 1w/3m, P6: 1m/3m.

Table V shows that 21.5% of patients in the encircling group presented after 1w with uncontrolled IOP despite receiving medications. after that , all IOPs were controlled.

table V: CLASSIFICATION OF PATIENTS ACCORDING TO IOP CONTROL IN THE SEGMENTAL GROUP

	Group 2					
	uncotrolled IOP with medications (IOP>21)		controlled IOP with medications (IOP≤21)		controlled IOP without medications (IOP≤21)	
	No %	Mean	No %	Mean	No %	Mean
1w	3(21.5%)	22.1 6±0.76	2(14.2%)	18.2 ±0.35	9(64.2%)	15.2 ±0.7
1m	0.0 (00%)	-	2(14.2%)	18± 0.42	12(85.8%)	15.2 ±0.88
3m	0.0 (00%)	-	0.0 (00%)	-	14(100%)	15.29 ±1.49

In the encircling group, the mean ACA at site 0 changed significantly from 31.56 ± 10.35 preoperatively to 20.29 ± 8.92, 22.36 ± 9.35 and 25.28 ± 10.6 at postoperative 1 week, 1 month and 3 months respectively (p value < 0.001) . In the segmental group , the mean ACA at site 0 changed significantly from 33.03 ± 8.73 degree preoperatively to 31.79 ± 8.49, 32.32 ± 8.62 and 32.73 ± 8.74 at postoperative 1 week , 1 month and 3 months respectively (p value =0.015) which is illustrated in fig.3.

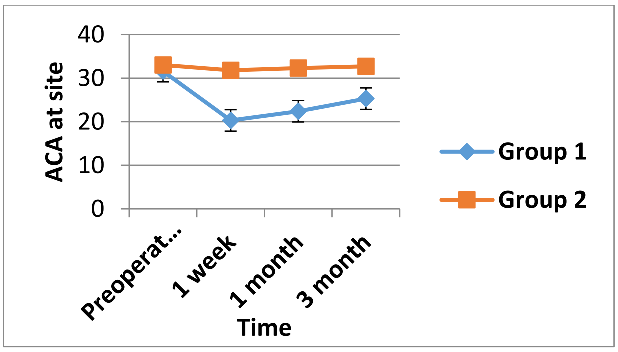

Figure 3. Line graph for the mean ACA 0 changes among the two groups

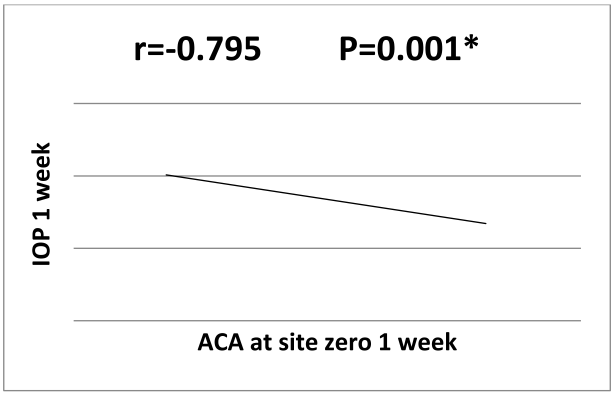

Figure 4: Correlation between IOP and ACA at site 0 at 1 week among Group 1 (n=14).

This figure shows that there was statistically significant negative correlation (P< 0.05*) between IOP and ACA at site 0 at 1 week among Group 1.

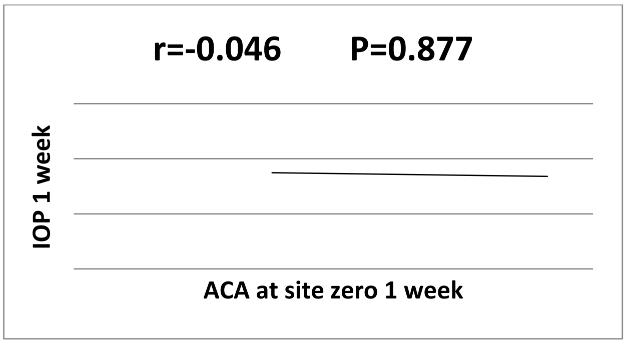

Figure 5: Correlation between IOP and ACA at site 0 at 1 week among Group 2 (n=14).

This figure shows that there was weak negative correlation between IOP and ACA at site 0 at 1 week among Group 2.

IV- Discussion

Scleral buckling surgery is a known risk factor for IOP elevation and further glaucomatous damage [10]. The incidence of angle closure following SB procedure has been estimated to be 1.4% to 4.4 % [13, 14]. More than one mechanism have been used to explain such IOP changes , the most important of which is the morphological changes that occur in the ciliary body which swells as a consequence of impaired venous drainage through vortex veins with supraciliary effusions[15,16] in about 33% to 100% of cases. Anterior rotation of the ciliary body [17] follows its swelling which induces narrowing of the AC angle elevating IOP. These changes were reported experimentally and proved by imaging techniques like ultrasound biomicroscopy (UBM) [13-17]. Another mechanism is that SB compresses the vitreous which causes forward displacement of iris-lens diaphragm leading to shallow AC which contributes to the IOP elevations [15, 18]. Several factors have been associated with IOP elevation after SB including use of encircling band[13] , excessive cryo applications[19] , large retinal break[16,18] , high myopia[20] , older age[20] and previous angle narrowing[20]. In this study , we documented the change in AC angle following SB using a noncontact device ,AS-OCT, and correlate these changes with IOP values for 3 months postoperatively and found significant decrease in All AC angle parameters that induced significant IOP elevation that persist during the whole follow up period. These changes were markedly reported in the encircling than the segmental group. Pavlin et al [15] examined 15 patients undergone SB before and 1 week after surgery using UBM. 73% of patients showed a decrease of >5 degrees in the angle opening. All of them had anterior rotation of the ciliary body and the iris root. Some patients showed pupillary block with bowing of the iris. Kawahara et al [16] evaluated 31 eyes diagnosed with RRD before and after SB surgery using UMB and slit lamp biomicroscopy. AC shallowness occurred in 100% of patients with encircling buckles and 60.0% of patients with segmental buckles. Two cases showed angle closure with marked elevation of IOP. Kawana et al [9] by means of UBM, evaluated the ciliary body thickness and anterior chamber depth after scleral buckling procedures and proved the existence of postoperative ciliary edema that reached its peak 3 days after surgery then gradually decreased till 1 month. Similar findings were reported by Wilkinson and Rice [21]. Wei et al [22] evaluated 33 patients after scleral buckling surgery using UBM and noticed that the trabecular-iris angle became narrower, the angle-open distance 500 decreased, scleral lateral side and iris long axis decreased statistically with no change in central AC depth. Goezinne et al [8] measured the anterior chamber depth and axial length of the eye globe after scleral buckles using anterior segment- optical coherence tomography and IOLMaster and reported that the anterior chamber depth remained decreased and the axial length remained enlarged after scleral buckling for 9 months. Khanduja et al [23] used anterior segment optical coherence tomography to evaluate the anterior chamber angle after application of scleral explants and found that the AC parameters decreased till 1 m after surgery. IOP increased at 48h but returned to preoperative level at 1w and 1m. In this study, decrease in AC angle parameters after SB surgery for RRD is in line with the results of Khanduja et al but we reported changes till 3 months not 1 month. IOP remained increased till 3 months because 60.7% of our study population were operated by scleral buckles >180˚ but with Khanduja et al, > 90% of the study population were operated by scleral buckles < 180˚. The peak of IOP and AC angle changes occurred in the early postoperative period which was in concordance with the finding of Kawana et al, Wilkinson and Rice. This is explained by the greater edema and anterior rotation of the ciliary body .Kawana et al reported significant difference in ciliary body thickness between the buckling site and the opposite site but in our study, there was no significant difference in AC angle parameters between the two sites. An explanation is that AC is affected by mechanisms other than ciliary body edema like forward displacement of iris lens diaphragm which may induce nearly equal changes between the two sites. In our study, 4 cases out of 28 patients (14.28%) developed angle closure with irido-trabecular contact. All of them had preoperative axial length ≤22.1 and performed encircling buckles which proved that short eyes are at risk of angle closure after encircling SB. UBM evaluation of the four cases revealed marked ciliary body edema, supraciliary effusion and bowing of the iris. These findings, as a mechanism of angle closure, were reported also by pavlin et al. Most previous studies evaluated anterior segment changes after SB using UBM which is a contact method of imaging that can be a risk factor for postoperative contamination. It also induces conformational changes in AC angle by the immersion cup used. The supine position adopted by patients while performing UMB may cause backward displacement of iris lens diaphragm and so the AC angle may falsely appear larger [24]. In contrast, AS-OCT is an excellent non-contact device that gives better resolution of the AC angle structures with no risk of contamination which is ideal for early postoperative evaluation [25]. Limitations to this study included missing AC angle evaluation in the first 2 days. Measurement under mydriasis, Intraoperative paracentesis, drainage of sub retinal fluid and the use postoperative mannitol or acetazolamide possibly influenced the IOP values.

V- CONCLUSION

Scleral buckling induces AC angle narrowing with elevation of IOP till 3 months postoperatively. These changes are more reported with the encircling than the segmental buckles. Shorter eye with encircling buckles are at risk of angle closure in the early postoperative period. The AC angle narrowing can be quantified and followed up postoperatively using AS-OCT.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

A.Yehya conducted the research, W.Elhaig revised the data, A. Saeed and M.Abdulkadir wrote the paper and all authors had approved the final version.

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