Egyptian Journal of Clinical Ophthalmology "*EJCO*"
An International peer-reviewed journal published bi-annually
Volume 5, Issue 1, July 2022: pp: 29-54 www. ejco.sohag-univ.edu.eg

Original Article

OPTICAL COHERENCE TOMOGRAPHIC STUDY AFTER VITRECTOMY FOR DISLOCATED LENS FRAGMENTS AND/OR INTRAOCULAR LENS

Ahmed, A.[(*)], **Radwan, G. Mostafa, E. & Farouk, M.**
Ophthalmology dept., Faculty of Medicine, Sohag Univ., Egypt

[*]*E-mail: alaa.abdelsadek@med.sohag.edu.eg*

Received: 9/3/2022
Accepted: 8/5/2022

Abstract

Background and Aim*: Posterior dislocation of lens fragments is uncommon complication of phacoemulsification. However it is associated with sight threatening sequelae. These may include intraocular inflammation, secondary glaucoma, corneal edema, cystoid macular edema, and retinal detachment. Proper management is crucial to reduce the risk of these complications. Pars plana vitrectomy with intravitreal emulsification of dislocated lens fragments is indicated. Optimal timing for intervention is controversial. This study aimed to determine clinical outcomes and optical coherence tomography (OCT) changes of prompt, early and late pars plana vitrectomy with and without the use of intravitreal ultrasonic emulsification for dislocated lens fragments and/ or IOL.* ***Methods****: Thirty five eyes of 35 patients were recruited for the study. All cases underwent pars plana vitrectomy (PPV) for dislocated nuclear fragments after complicated phacoemulsification. A control group of 85 eyes with uneventful phacoemulsification were included. The clinical outcomes were visual acuity, intraocular pressure (IOP) and postoperative complications. OCT parameters including OCT-macula, OCT-Optic nerve head (ONH), and anterior segment OCT were measured at the 1st, the 3rd, the 6th, the 9th, and 12th months postoperatively.* ***Results****: The results illustrated that eight eyes (22.8%) had CME detected by OCT at the 3rd months, while only 5 eyes (14.3%) at the 12th months and only 4 eyes (11.4%) had chronic CME. Conclusion: Timing of PPV is an important factor affecting clinical and in dislocated nuclear fragments and IOL. The prompt PPV was associated with the best outcome followed by the early PPV. Cases in which, intravitreal ultrasound emulsification was indicated, had poorer prognostic outcome.*

Keywords: *Dislocated lens fragments, Pars plane vitrectomy, Cystoid macular edema, OCT.*

1. Introduction

Phacoemulsification is associated with high success rate, however certain complications may occur. Posterior capsule rupture (PCR) with posteriorly dislocated lens fragments is considered one of these serious complications. Although it is a fairly uncommon complication with an incidence of 0.2% to 1.5%, it can be sight threatening due to sequelae of severe intraocular inflammation, corneal edema, secondary glaucoma, cystoid macular edema (CME), increased risk of endophthalmitis and retinal detachment [1]. Pars plana vitrectomy (PPV) is indicated in retained

nuclear fragments to reduce intraocular inflammation and to prevent other sequelae. Optimal timing for intervention and its impact on outcomes is still controversial [2].

2. Patient and Methods

This paper presents a prospective nonrandomized interventional case series conducted in Department of Ophthalmology, Sohag Faculty of Medicine, Sohag Univ., Sohag, Egypt between February 2019 and December 2020. All participants agreed to sign in a written informed consent about the planned procedure, nature and aim of the study. Additionally, the approval of the ethical committee of Sohag Faculty of Medicine was fulfilled. The study followed the tenets of the Declaration of Helsinki. Thirty five eyes of 35 subjects with dislocated nuclear fragments and/or intraocular lens (IOL) after complicated phacoemulsification were included in the study group. This group was classified according to the timing of PPV relative to the complicated cataract surgery into three categories: 'prompt PPV' (immediate or same-setting PPV), 'early PPV' (within the first week), and 'late PPV' (delayed more than one week). Further classification was done according to the method of surgical intervention into two categories: 'vitreous cutter only' subgroup and 'phacofragmatome' subgroup (where phacofragmatome or alternatively un-sleeved phacotip were indicated). The control group included 85 eyes of 67 patients who underwent uneventful phacoemulsification. Individuals with one or more of the following conditions were excluded from the study: Previous pars plana vitrectomy, cases complicated with retinal detachment or endophthalmitis, presence of CME documented before cataract surgery, diabetic retinopathy, coexisting glaucoma preoperatively, and lost follow up for more than two visits. All individuals were subjected to routine ophthalmic evaluation with special emphasis on nature, size, site, number, and density of the dislocated lens fragments. All operations were performed by 23-Gauge vitrectomy system (*Oertli OS-4 surgical platform, Switzerland*). Fundus visualization during vitrectomy was ach-ieved using wide angle viewing system; binocular indirect ophthalmoscopy (*BIOM, Oculus*). Additional procedures were nec-essary in some cases including IOL repositioning, exchange or secondary impl-antation. The first sclerotomy was made in the inferotemporal quadrant, 3.5 mm from the corneoscleral limbus. The infusion cannula was secured to the microcannula. The superotemoral and superonasal micro-cannulae were inserted in similar fashion, fig. (1).

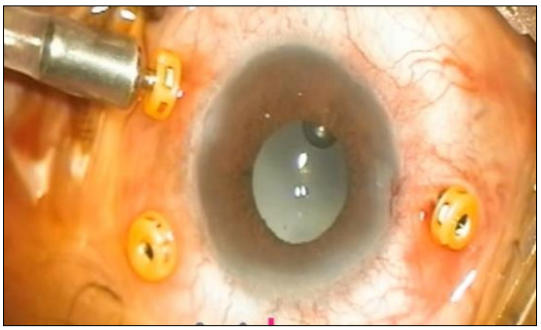

Figure 1: 23-G microcanulae with infusion tube inserted.

The 23-G endoillumination probe was inserted, then the BIOM system was repositioned and stereoscopic diagonal inverter was rotated. The BIOM system was adjusted until clear image focusing and the field was adjusted using the focusing system of the surgical microscope. The following vitrectomy cutting parameters were used: A cut rate of 2000 cuts/min and a vacuum level of 550 mmHg. First, anterior vitrectomy was done associated with aspiration of any retained cortical material within the capsular bag aided with alternation between cut/irrigation-aspiration mode and irrigation-aspiration/cut mode. Next, all vitreous was removed, starting by core vitrectomy and then

separation and removal of the posterior hyaloid (if not already separated). Intravitreal injection of suspension triamcinolone acetonide was injected for vitreous staining and to ensure complete removal of posterior cortical vitreous. In cases in which the retained fragments were soft epinucleus, low-medium nuclear density or small nuclear fragments. The nucleus or the nuclear fragment(s) were aspirated by the vitrectomy probe in the mid-vitreous to avoid inadvertent retinal injury, fig. (2).

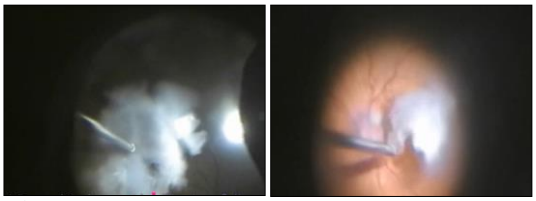

Figure 2: Soft dislocated lens fragments removed by the vitrectomy probe (2 different cases).

The endoillumination probe was used as a chopper to assist in aspiration and removal of nuclear fragment(s). However, in cases in which the retained fragments were high-density nuclear fragments, the vitrectomy probe was used to aspirate any cortical materials, epinucleus and trimming the nuclear fragments as much as possible. Then a 20 gauge phacofragmatome or alternatively an un-sleeved titanium phaco tip 30° (Oertli OS-4 surgical platform, Switzerland) was used. The endoillumination probe was used as a chopper to assist in fragmentation and removal of nucleus or nuclear fragment(s). For the phacofragmatome to be introduced inside the vitreous cavity, one of the superior microcannulae was extracted, and the incision was enlarged using 20 gauge microvitroretinal (MVR) instrument, figs. (3-5).

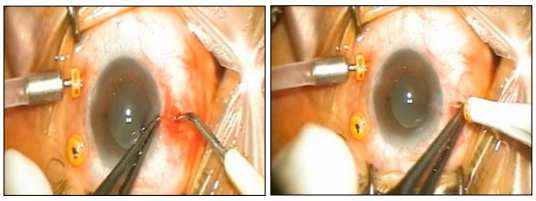

Figure 3: *left*: Extraction of the superonasal microcanula, *right*: widening of the pars plana incision by MVR.

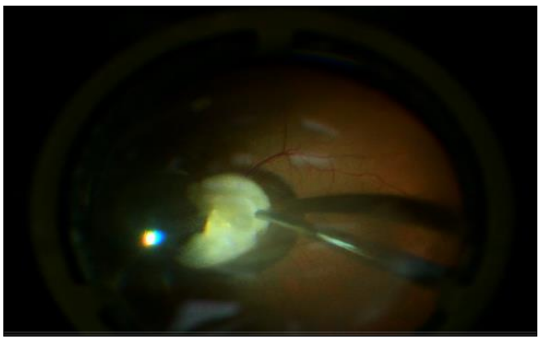

Figure 4: Intravitreal phacoemulsification using unsleeved phacotip.

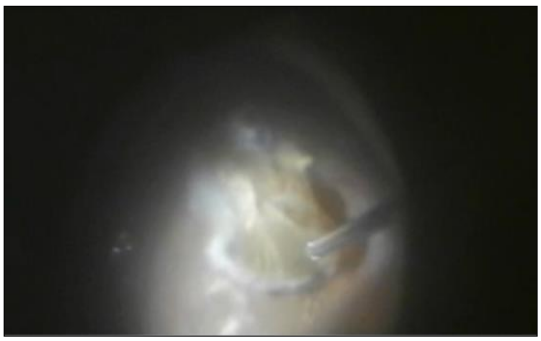

Figure 5: Intravitreal phacoemulsification using phacofragmatome.

In two cases with dislocated hard nucleus, a medium-sized perfluorocarbon (PFCL) bubble was injected to cushion the macula during intravitreal emulsification, and it was completely removed at the end of surgery. In presence of dislocated IOL, the IOL-haptic was secured using the vacuum of the vitrectomy probe or serrated retinal forceps, and lifted to the anterior segment. In some cases, the IOL was kept in the ciliary sulcus or the AC for assessment and decision was taken according to many factors; including: status of the capsular bag, anterior capsulorrhexis, and the type of the IOL, fig. (6).

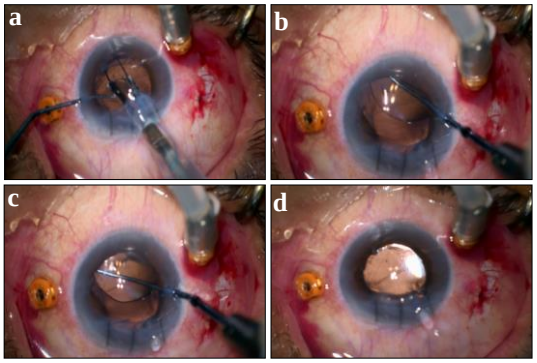

Figure 6: Implantation of foldable 3-piece IOL.

Finally, thorough shaving of the vitreous base was done. Additionally, 360 degree scanning aided with scleral depression was done in all cases to exclude preexisting or iatrogenic retinal breaks. Postoperatively, all patients received moxifloxacin 0.1% five times per day for two weeks and prednisolone acetate 0.1% hourly during the first two days, then five times per day for a week, and three times for the next week. All patients were examined on the second day of surgery. Follow up visits were scheduled at the end of the 1st week, the 1st month, the 3rd month, the 6th month, 9th month the 12th month. The final visual outcome was defined as BCVA by the end of the study and classified into three categories: Good visual outcome (BCVA was 0.5 or better), moderate visual outcome (BCVA was between 0.1 and 0.3), and poor visual outcome (BCVA was worse than 0.1). Starting at the 1st month postoperatively, all individuals were subjected to the following investigations: OCT-macula imaging: macular map, grid pattern and radial pattern were captured. The following parameters were documented: Central foveal thickness in um, average parafoveal thickness in um, and macular volume in mm^3. Additionally, RPE line, IS/OS line, inner retinal layers, and vitromacular interface were evaluated. Additionally, OCT-glaucoma profile imaging including ONH imaging, RNFL3.45 imaging, and GCC imaging were captured and the following parameters were documented: Average RNFL thickness, average cup/disc ratio, and ganglion cell layer thickness. After inserting and adjustment of the specified lens for anterior segment OCT, pachymetry imaging was captured and central corneal thickness was documented. Imaging of the AC-angle was performed and it was measured at both 3- and 9-o'clock positions. The average of AC-angle was also documented. The used device for OCT imaging was RTVue SD-OCT scanner (*Optovue, Fremont, California, USA*). Finally, AC depth was measured by interferometry using Aladdin optical biometer HW3.0 (*Topcon Europe Medical B.V., Netherlands*). The Statistical Package for the Social Sciences (SPSS) version 16.0 (*SPSS, Inc, Chicago, Intl*) was utilized to analyze the data statistically. The Chi-square test was used to compare demographic data, Mann-Whitney test was used to compare initial and final BCVA and the occurrence of complications. Independent-t test was used to assess statistical significance among groups in predetermined parameters. The paired-t test was used to assess statistical significance within the same group. The Anova test was used for comparison among more than two groups. Statistical difference was considered significant if *P* value was less than 0.05 and highly significant if *P* value was less than 0.01.

3. Results

The study group included 35 eyes of 35 patients with mean age of 56±10 years (19 men and 16 women). Cases in the study group were distributed to three subgroups according to the timing of PPV as following: 'prompt PPV' subgroup (9 eyes, 25.71%), 'early PPV' subgroup (12 eyes, 34.29%), and 'late PPV' subgroup (14 eyes, 40%). Additionally, another classification was done regarding the surgical procedure into two subgroups: The 'vitreous cutter only' subgroup (14 eyes, 40%) and the 'phacofragmatome' subgroup (21 eyes, 60%). Surgical characteristics of the study group are shown in details in tab. (1). The control group included 85 eyes of 67 patients (one eye in 49 patients and both eyes in 18 patients) with mean age of 63±8 years (37 men and 30 women). Both groups were matched regarding socio-demographic data and axial length, with statistically insignificant difference, tab. (2).

Table 1: Surgical characteristics of the study group

Parameter		Number	%
Dislocated item	Complete nucleus	3	8.6
	3/4 nucleus	11	31.4
	1/2 nucleus	9	25.7
	1/4 nucleus	3	8.6
	IOL	6	17.1
	nucleus + IOL	3	8.6
IOL status (pre-vitrectomy)	Sulcus acrylic IOL	1	2.9
	Sulcus PMMA	2	5.7
	Sulcus 3 piece IOL	4	11.4
	ACIOL	4	11.4
	Aphakia	24	68.6
Timing of vitrectomy	Prompt	9	25.71
	Early	12	34.29
	Late	14	40
Method for removal of dislocated nuclear fragment	Vitreous cutter only	14	40
	Phacofragmatome	21	60
IOL manipulation in aphakic eyes (24 eyes) • IOL repositioning (6 eyes) • IOL exchange (3 eyes) • IOL implantation (15 eyes)	Sulcus acrylic IOL	6	25
	Sulcus PMMA	2	8.33
	Sulcus 3 piece IOL	14	58.33
	ACIOL	1	4.17
	Scleral fixation	1	4.17

Table 2: Socio-demographic characteristics and mean axial length in the study and control groups.

	Cases (35 eyes, 35 patients)	Controls (85 eyes of 67 patients)	*p* value*
Gender •Male •Female	 19 (54.3%) 16 (45.7%)	 37 (55.2%) 30 (44.7%)	0.8
Age (years)**	56±10 (49-82)	63±8 (48-81)	0.2
Axial length (mm)**	23.6±1.4 (21.2-27.6)	23.7±1.5 (21-28.2)	0.7

:** *p-value was calculated by Fisher's Exact Test or independent sample t- test wherever suitable,* *:** *The data is presented as mean ± standard deviation (range).*

3.1. *Visual acuity*

All over the follow up period, there was high statistically significant difference in favor of the control group in both UCVA and BCVA. In the studied eyes; the improvement in UCVA was significant at the 3rd, 6th, and 9th months. However, the mean of BCVA showed greater change from 0.15 to 0.23 with significant improvement by the end of the study. On the other hand, the changes in both UCVA and BCVA in the control group were statistically insignificant, tab. (3) & fig. (7). Regarding the timing of PPV, there was a highly statistically significant difference among the three subgroups during the whole follow up period. All subgroups showed improvement in UCVA and BCVA levels by the end of the follow up period. In order to detect the statistical significance difference between every two subgroups, the data was analyzed using one way ANOVA-Post Hoc multiple comparison, tab. (4). There was statistically significant difference between prompt PPV and late PPV in UCVA and BCVA all over the follow up period. However, there was no statistically significant difference between early PPV and late PPV subgroups except in BCVA at 1 month. In addition there was no significant difference between prompt PPV and early PPV during the whole follow up period except in UCVA at 1 month (table 4, *p1* value). The prompt PPV

subgroup achieved the best visual outcomes, followed by the early PPV. The following charts, fig. (8) shows gradual improvement in UCVA and BCVA in the three subgroups. The mean UCVA and BCVA showed high significant difference between the vitreous cutter only subgroup and the phacofragmatome subgroup in all follow up visits, in favor of the first subgroup, tab. (5) & fig. (9). The vitreous cutter only subgroup showed better visual outcome than the phacofragmatome subgroup in which one third of eyes had poor visual outcome compared to only one eye in the other subgroup. The final visual outcome at 12 month postoperatively is illustrated in tab$_s$. (6-8).

Table 3: The mean postoperative UCVA and BCVA in the study and the control groups.

Decimal VA	Study group		Control group		*p* value*
	Mean±SD	*p1 value***	*Mean±SD*	*p1 value***	
UCVA					
▪ 1 month	0.104±0.44		0.355±0.13		0.0007
▪ 3 months	0.114±0.42	0.037	0.355±0.11	0.521	0.0001
▪ 6 months	0.140±0.59	0.000	0.367±0.08	0.432	0.0003
▪ 9 months	0.160±0.67	0.011	0.403±0.11	0.445	0.0004
▪ 12 months	0.180±0.88	0.852	0.398±0.12	0.656	0.0001
BCVA					
▪ 1 month	0.147±0.05		0.380±0.12		0.0004
▪ 3 months	0.145±0.07	0.597	0.490±0.11	0.634	0.0004
▪ 6 months	0.191±0.09	0.531	0.541±0.10	0.644	0.0004
▪ 9 months	0.216±0.09	0.664	0.514±0.13	0.734	0.0008
▪ 12 months	0.228±1.01	0.000	0.535±0.18	0.543	0.002

: p-value was calculated by independent sample t- test, *: p1 value was calculated by ANOVA test for changes overtime, **UCVA**: uncorrected visual acuity, **BCVA**: best corrected visual acuity.*

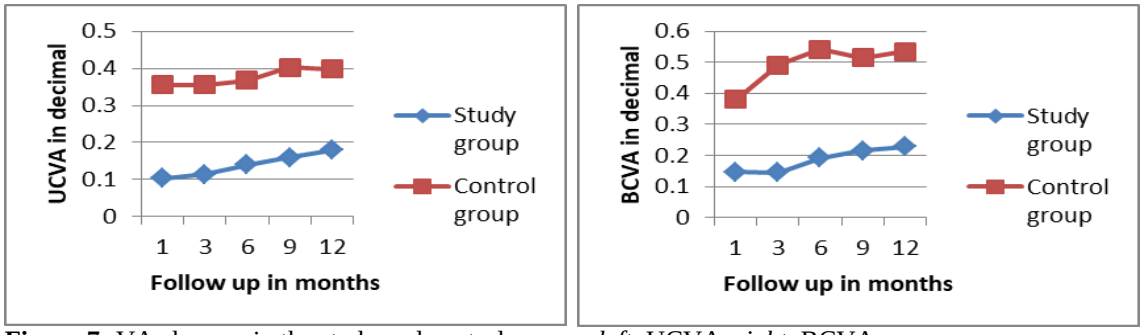

Figure 7: VA changes in the study and control groups. *left*: UCVA, *right*: BCVA.

Table 4: Mean VA in prompt, early and late PPV subgroups.

	Prompt PPV	Early PPV	Late PPV	*p* value*	*p1* value**		
					Prompt / early	Prompt / late	Early/ late
UCVA							
▪ 1 month	0.15±0.03	0.095±0.05	0.05±0.03	0.010	0.034	0.005	0.450
▪ 3 months	0.17±0.04	0.094±0.02	0.05±0.04	0003	0.473	0.005	0.407
▪ 6 months	0.23±0.04	0.112±0.03	0.08±0.05	0.0002	0.161	0.037	0.519
▪ 9 months	0.24±0.06	0.135±0.05	0.07±0.06	0.001	0.298	0.049	0.398
▪ 12 months	0.29±0.09	0.143±0.05	0.12±0.08	0.0003	0.427	0.045	0.348
BCVA							
▪ 1 month	0.20±0.05	0.14±0.05	0.09±0.05	0.005	0.342	0.003	0.033
▪ 3 months	0.24±0.06	0.14±0.05	0.11±0.05	0.0007	0.277	0.014	0.167
▪ 6 months	0.31±0.09	0.18±0.08	0.13±0.08	0.0002	0.335	0.007	0.063
▪ 9 months	0.32±0.10	0.19±0.07	0.15±0.07	0.001	0.358	0.004	0.036
▪ 12 months	0.34±0.95	0.21±0.20	0.17±0.12	0.04	0.161	0.026	0.880

***p:** value was calculated by one way **ANOVA**, ****p1:** value was calculated by **ANOVA**- Post Hoc multiple comparison.*

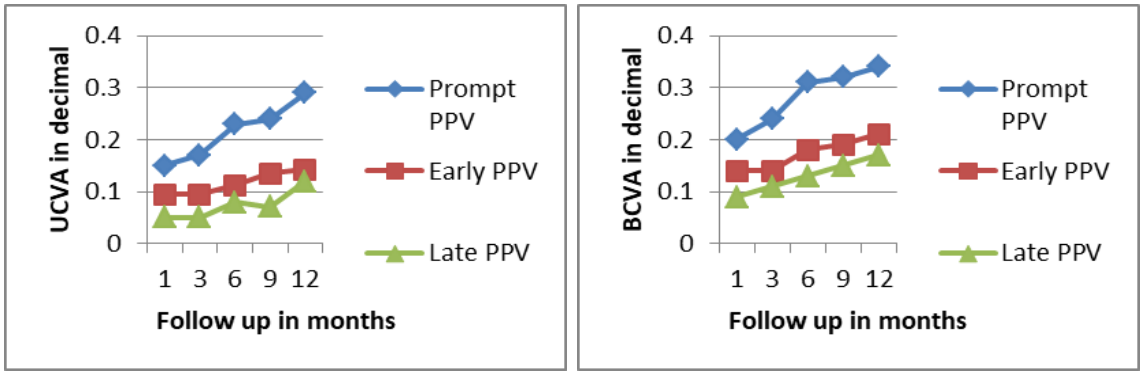

Figure 8: VA changes in prompt, early and late PPV; *left*: UCVA, *right*: BCVA.

Table 5: The mean UCVA and BCVA in the vitreous cutter only and phacofragmatome subgroups*

Snellen VA in decimal	Vitreous cutter only	Phacofragmatome	*p* value**
UCVA			
▪ 1 month	0.135±0.05	0.084±0.03	0.0004
▪ 3 months	0.139±0.05	0.098±0.03	0.003
▪ 6 months	0.183±0.06	0.112±0.03	0.0001
▪ 9 months	0.206±0.07	0.129±0.04	0.0003
▪ 12 months	0.240±0.10	0.139±0.05	0.0003
BCVA			
▪ 1 month	0.177±0.06	0.126±0.04	0.004
▪ 3 months	0.189±0.08	0.116±0.04	0.001
▪ 6 months	0.252±0.10	0.151±0.06	0.001
▪ 9 months	0.274±0.25	0.178±0.06	0.001
▪ 12 months	0.328±0.20	0.190±0.06	0.010

***: The data is presented as mean±SD, **: p-vale was calculated by independent sample t- test.*

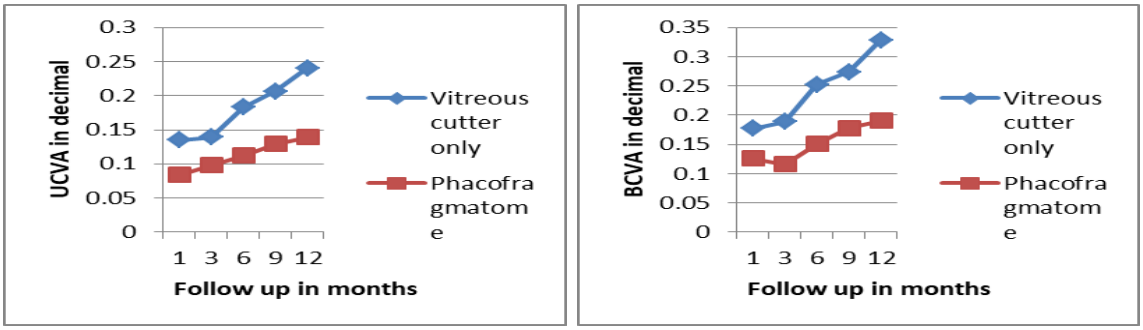

Figure 9: Mean VA changes in vitreous cutter only and phacofragmatome subgroups; *left*: UCVA, *right*: BCVA.

Table 6: The final visual outcome in the study and the control groups*

Final BCVA	Study group	Control group	p value
Good visual outcome (0.5 or better)	4 (11.4%)	62 (72.9%)	0.0001
Moderate visual outcome (0.1-0.3)	23 (65.7%)	21(24.7%)	0.0001
Poor visual outcome (worse than 0.1)	8 (22.9%)	2 (2.4%)	0.0002

***: The data is presented as number of eyes (percentage).*

Table 7: The final BCVA outcome in prompt, early and late PPV subgroups.

Final BCVA	Good visual outcome (0.5 or better)	Moderate visual outcome (0.1-0.3)	Poor visual outcome (worse than 0.1)
Prompt	2(22.2%)	6(66.7%)	1(11.1%)
Early	1(8.3%)	9(75%)	2(16.7%)
Late	1(7.14%)	8(57.1%)	5(35.7%)

Table 8: The final visual outcome in the vitreous cutter only and phacofragmatome subgroups

Final BCVA	Vitreous cutter only	Phacofragmatome
Good visual outcome (0.5 or better)	3 (21.4%)	1(4.8%)
Moderate visual outcome (0.1-0.3)	10 (71.4%)	13(61.9)
Poor visual outcome (worse than 0.1)	1 (7.1%)	7(33.3%)

3.2. *IOP*

There was statistically significant difference between cases and controls during the whole follow up period with higher IOP levels were documented in the study group, tab. (9). The mean IOP showed significant difference in all follow up visits between prompt PPV and late PPV subgroups, while there was neither significant difference between prompt versus early PPV subgroups nor early versus late PPV subgroups, tab. (10). On the other hand, the IOP showed statistically significant difference between vitreous cutter only and phacofragmatome subgroups only at the 1st and 3rd month follow up with insignificant difference later on, tab. (11).

Table 9: The mean IOP changes in the study and the control groups.

IOP (mmHg)	Study group		Control group		*p* value*
	mean±SD	***p1 value***	***mean±SD***	***p1 value***	
▪ **1 month**	21.17±2.68		18.08±1.74		0.0001
▪ **3 months**	19.29±2.44	0.001	17.04±1.28	0.08	0.0001
▪ **6 months**	17.94±1.86	0.001	16.81±1.23	0.08	0.0001
▪ **9 months**	17.40±1.29	0.001	16.62±1.24	0.06	0.003
▪ **12 months**	17.14±1.24	0.774	16.46±1.08	0.10	0.003

***p-vale:** was calculated by independent sample t- test, ****p1**: value was calculated by ANOVA test for changes overtime, **IOP:** intraocular pressure.*

Table 10: Mean IOP in prompt, early and late PPV subgroups*.

IOP(mmHg)	Prompt PPV	Early PPV	Late PPV	*p* value**	*p1* value***		
					Prompt / early	Prompt / late	Early/ late
▪ 1 month	18.92±0.95	22.71±2.31	21.40±2.84	0.002	0.397	0.045	0.249
▪ 3 months	16.86±1.21	20.11±2.32	19.50±2.32	0.007	0.381	0.025	0.156
▪ 6 months	16.29±0.95	18.72±1.99	17.70±1.25	0.008	0.612	0.040	0.423
▪ 9 months	16.29±0.94	17.78±1.22	17.50±1.27	0.027	0.503	0.076	0.258
▪ 12 months	16.00±0.58	17.56±1.25	17.20±1.14	0.014	0.577	0.094	0.253

***p:** value was calculated by one way ANOVA, ****p1:** value was calculated by ANOVA- Post Hoc multiple comparison.*

Table 11: The mean IOP in the vitreous cutter only and phacofragmatome subgroups.

IOP (mmHg)	Vitreous cutter only	Phacofragmatome	*p* value*
▪ 1 month	20.10±2.20	22.00±2.22	0.04
▪ 3 months	18.25±2.10	20.10±1.95	0.04
▪ 6 months	18.00±1.95	18.33±1.56	0.50
▪ 9 months	17.33±1.85	18.20±1.25	0.30
▪ 12 months	17.14±1.25	17.00±1.01	0.50

**p-vale was calculated by independent sample t- test.*

3.3. *Postoperative complications*

There was high significant difference between both groups all postoperative complications with higher incidence in the study group, tabs. (12 & 13). Examples of postoperative complications are shown in figs. (10-12). The prevalence of postoperative complications was significantly higher in late PPV than the other subgroups except for hypotony and IOL decentration which were encountered more in prompt PPV subgroup, tabs. (14 & 15). Additionally, there was high significant

difference between vitreous cutter only and phacofragmatome subgroups with higher incidence in the second subgroup in all postoperative complications except for IOL decentration, tab$_s$. (16 & 17).

Table 12: Early postoperative complications in the study and control groups.

	Study group	Control group	*p* value*
Corneal edema	13 (37.1%)	6 (7.1%)	0.002
Iridocyclitis	9 (25.7%)	4 (4.7%)	0.004
Hypotony**	6 (17.1%)	2 (2.4%)	0.030
Elevated IOP***	11 (31.4%)	5 (5.9%)	0.005

**** p value**: was calculated using Chi-square test, ****Hypotony**: was defined as IOP < 8 mmHg, *****Elevated IOP**: was defined as IOP >= 22 mmHg.*

Table 1): Late postoperative complications in the study and control groups.

	Study group	Control group	p value*
Corneal opacification	3 (8.6%)	0.00	0.080
Elevated IOP	7 (20%)	4 (4.7%)	0.004
Chronic iritis	4 (11.4%)	1 (1.2%)	0.020
IOL decentration	6 (17.1%)	2 (2.4%)	0.030
Spongiform macular edema	17 (48.6%)	7 (8.2%)	0.005
Cystoid macular edema	8 (22.8%)	3 (3.5%)	0.002

**** p value:** was calculated using Chi-square test.*

Table 14: Early postoperative complications in prompt, early and late PPV subgroups.

	Prompt PPV	Early PPV	*Late PPV*	*p* value
Corneal edema	5(55.5%)	3(25%)	5(35.7%)	0.002
Iridocyclitis	2(22.2%)	3(25%)	4(28.6%)	0.004
Hypotony	3(33.3%)	1(8.3%)	2(14.3%)	0.03
Elevated IOP	3(33.3%)	3(25%)	5(35.7%)	0.005

Table 15: Late postoperative complications in prompt, early and late PPV subgroups.

	Prompt PPV	Early PPV	*Late PPV*	*p* value
Corneal opacification	0	1(8.3%)	2(14.3%)	0.08
Elevated IOP	1(11.1%)	2(16.7%)	4(28.6%)	0.004
Chronic iritis	1(11.1%)	1(8.3%)	2(14.3%)	0.02
IOL decentration	2(22.2%)	1(8.3%)	3(21.4%)	0.03
Spongiform macular edema	4(44.4%)	6(50%)	7(50%)	0.005
Cystoid macular edema	2(22.2%)	2(16.7%)	4(28.6%)	0.002

Table 16: Early postoperative complications in the vitreous cutter only and phacofragmatome subgroups.

	Vitreous cutter only	Phacofragmatome	*p* value*
Corneal edema	5 (35.7%)	8(38.1%)	0.02
Iridocyclitis	3 (21.4%)	6(28.6%)	0.04
Hypotony**	1(7.1%)	5(23.8%)	0.003
Elevated IOP***	3 (21.4%)	6(28.5%)	0.04

**** p value:** was calculated using Chi-square test,****Hypotony:** was defined as IOP < 8 mmHg,*****Elevated IOP:** was defined as IOP >= 22 mmHg.*

Table 17: Late postoperative complications in the vitreous cutter only and phacofragmatome subgroups.

	Vitreous cutter only	Phacofragmatome	*p* value*
Corneal opacification	0	3(14.3%)	0.005
Elevated IOP	1 (7.1%)	6 (28.6%)	0.04
Chronic iritis	1 (7.1%)	3(14.3%)	0.03
IOL decentration	3 (21.3%)	3 (14.3%)	0.02
Spongiform macular edema	5 (35.7%)	12 (57.1%)	0.04
Cystoid macular edema	2 (14.2%)	6(28.6%)	0.02

** p value was calculated using Chi-square test.*

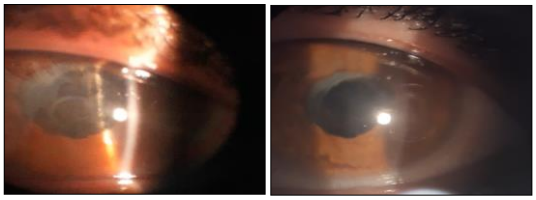

Figure 10: Postoperative uveitis; *left*: before treatment, *right*: after treatment.

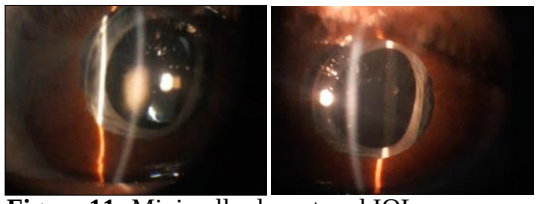

Figure 11: Minimally decentered IOL.

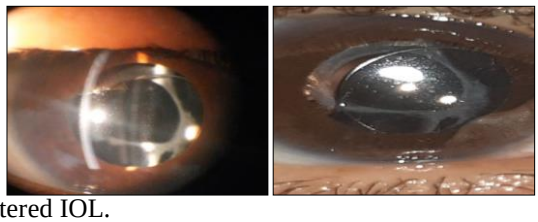

Figure 12: Markedly decentered IOL.

3.4. *OCT-macula changes*

There was a high statistically significant difference (p value<0.01) between cases and controls in all OCT-macula parameters which showed higher levels in the study group. In the study group, there was a significant decline in central foveal thickness, average macular thickness and macular volume during up to the 6th month postoperatively, and the change became insignificant later on. In the control group, the same parameters showed changes but to a lesser extent and was statistically insignificant, tab. (18). The following charts in figs. (13-15) show gradual decrease in central foveal thickness, average macular thickness and macular volume in the study group all over the follow up period. While the remarkable changes in the control group was noticed in the average macular thickness at the 3rd month with nearly stable parameters afterwards. Examples of OCT-macula findings are illustrated in figs. (16-18). A negative correlation was detected between central foveal thickness, average macular thickness and macular volume on one hand, and both UCVA and BCVA on the other hand. It was statistically significant in all follow up period except the final BCVA, tab. (19). Regarding PPV timing, the three subgroups showed high statistically significant difference in the mean of central foveal thickness and macular volume. However, they did not show any significant difference in the average macular thickness, tab. (20). Additionally, the data was analyzed using one way ANOVA-Post Hoc multiple comparison. There was no statistically significant difference between prompt PPV and early PPV subgroups in all parameters. Although there was significant difference between prompt PPV and late PPV subgroups on one hand, and early PPV and late PPV subgroups on the other hand in the mean central foveal thickness and average macular volume, tab. (20). All parameters showed the highest levels in the late PPV, followed by the early PPV and finally the prompt PPV, with gradual improvement overtime in all subgroups. The following charts, figs. (19-21) show gradual decrease in the average values of OCT-macula parameters in the three subgroups of the study group. Both vitreous cutter only and phacofragmatome subgroups did not show any statistically significant difference in all measured parameters by OCT-macula. However, in both groups, there was significant change between the baseline measurements at 1 month postoperative and the final measurements at 12 month, tab. (21).

Table 18: OCT-macula changes in the study and control groups*

	Study group		Control group		P value*
	mean±SD	*p1 value***	*mean±SD*	*p1 value***	
Central foveal thickness (um)					
▪ 1 month	312.09 ± 84.11		256.86 ± 77.41		0.001
▪ 3 months	306.18 ± 75.55	0.000	253.65 ± 72.88	0.075	0.001
▪ 6 months	288.63 ± 61.19	0.000	245.76 ± 57.16	0.100	0.0003
▪ 9 months	272.88 ± 44.13	0.723	238.91 ± 38.06	0.254	0.0004
▪ 12 months	260.19 ± 32.87	0.064	235.67 ± 29.76	0.156	0.0001
Average macular thickness (um)					
▪ 1 month	274.77 ± 38.88		263.27 ± 43.92		0.04
▪ 3 months	272.02 ± 34.87	0.000	241.72 ± 26.37	0.230	0.0008
▪ 6 months	264.70 ± 27.68	0.000	241.74 ± 25.98	0.671	0.0003
▪ 9 months	258.62 ± 25.47	0.808	239.05 ± 22.01	0.089	0.0004
▪ 12 months	250.23 ± 16.56	0.685	238.14 ± 20.65	0.260	0.003
Macular volume (mm^3)					
▪ 1 month	8.007 ± 1.19		7.383 ± 0.77		0.001
▪ 3 months	7.946 ± 1.09	0.036	7.008 ± 0.63	0.301	0.0003
▪ 6 months	7.679 ± 0.96	0.000	6.990 ± 0.61	0.093	0.0007
▪ 9 months	7.469 ± 0.80	0.717	6.945 ± 0.58	0.420	0.0001
▪ 12 months	7.368 ± 0.72	0.889	6.916 ± 0.56	0.301	0.0003

***p-vale:** was calculated by independent sample t- test, ****p1 value:** was calculated by ANOVA test for changes overtime.*

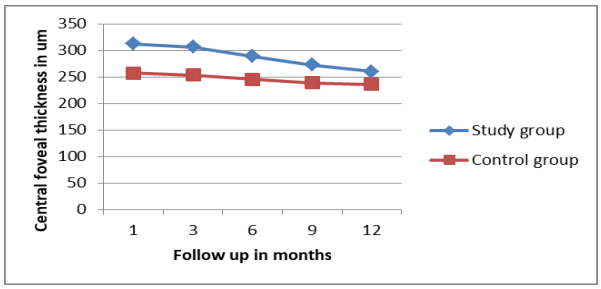

Figure 13: Central foveal thickness changes in study and control groups.

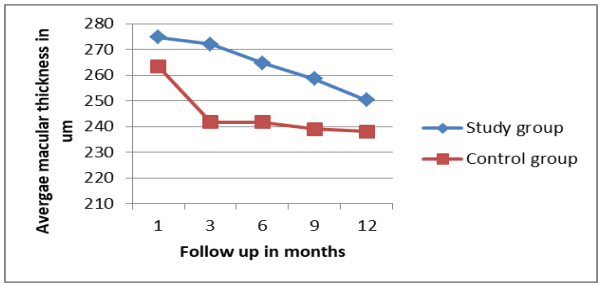

Figure 14: Average macular thickness changes in study and control groups.

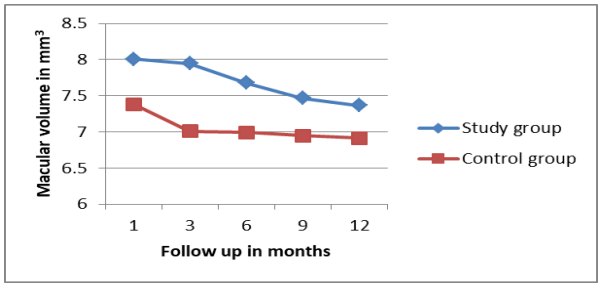

Figure 15: Macular volume changes in study and control groups.

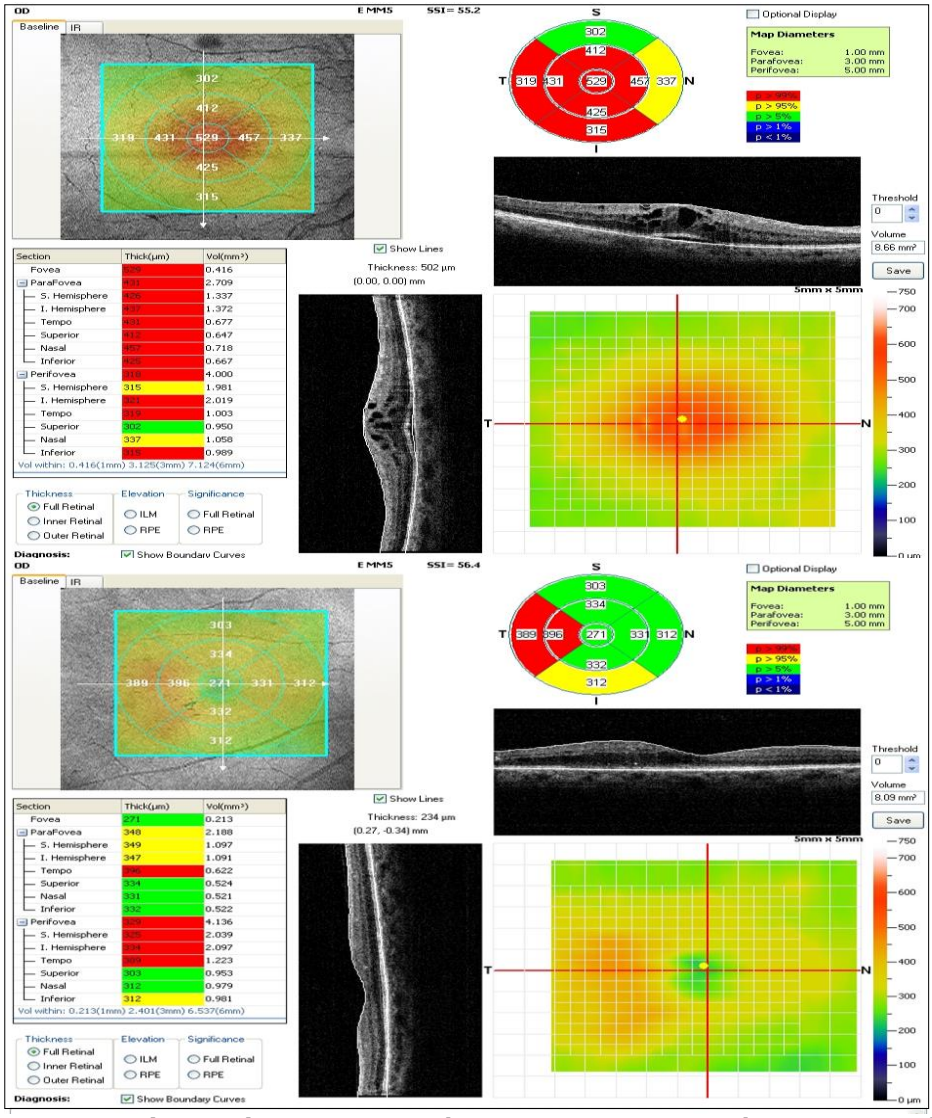

Figure 16: OCT-macula; macular map printout showing CME; *top*: 1 month postoperative, *bottom*: 3 months postoperatively (*received intravitreal triamcinolone acetonide*).

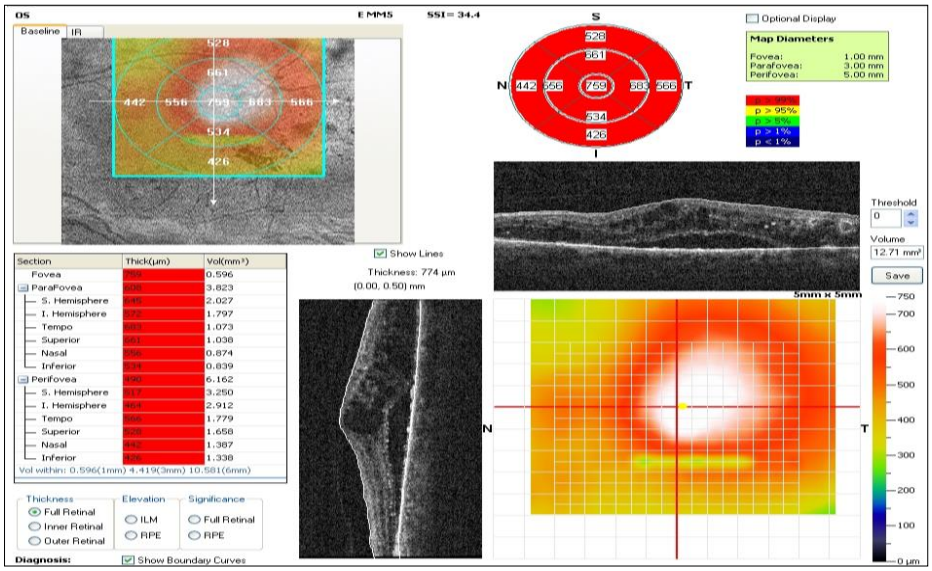

Figure 17: OCT-macula; macular map printout showing CME with sub retinal fluid.

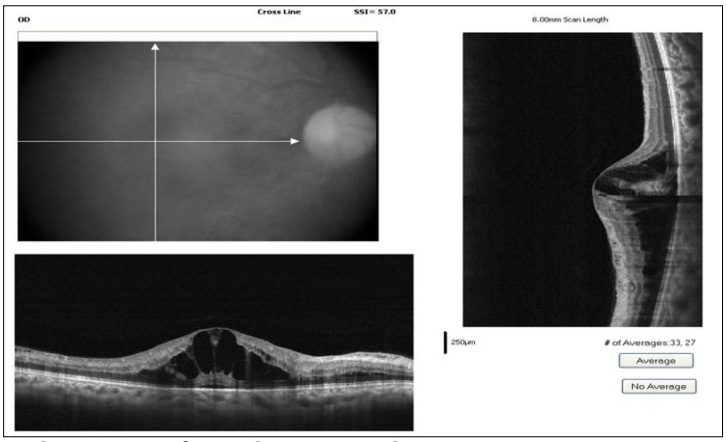

Figure 18: OCT-macula; printout of cross line pattern showing CME.

Table 19: Correlation between VA and parameters of OCT-macula in the study group

	Follow-up visits	UCVA r*	*p* value	BCVA r*	*p* value
Central foveal thickness	1 month	-0.545	0.001	-0.599	0.000
	3 months	-0.503	0.003	-0.576	0.000
	6 months	-0.528	0.003	-0.571	0.000
	9 months	-0.443	0.011	-0.604	0.000
	12 months	-0.500	0.004	-0.201	0.248
Average macular thickness	1 month	-0.456	0.007	-0.436	0.010
	3 months	-0.539	0.000	-0.599	0.000
	6 months	-0.558	0.001	-0.499	0.002
	9 months	-0.354	0.047	-0.354	0.037
	12 months	-0.414	0.018	-0.108	0.962
Macular volume	1 month	-0.488	0.003	-0.556	0.001
	3 months	-0.595	0.000	-0.583	0.000
	6 months	-0.514	0.002	-0.539	0.001
	9 months	-0.445	0.011	-0.571	0.000
	12 months	-0.447	0.010	-0.112	0.522

***** *Pearson correlation.*

Table 20: OCT-macula changes in prompt, early and late PPV subgroups*.

	Prompt PPV	Early PPV	Late PPV	*P* value**	*P1* value***		
					Prompt / early	*Prompt / late*	*Early/ late*
Central foveal thickness							
1 month	246.4±21.2	313.9±68.6	336.6±95.3	0.0004	0.454	0.001	0.004
3 months	242.5±16.5	296.7±59.9	336.2±81.1	0.0001	0.769	0.018	0.037
6 months	241.4±14.2	279.9±52.3	311.8±66.6	0.0001	0.684	0.003	0.007
9 months	239.0±14.6	267.5±37.1	289.0±48.2	0.0001	0.620	0.001	0.004
12 months	237.0±13.6	258.4±26.1	270.2±37.5	0.0001	0.568	0.001	0.004
Average macular thickness							
1 month	251.3±16.5	282.7±53.7	279.5±44.4	0.20	0.481	0.080	0.060
3 months	246.4±14.0	271.4±42.1	282.3±32.2	0.06	0.755	0.081	0.153
6 months	245.2±12.4	263.8±35.3	272.8±24.7	0.08	0.467	0.135	0.074
9 months	249.6±38.4	251.2±26.1	262.4±19.2	0.50	0.974	0.166	0.165
12 months	242.7±10.6	248.9±23.9	253.9±12.9	0.30	0.399	0.070	0.080
Macular volume							
1 month	7.38±0.78	8.13±1.40	8.28±1.16	0.0002	0.879	0.040	0.025
3 months	7.01±0.63	7.93±1.30	8.30±1.03	0.0002	0.864	0.081	0.046
6 months	6.99±0.61	7.70±1.10	7.91±0.96	0.0005	0.955	0.017	0.015
9 months	6.95±0.58	7.56±0.97	7.59±0.81	0.0002	0.981	0.029	0.026
12 months	6.92±0.56	7.39±0.82	7.50±0.78	0.001	0.802	0.042	0.020

***:** *The data is presented as mean ± SD,* ****p value:** *was calculated by one way ANOVA,* *****p1 value:** *was calculated by ANOVA- Post Hoc multiple comparison.*

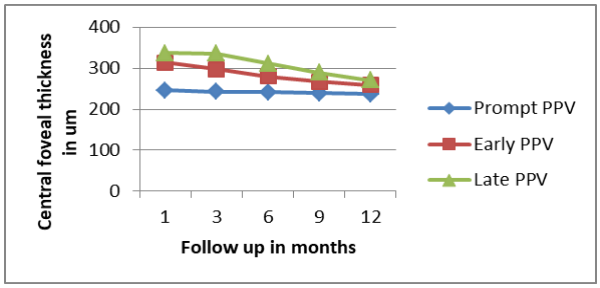

Figure 19: Central foveal thickness changes in prompt, early and late PPV.

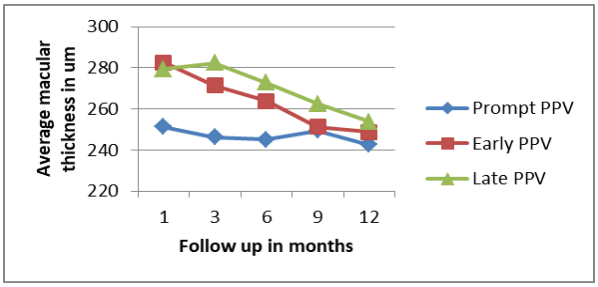

Figure 20: Average macular thickness changes in prompt, early and late PPV.

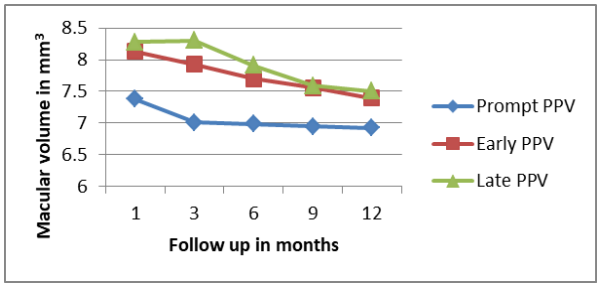

Figure 21: Macular volume changes in prompt, early and late PPV.

Table 21 : OCT-macula changes in the vitreous cutter only and phacofragmatome subgroups*

	Vitreous cutter only	Phacofragmatome	*p* value**
Central foveal thickness (um)			
▪ 1 month	307.4 ± 100.5	315.2 ± 73.6	0.7
▪ 3 months	300.1 ± 88.5	310.2 ± 67.6	0.7
▪ 6 months	282.6 ± 70.2	292.7 ± 55.8	0.6
▪ 9 months	264.4 ± 43.8	278.5 ± 44.5	0.3
▪ 12 months	251.3 ± 26.9	266.1 ± 35.7	0.1
Average macular thickness (um)			
▪ 1 month	269.48 ± 47.53	278.29 ± 32.7	0.5
▪ 3 months	260.66 ± 37.76	279.60 ± 31.5	0.1
▪ 6 months	257.87 ± 32.15	269.26 ± 24.3	0.2
▪ 9 months	256.97 ± 32.93	259.71 ± 19.9	0.7
▪ 12 months	245.14 ± 18.88	253.62 ± 14.3	0.1
Macular volume (mm^3)			
▪ 1 month	7.70 ± 1.20	8.20 ± 1.10	0.2
▪ 3 months	7.70 ± 1.20	8.00 ± 1.00	0.3
▪ 6 months	7.40 ± 0.96	7.80 ± 0.90	0.2
▪ 9 months	7.30 ± 0.70	7.60 ± 0.84	0.2
▪ 12 months	7.20 ± 0.62	7.52 ± 0.78	0.1

***:** *The data is presented as mean±SD,* ****p-vale:** *was calculated by independent sample t- test*

3.5. *OCT-glaucoma profile*

During the whole follow-up period, both the study and the control groups showed a high statistically significant difference in the average RNFL and GCL

thickness with higher levels were documented in the control group. The average RNFL thickness at 1 month postoperative was 91.86±10.75um and 102.81±11.23um in the study and control groups, respectively, and decreased at 12 month postoperative to 85.97±11.77um and 99.44± 10.23um, respectively. The mean GCL thickness at 1 month postoperative was 89.14±6.43um and 93.78±5.73um in the study and control groups, respectively, and changed at 12 month postoperative to 85.74±7.92um and 90.75±5.36um, respectively. The cup/disc (C/D) ratio did not show any statistically significant difference between both groups. At the first follow-up visit, the mean C/D ratio was 0.39 and 0.38 in the study and control group, respectively, and increased to 0.45 and 0.43, respectively by the end of the follow-up period, tab. (22). In the study group, the changes were statistically significant during the follow up period for all parameters of OCT-glaucoma profile except at the 3rd month for both average RNFL thickness and mean C/D ratio. However, changes in all parameters for the control group did not show any significant difference. Examples of OCT-ONH, RNFL and GCC imaging are shown in figures 17 and 18. A negative correlation was detected between the mean IOP and both RNFL and GCL thickness. While a positive correlation was present between IOP and C/D ratio. The correlation was significant for GCL thickness and C/D ratio in all follow up visits. However, regarding RNFL thickness, the correlation was significant only at the 3rd and 12th postoperative follow up visits, tab. (23). During the whole period of the study, the prompt, early and late PPV subgroups showed no statistically significant difference in any parameter of OCT-glaucoma profile as shown in tab. (24). The extent of change in mean between the 1st and 12th month in the prompt, early and late PPV subgroups was as following: RNFL thickness was (-2.8 um, -7 um, and -5.9 um respectively). GCC thickness was (-1.94 um, -4.72 um, and -3.1 um, respectively). C/D ratio was (+0.05, +0.08, and +0.02, respectively). The following charts in figs. (22-24) show minimal changes in RNFL thickness, GCL thickness and C/D ratio in all subgroups. Similarly, the average of RNFL thickness, GCL thickness and C/D ratio showed no statistically significant difference between vitreous cutter and phacofragmatome subgroups with minimal changes over the follow up period, tab. (25).

Table 22: OCT- glaucoma profile parameters in the study and control groups.

	Study group		Control group		*p* value*
	mean±SD	*p1 value***	*mean±SD*	*p1 value***	
Average RNFL thickness (um)					
▪ 1 month	91.86 ± 10.75		102.81 ± 11.23		0.0003
▪ 3 months	88.80 ± 11.51	0.501	100.01 ± 10.42	0.801	0.0008
▪ 6 months	87.57 ± 11.68	0.000	99.64 ± 10.50	0.564	0.0001
▪ 9 months	86.49 ± 12.25	0.000	99.26 ± 10.30	0.302	0.0004
▪ 12 months	85.97 ± 11.77	0.001	99.44 ± 10.23	0.080	0.0006
GCL thickness (um)					
▪ 1 month	89.14 ± 6.43		93.78 ± 5.73		0.0001
▪ 3 months	88.91 ± 5.75	0.000	91.95 ± 6.04	0.076	0.010
▪ 6 months	87.60 ± 6.00	0.013	91.40 ± 6.20	0.210	0.002
▪ 9 months	86.26 ± 7.10	0.000	90.64 ± 5.62	0.089	0.0004
▪ 12 months	85.74 ± 7.29	0.002	90.74 ± 5.36	0.102	0.0005
C/D ratio					
▪ 1 month	0.39 ± 0.06		0.38 ± 0.07		0.30
▪ 3 months	0.41 ± 0.06	0.652	0.39 ± 0.07	0.402	0.30
▪ 6 months	0.43 ± 0.07	0.000	0.41 ± 0.07	0.320	0.20
▪ 9 months	0.44 ± 0.07	0.000	0.42 ± 0.08	0.112	0.10
▪ 12 months	0.45 ± 0.08	0.000	0.43 ± 0.08	0.090	0.10

***p-vale:** was calculated by independent sample t- test, ****p1 value:** was calculated by ANOVA test for changes overtime.*

Table 23: Correlation between IOP and RNFL thickness in the study group.

Follow up visits (months)	RNFL thickness		GCL thickness		C/D ratio	
	r *	*p* value	r*	*p* value	r*	*p* value
1	-0.209	0.243	-0.412	0.017	0.348	0.047
3	-0.398	0.020	-0.543	0.001	0.599	0.000
6	-0.232	0.179	-0.534	0.001	0.642	0.000
9	-0.261	0.130	-0.629	0.000	-0.690	0.000
12	-0.352	0.038	-0.572	0.000	-0.516	0.002

***:** *Pearson correlation.*

Table 24: OCT-glaucoma profile changes in prompt, early and late PPV subgroups*.

	Prompt PPV	Early PPV	Late PPV	P value**
RNFL				
▪ 1 month	95.10±14.9	92.80±11.2	87.80±4.7	0.30
▪ 3 months	94.00±14.6	89.40±12.1	84.10±5.9	0.20
▪ 6 months	93.40±14.1	87.60±12.4	83.50±6.8	0.20
▪ 9 months	92.60±14.3	86.60±12.8	82.10±8.3	0.20
▪ 12 months	92.30±14.4	85.80±11.8	81.90±8.4	0.20
GCL				
1 month	90.43±7.6	89.83±7.1	88.10±4.4	0.70
▪ 3 months	90.21±6.2	89.00±5.9	87.70±5.4	0.60
▪ 6 months	89.40±5.6	87.40±6.3	86.70±6.0	0.60
▪ 9 months	89.00±5.8	85.78±7.2	85.20±7.9	0.50
▪ 12 months	88.49±5.6	85.11±7.5	85.00±8.1	0
C/D ratio				
▪ 1 month	0.35±0.06	0.39±0.05	0.41±0.05	0.10
▪ 3 months	0.37±0.06	0.42±0.05	0.40±0.05	0.07
▪ 6 months	0.37±0.07	0.45±0.07	0.43±0.06	0.08
▪ 9 months	0.38±0.06	0.46±0.07	0.42±0.06	0.06
▪ 12 months	0.38±0.05	0.47±0.08	0.43±0.07	0.06

***:** *The data is presented as mean ± SD,* ***p**: value was calculated by one way ANOVA.*

Table 25 : OCT-glaucoma profile changes in both subgroups.*

	Vitreous cutter only	Phacofragmatome	p value**
RNFL thickness (um)			
▪ 1 month	94.00 ± 11.00	91.01 ± 11.01	0.4
▪ 3 months	92.01 ± 11.01	87.00 ± 12.00	0.2
▪ 6 months	90.00 ± 12.00	86.00 ± 12.04	0.2
▪ 9 months	89.10 ± 12.01	85.04 ± 12.00	0.2
▪ 12 months	89.02 ± 12.03	84.02 ± 11.01	0.1
GCL thickness (um)			
▪ 1 month	90.01 ± 7.40	88.48 ± 5.80	0.4
▪ 3 months	90.00 ± 6.00	88.00 ± 5.00	0.2
▪ 6 months	89.00 ± 6.00	86.00 ± 6.00	0.1
▪ 9 months	88.02 ± 7.01	85.03 ± 7.01	0.2
▪ 12 months	87.40 ± 7.20	84.60 ± 7.30	0.2
C/D ratio			
▪ 1 month	0.37 ± 0.05	0.40 ± 0.05	0.3
▪ 3 months	0.39 ± 0.05	0.43 ± 0.05	0.4
▪ 6 months	0.40 ± 0.06	0.45 ± 0.06	0.4
▪ 9 months	0.40 ± 0.06	0.46 ± 0.07	0.3
▪ 12 months	0.42 ± 0.08	0.47 ± 0.07	0.3

***:** *The data is presented as mean±SD,* ***p-vale:** *was calculated by independent sample t- test*

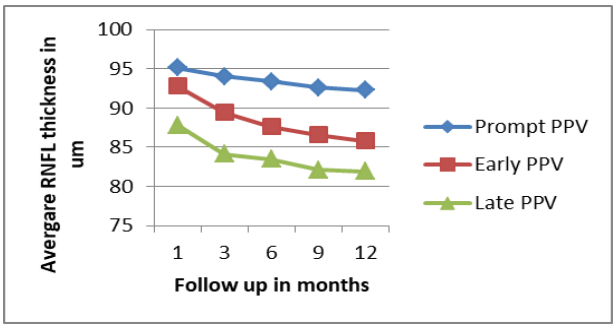

Figure 22: Average RNFL thickness changes in prompt, early and late PPV.

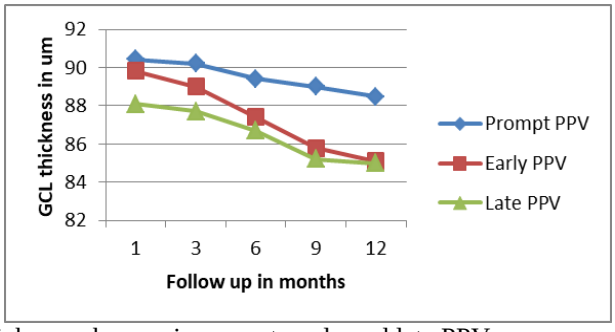

Figure 23: GCL thickness changes in prompt, early and late PPV.

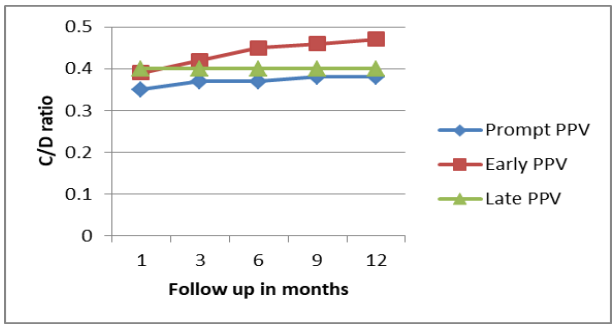

Figure 24: C/D ratio changes in prompt, early and late PPV.

3.6. *Anterior segment OCT changes*

Apart from the mean CCT at the 1st month, there was no significant difference all over the follow-up period between both groups in the three measured parameters. The mean AC angle was 28.8° and 29° in cases and controls, respectively at 1 month with minimal changes to 27.54° and 28.42° respectively at 12 month. The mean AC depth was 2.89mm and 2.88mm in cases and controls, respectively at 1 month, and minimally changed to 2.84mm and 2.86mm respectively at 12 month. At 1 month postoperative, CCT was 557.43 um and 552.69um in the study and control groups, respectively, to become 538.60um and 528.01um respectively at 12 month, tab. (26). Additionally, the changes over-time did not show any significant difference except for CCT at the 3rd month, figs. (25 & 26). As regard the measured anterior segment OCT parameters, no statistically significant difference was detected all over the follow up period among prompt, early and late PPV subgroups as shown in table, tab. (27). Similarly, there was no statistically significant difference between vitreous cutter and phacofragmatome subgroups in all postoperative follow up visits with minimal changes, tab. (28).

Table 26: Anterior segment OCT changes in the study and control groups.

	Study group		Control group		*p* value*
	mean±SD	*p1 value***	*mean±SD*	*p1 value***	
AC angle					
▪ 1 month	28.8 ± 2.0		29.0 ± 2.1		0.50
▪ 3 months	28.0 ± 2.0	0.302	29.o ± 2.0	0.910	0.60
▪ 6 months	28.3 ± 2.0	0.356	28.5 ± 2.2	0.722	0.60
▪ 9 months	28.3 ± 1.9	0.421	28.5 ± 2.0	0.440	0.70
▪ 12 months	27.54 ± 1.6	0.890	28.42 ± 1.85	0.301	0.10
ACD					
▪ 1 month	2.89 ± 0.26		2.88 ± 0.27		0.93
▪ 3 months	2.86 ± 0.24	0.091	2.84 ± 0.25	0.213	0.81
▪ 6 months	2.85 ± 0.25	0.430	2.85 ± 0.26	0.356	0.93
▪ 9 months	2.86 ± 0.25	0.223	2.87 ± 0.27	0.492	0.73
▪ 12 months	2.84 ± 0.25	0.819	2.86 ± 0.27	0.091	0.69
CCT					
▪ 1 month	557.43 ± 19.88		552.69 ± 15.52		0.02
▪ 3 months	549.86 ± 14.74	0.000	545.32 ± 11.46	0.401	0.06
▪ 6 months	544.31 ± 12.42	0.069	539.67 ± 8.87	0.070	0.07
▪ 9 months	539.66 ± 10.70	0.383	534.17 ± 9.71	0.082	0.07
▪ 12 months	538.60 ± 9.82	0.401	528.01 ± 12.84	0.090	0.20

***p-vale:** was calculated by independent sample t- test, ****p1 value:** was calculated by ANOVA test for changes overtime.*

Table 27: Anterior segment- OCT changes in prompt, early and late PPV subgroups*.

	Prompt PPV	Early PPV	Late PPV	*P* value**
ACA				
▪ 1 month	29.30±2.4	28.50±2.0	28.70±1.3	0.60
▪ 3 months	29.00±2.0	28.00±2.0	28.00±2.0	0.70
▪ 6 months	28.80±2.3	28.10±2.0	28.30±1.6	0.60
▪ 9 months	28.80±2.3	28.15±1.9	28.10±1.3	0.60
▪ 12 months	28.09±2.4	28.06±1.8	28.29±1.1	0.50
ACD				
▪ 1 month	2.94±0.25	2.87±0.27	2.86±0.24	0.70
▪ 3 months	2.90±0.18	2.84±0.28	2.83±0.24	0.70
▪ 6 months	2.88±0.20	2.85±0.29	2.80±0.20	0.80
▪ 9 months	2.89±0.23	2.86±0.29	2.80±0.20	0.70
▪ 12 months	2.88±0.22	2.84±0.29	2.79±0.22	0.70
CCT				
▪ 1 month	561.9±21.9	561.0±19.6	541.9±9.3	0.06
▪ 3 months	553.5±14.5	552.0±15.3	539.0±9.0	0.08
▪ 6 months	548.2±12.4	544.8±12.8	537.4±9.8	0.20
▪ 9 months	543.2±12.4	538.8±11.2	536.7±9.5	0.40
▪ 12 months	540.7±8.9	538.4±10.5	536.0±10.0	0.60

: The data is presented as mean ± SD, ***p: value was calculated by one way ANOVA.*

Table 28: Anterior segment OCT changes in the vitreous cutter only and phacofragmatome subgroups*

	Vitreous cutter only	Phacofragmatome	p value**
AC angle			
▪ 1 month	28.8 ± 2.2	28.7 ± 1.9	0.90
▪ 3 months	29.0 ± 2.0	28.0 ± 2.0	0.90
▪ 6 months	28.4 ± 2.1	28.2 ± 1.9	0.80
▪ 9 months	28.3 ± 2.0	28.4 ± 2.4	0.90
▪ 12 months	28.2 ± 1.7	27.10 ± 0.9	0.40
ACD			
▪ 1 month	2.91 ± 0.26	2.87 ± 0.26	0.08
▪ 3 months	2.88 ± 0.23	2.84 ± 0.25	0.10
▪ 6 months	2.86 ± 0.23	2.84 ± 0.26	0.10
▪ 9 months	2.86 ± 0.23	2.86 ± 0.27	0.20
▪ 12 months	2.84 ± 0.24	2.84 ± 0.27	0.50
CCT			
▪ 1 month	550.43 ± 19.23	562.10 ± 19.35	0.10
▪ 3 months	545.29 ± 14.54	552.90 ± 14.41	0.07
▪ 6 months	540.29 ± 10.62	547.00 ± 13.04	0.06
▪ 9 months	537.29 ± 9.55	541.24 ± 11.35	0.07
▪ 12 months	537.21 ± 9.20	539.52± 10.33	0.05

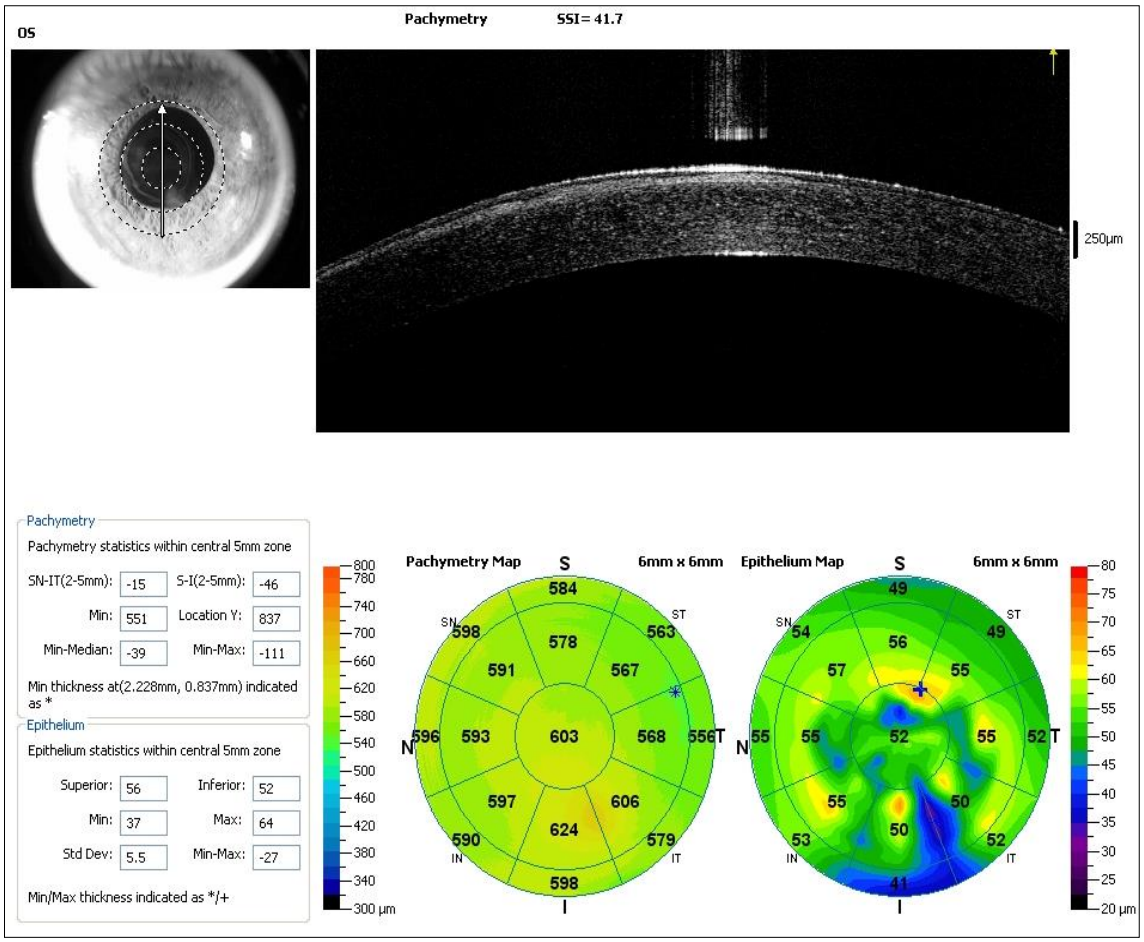

Figure 25: AS-OCT, printout of pachymetry map.

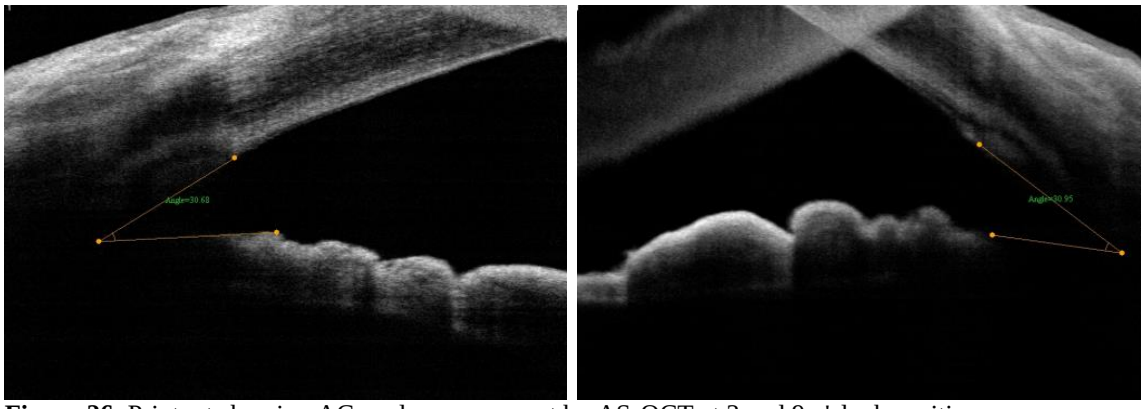

Figure 26: Printout showing AC angle meaurement by AS-OCT at 3 and 9 o'clock positions.

4. Discussion

The aim of this prospective non-randomized case study was to determine outcomes of prompt, early and late pars plana vitrectomy for dislocated lens fragments and/ or IOL in complicated phaco-emulsification with or without the use of intravitreal ultrasound, and to correlate functional outcomes with ultrastructural findings detected by OCT of the macula, the optic disc and the anterior segment. In previous studies, the main aim was to evaluate the clinical outcomes of PPV for cases complicated with dislocated lens fragments. They focused on visual outcomes and incidence of postoperative complications. One example was a ret-

rospective study performed by Ghasemi et al who studied 22 patients to report the outcomes of PPV and intravitreal phacoemulsification in patients with dropped nuclei/nuclear fragments following complicated cataract surgery [3]. In this study we tried to determine the prognostic factors in such cases, with special emphasis on the timing of PPV on one hand, and the use of intravitreal ultrasound emulsification on the other hand. Most previous studies were retrospective studies through reviewing the medical records of the patients. Koh, et al performed a retrospective, non-comparative case series where the medical records of 45 eyes of 45 consecutive patients were reviewed [4]. Similarly, Olokoba et al reviewed 32 eyes of patients who had PPV as treatment for dropped lens fragments complicating cataract surgery [5]. Few examples of prospective studies are that conducted by Yeo et al, Ahmed AN et al and Kumar et al. [6-8]. However, in our prospective study, we evaluated all cases and controls in 5 follow up visits as following; the end of 1st month, 3rd month, 6th month, 9th month and 12th month in order to detect both early and late postoperative changes.

4.1. *Visual outcomes*

Our results showed high statistically significant difference (p <0.01) between cases and controls in both UCVA and BCVA during the whole follow up visits. As expected, the control group which included uncomplicated cases had better visual outcomes than the study group. In the study group, we reported that more than two thirds of cases (65.7%) achieved favorable visual outcome (final BCVA 0.1-0.3), four eyes only (11.4%) had good visual outcome (final BCVA 0.5 or better), while about one fifth of cases (22.9%) ended with poor visual outcome (final BCVA worse than 0.1). Comparatively, a better visual outcome was reported by Chen et al who found that 49% of cases had final VA 0.5 or better [12]. Yang et al reported final VA 0.5 or better in 54% of cases [13]. In a relatively larger study, Paul et al studied the surgical and visual outcomes of posteriorly dislocated lens fragments after PPV in 149 eyes [14]. They reported that successful visual outcome was achieved in 85.2% of patients at 3 months follow up [14]. The lower percentage of the good visual outcome in our study in comparison to some previous studies can be explained with the difference in distribution of the cases according to the timing of PPV on one hand and the difference in the duration of the follow up period.

Dealing with an intraoperative complication and lacking preoperative OCT baseline data in the study group necessitated comparison with nearly matched control group. Many studies reported that 23-gauge PPV is a feasible approach in the surgical management of selected cases of retained lens fragments. One example of these studies was that conducted by Paul et al. [9]. In our study, we used 23-gauge transconjunctival PPV system in all cases. In cases necessitated the use of 20-gauge phacofragmatome, one sclerotomy was enlarged by a MVR blade to accommodate the 20-gauge phacofragmatome. Scupola et al studied the efficacy of 25-gauge (PPV) for the management of posteriorly dislocated lens material, and concluded that 25-gauge PPV is more efficient for cases with a limited amount of dislocated lens material [10]. Using a different technique, Gurunadh et al studied 36 eyes with dislocated nucleus where the nucleus was impaled with a MVR blade and brought into the anterior chamber from where it was delivered out. They reported visual recovery of 6/18 or better in 74% of cases [11].

4.2. *Postoperative complications*

The incidence of early and late postoperative complications was signifycantly higher in the study group. Early complications included corneal edema (37.1%), iritis (25.7%), hypotony (17.1%) and elevated IOP (31.4%). Some cases had a combination of these complications. By the end of the study, 3 eyes (8.6%) had a variety of corneal opacification, 7 eyes (20%) suffered 2^{ry} glaucoma and 4 eyes (11.4%) with chronic iritis. In a retrospective study enrolled on 60 eyes, Salehi et al found higher incidence of postoperative complications; 66.6% of eyes developed persistent uveitis, 53.3% of eyes showed elevated intra-ocular pressure (IOP) and 5 eyes retinal detachment [2]. In our study, we did not report any intraoperative complications. Also, no cases complicated with retinal breaks, retinal detachment or endophthalmitis were reported. This can be explained by thorough screening of the retinal periphery with scleral indentation by the end of PPV to exclude any missed or iatrogenic retinal breaks. Some previous studies reported cases complicated with RD associated with delayed vitrectomy, as that conducted by Chen et al [12]. (10% incidence of RD) and a higher incidence (30%) reported by Maria et al [15]. In their study, Paul et al reported iatrogenic retinal break in five patients during vitrectomy and five patients had retinal detachment [6]. In our study, the incidence of macular edema was higher in cases than controls. Spongiform macular edema was present in 17 eyes (48.6%) of the studied eyes compared to only 7 eyes (8.2%) in the control group. Cystoid macular edema was detected in more than one fifth (8 eyes, 22.8%) of the study group, while in the control group the incidence was only 3.5% (3 eyes). Our results are not markedly different from that found by Chen et al who reported an incidence of 27% for CME [12]. However, some studies reported a lower incidence of CME, and it was reported in only 4 eyes out from 149 eyes in a study conducted by Paul et al [9]. Moore et al investigated the incidence and outcomes of RD associated with dislocated lens fragments during cataract surgery. They reported that RD occurred in 44 of 343 (12.8%) patients, including 25 (7.3%) before or during PPV and 19 (5.5%) after PPV. The RD was macula-on in 22 of 44 (50%) patients and macula-off in 22 of 44 (50%) patients [16].

4.3. *OCT-changes*

As regard OCT-macula changes, there was a high significant difference between cases and controls (p value <0.01). Along the follow up period, both groups showed improvement in OCT-macula findings. Apart from the final follow up visit, a negative correlation was detected between parameters of OCT-macula and VA. Comparatively, in the control groups these parameters showed limited changes. Similarly, there was statistically high significant difference between both groups in the mean of RNFL thickness and GCL thickness, while C/D showed no significant difference between both groups. The mean of AC angle and ACD did not show any significant difference. However, the mean CCT had a significant difference from the 6th month postoperative and up to the end of the study. According to our best knowledge, there is no previous studies which assessed the OCT-changes in such cases including OCT-macula, OCT-glaucoma profile and anterior segment OCT. All previous studies assessed only the clinical outcomes, and some studies reported the changes in OCT-macula to determine the incidence of postoperative CME. In this study, we did not report any case with vitromacular interface disorders as epiretinal membrane (ERM) or vitromacular traction (VMT).

4.4. *The timing of PPV*

In this study, there were many factors upon which the timing of PPV was decided. These factors included availability of vitrectomy setting and posterior segment surgeon at the time of complicated cataract surgery, the status of the anterior segment especially presence of corneal edema or uveitis which precluded posterior segment visualization, and the nature of the dislocated item where in cases of only dislocated IOL, the risk of intraocular inflammation was minimal even with delayed PPV. Many studies tried to correlate the outcomes with the timing of PPV, comparing between early and late PPV. However, optimal vitrectomy timing is undetermined, and the effect of timing on outcomes is controversial. Some studies have suggested that outcomes are better if PPV is performed within two weeks of nucleus drop. Nevertheless, early PPV may avoid chronic glaucoma, and break the cycle of progressive lens-associated inflammation [17-22]. On the other hand, visualization for the retinal surgeon may also be initially poor due to corneal edema. As such, it may preferable to wait for edema and inflammation to decrease with medical therapy prior to PPV. In some cases, it may be preferable to treat the patient aggressively with topical steroids with or without aqueous suppressants to reduce corneal edema, inflammation, and fluctuation in the IOP prior to undertaking a secondary surgery [20-26]. A large retrospective series conducted by Modi et al reported no difference in visual acuity outcomes and complication rates between same-day and deferred PPV [22]. Similarly, Hansson et al reviewed case series of 65 patients and concluded that there was no statistically significant difference in outcomes between early and late vitrectomy [17]. Also, Rofagha et al reported that most retrospective studies assessing the timing of vitrectomy and lensectomy showed no advantage for early (within 1 week) PPV. However, they reported that delayed vitrectomy beyond 30 days is associated with poorer outcomes. On the other hand, several studies reported that early PPV carries better visual prognosis than late PPV [18]. In a prospective study of 22 patients, Yeo et al concluded that late vitrectomy was associated with higher risk of uveitis and raised IOP with poor visual outcomes compared to early vitrectomy [6]. In a retrospective review of the records of 78 patients, Chen et al compared the outcomes among three groups; same-day, early and late vitrectomy [12]. They concluded that immediate pars plana vitrectomy for retained lens fragments may achieve a better visual outcome, with reduced risk of secondary glaucoma, retinal detachment or cystoid macular edema. In our study, we found that prompt or same-day PPV had better outcomes than delayed PPV, while there was no statistically significant difference between prompt and early PPV on one hand, and between early and late PPV on the other hand in some parameters. However, the main significant difference was between prompt and late PPV subgroups. We found that there was statistically high significant difference ($p < 0.01$) in clinical outcomes among prompt, early and late subgroups. In order to detect the statistical significance difference between every two subgroups, the data was analyzed using one way ANOVA- Post Hoc multiple comparison. We detected that the significant difference was present between prompt and late subgroups, while there was no significant difference between prompt and early subgroups on one hand or between early and late subgroups on the other hand. More than one third of cases (5 eyes, 35.7%) in late PPV subgroup ended with poor visual outcome compared to 16.7% (2 eyes) and only 11.1% (one eye) in early and prompt PPV subgroups

respectively. The incidence of spongiform macular edema was 4 eyes (44.4%), 6 eyes (50%), and 7eyes (50%) in the prompt, early and late subgroups respectively. Cystoid macular edema was detected in 2 eye (22.2%), 2 eyes (16.7%) and 4 eyes (28.6%) respectively. Similarly, Ahmed et al evaluated the outcome of same-setting PPV in 8 eyes. They concluded that the same-setting PPV for the dislocated lens fragment has good visual prognosis and takes the advantage of surgery with a clear cornea and minimally inflamed eye that enable better removal of retained lens fragments with fewer complications [7]. Also, Soliman et al retrospectively reviewed 23 patients who underwent immediate pars plana vitrectomy. They concluded that immediate vitrectomy and intravitreal phacoemulsification is relatively safe procedure and most patients achieved a good visual outcome [19]. In a trial to correlate timing of PPV with visual outcomes, Maria et al who reviewed the records of 26 patients over 3-9 months follow up period. They concluded that early vitrectomy (fewer than 3 weeks) was associated with better visual results, while late vitrectomy resulted in limited visual acuity in a high percentage of patients and increased the risk for glaucoma and retinal detachment [15]. Expanding the duration of early vitrectomy for 3 weeks in that study should be taken in consideration as some studies defined early vitrectomy to be within one or two weeks from the cataract surgery. Comparatively, Travis et al tried to compare the outcomes between early versus late PPV through reviewing the records of 41 patients. They reported that there were no differences in rates of glaucoma, retinal detachment, or cystoid macular edema between the groups. They concluded that clinical outcomes were similar in patients undergoing early and late vitrectomy [20]. Similarly, Al-Amri reported that there was no statistically significant difference in outcome between those having vitrectomy the first week after cataract surgery and those having it later; however, there was a trend of better visual outcome in early vitrectomy patients [21]. However, in a retrospective study enrolled on 60 eyes, Salehi et al found that the early use of PPV to remove posterior dislocated lens fragments within the first week was shown to be advantageous. The inflammatory response was less pronounced, IOP rose less significant, the incidence of retinal detachment was lower and visual recovery was faster [2]. Merani et al reviewed the data of 223 eyes with mean follow up 20.5 months. They found that there was a high significant association between retinal detachment and a long interval (>30 days) between cataract surgery and vitrectomy (P= .00047) [22]. Comparatively, Marcus et al who analyzed the data of 172 eyes that underwent 20-, 23- or 25- PPV for retained lens fragments. They reported that the outcomes of same-day PPV appear to be similar to delayed PPV [23]. However, A recent retrospective study conducted by Chan et al and contemporary outcomes of 23-gauge PPV were evaluated. The study included 291 eyes. They detected that most frequent complications were de novo ocular hypertension (29 eyes, 10%) and transient cystoid macular edema (25 eyes, 8.6%). Post-vitrectomy retinal detachment occurred in 9 eyes (3.1%). They reported that only poorer pre-cataract surgery VA, delaying vitrectomy to later than 2 weeks, and final aphakic status were independently predictive of 20/200 or worse VA (P< .05). They also reported that IOL type or timing of placement do not impact final VA [24]. In our study, analysis of the OCT-macula findings showed that there was statistically high significant difference among the three subgroups in both central foveal thickness and macular volume. However, there was no significant difference in the average macular thickness. In order to detect the statistical difference significance between every two subgroups, the data was analyzed using one way ANOVA- Post Hoc multiple comparison. There was no statistically sig-

nificant difference between prompt PPV and early PPV subgroups in all parameters. Although there was significant difference between prompt PPV and late PPV subgroups on one hand and between early PPV and late PPV subgroups on the other hand. This difference was reported in all items of OCT-macular changes except the average macular thickness. On the other hand, there was no detected significant difference among the three subgroups in any parameters of neither OCT-glaucoma profile nor anterior segment OCT changes.

4.5. *The method of intravitreal emulsification*

In our study, the surgical techniques were built on an existing evidence of the efficacy and efficiency of 23-gauge transconjunctival PPV system in managing such complication. We classified the study group into two categories, the vitreous cutter only subgroup and the phacofragmatome subgroup. The same technique was used in many previous studies, one example is that conducted by Barthelmes et al who evaluated the outcomes of hybrid 20/23-gauge PPV in 42 eyes. They found that the majority (83.3%) achieved a visual acuity of 0.3 (Log MAR) or better, and 19 eyes (45.2%) achieved a final visual acuity of 0 (Log MAR). Overall, 95.2% of the eyes had a better postoperative visual acuity compared with the preoperative visual acuity [25]. Some previous studies evaluated the efficacy of 25-gauge pars plana vitrectomy (PPV) for the management of posteriorly dislocated lens material. Scupola et al reviewed the medical records of 40 patients who have been classified into two groups; group A (≤50% dropped nucleus) and group B (>50% dropped nucleus). They concluded that 25-gauge PPV is an effective procedure, although it appears to be most efficient for cases with a limited amount of dislocated lens material [10]. In this study, we reported better visual outcome in the vitreous cutter only subgroup compared to the phacofragmatome subgroup. This can be explained by the lower incidence of postoperative complications in the 1st subgroup and that it also included cases with only dislocated IOL with lesser inflammatory response. Both UCVA and BCVA showed a high significant difference in all follow up visits. One third of eyes in the 2nd subgroup had poor visual outcome, while only one eye (7.1%) in the 1st subgroup had the same outcome. All postoperative complications apart from IOL decentartion occurred with higher incidence in the phacofragmatome subgroup with incidence of CME was 28.6% compared to only 14.2% in the vitreous cutter subgroup. However both subgroups did not show any significant difference in all parameters measured by OCT. For analysis of a different factor, Chiang et al conducted a retrospective case series to compare between the torsional phacoemulsification hand piece versus the fragmatome during PPV for removal of posterior segment retained lens material. They reported that the use of torsional phacoemulsification during PPV for retained lens material is a novel approach with potential advantages over the standard 20-gauge fragmatome, including improved followability and purchase of lens material attributable to the addition of torsional movement [26]. In comparison, we used longitudinal intravitreal phacoemulsification and we did not evaluate the correlation between total ultrasound time and outcomes. Similarly, in a prospective case series on 15 eyes, Kumar and Takkar evaluated the results of intravitreal phacoemulsification using sleeveless, torsional hand piece (*OZiL™, Alcon's Infiniti Vision System*).They concluded that intravitreal phacoemulsification using torsional hand piece is a safe and effective alternative to conventional longitudinal phacofragmentation [8]. Jang et al described using perfluorocarbon liquid (PFCL) during 23-gauge PPV in management of dislocated crystalline lens. The dislocated lens floated

on the PFCL, and the injection was ceased once the lens had risen to the iris plane. The lens was then removed from the anterior chamber using standard phacoemulsification procedures [27]. Similarly, Lee et al concluded that PFCL reduces lens repulsion and blocks the transmission of the ultrasound stream to the retina [28]. In our study; we used PFCL only in selected cases with dislocated whole nucleus on the macula (2 eyes). A medium-sized perfluorocarbon (PFCL) bubble was injected beneath the nucleus in order to float the nucleus away from the macula, and to protect the macula during frequent nuclear dislodgment from the vitrectomy probe.

5. Conclusion

Timing of PPV is an important factor affecting both clinical and OCT-outcomes in dislocated nuclear fragments and IOL. The prompt PPV was associated with the best outcome followed by the early PPV. Cases in which, intravitreal ultrasound emulsification was indicated, had poorer prognostic outcome.

References

1. Schaal, S., Barr, C. Management of retained lens fragments after cataract surgery with and without pars plana vitrectomy. ***J Cataract Refract Surg***. 2009; 35 (5): 863-867.

2. Salehi, A., Razmju, H., Beni, A., et al. Visual outcome of early and late pars plana vitrectomy in patients with dropped nucleus during phacoemulsification. ***J Res Med Sci.*** 2011; 16: 1422-1429.

3. Ghasemi, F., Hashemi, M., Jalili, F., et al. Pars plana vitrectomy and intravitreal phacoemulsification for dropped nuclei. ***J Ophthalmic Vis Res.*** 2012; 7: 125-129.

4. Koh, K., Kim, H., Cho, H., et al. Surgical outcomes of 23-gauge vitrectomy for the management of lens fragments dropped into the vitreous cavity during cataract surgery. ***Saudi J Ophthalmol.*** 2014; 28: 253-256.

5. Olokoba, L., Islam, T., Nahar, N., et al. A 3-year review of the outcome of pars plana vitrectomy for dropped lens fragments after cataract surgery in a tertiary eye hospital in Dhaka, Bangladesh. ***Ethiop J Health Sci.*** 2017; 27:427-432.

6. Yeo, L., Charteris, D., Bunce, C., et al. Retained intravitreal lens fragments after phacoemulsification: A clinicpathological correlation. ***Br J Ophthalmol***. 1999; 83 (10): 1135-1138.

7. Ahmed, A., Yousef, H. & Abdelrahaman, H. Same-setting pars plana vitrectomy for management of dislocated lens fragments during phacoemulsification. ***Al-Azhar Assiut Med J*** 2018; 16: 38-42.

8. Kumar, D., Agarwal, A., Prakash, G., et al. IOL scaffold technique for posterior capsule rupture. ***J Refract Surg***. 2012; 28: 314-315.

9. Baker, P., Spirn, M., Chiang, A., et al. 23-Gauge transconjunctival pars plana vitrectomy for removal of retained lens fragments. ***Am J Ophthalmo***l. 2011; 152(4): 624-627.

10. Scupola, A., Abed, E., Sammarco, M., et al. 25-gauge pars plana vitrectomy for retained lens fragments in complicated cataract surgery. ***Ophthalmologica***. 2015; 234: 101-108.

11. Gurunadh, V., Banarji, A., Ahluwalia, T., et al. Management of nucleus and IOL drop. ***J Cataract Refract Surg.*** 2003; 29 (10): 1985-1988.

12. Chen, C., Wang, T., Cheng, J., et al. Immediate pars plana vitrectomy improves outcome in retained intravitreal lens fragments after phacoemulsification. ***Ophthalmologica***. 2008; 222 (4): 277-283.

13. Yang, C., Lee, F., Hsu, W., et al. Management of retained intravitreal lens fragments after phacoemulsification

surgery. ***Ophthalmologica.*** 2002; 216: 192-197

14. Paul, L., Agarwal, M., Singh, S., et al. Surgical and visual outcomes of posterior dislocated lens fragments after cataract surgery during 5-years at a tertiary eye hospital of North India. ***Nepal J Ophthalmol.*** 2019; 11 (2): 172-180.

15. Maria, S., Miltiadis, A., Chrisavgi, P., et al. Timing of dislocated nuclear fragment management after cataract surgery. ***Review Int Ophthalmol***. 2018; 38 (6): 2699-2707.

16. Moore, J., Scott, I., Flynn Hw, Jr., et al. Retinal detachment in eyes undergoing pars plana vitrectomy for removal of retained lens fragments. ***Ophthalmology.*** 2003; 110: 709-713.

17. Modi, Y., Epstein, A., Smiddy, W., et al. Retained lens fragments after cataract surgery: Outcomes of same-day versus later pars plana vitrectomy. ***Am J Ophthalmol.*** 2013; 156: 454-459.

18. Rofagha, S., Bhisitkul, R. Management of retained lens fragments in complicated cataract surgery. ***Curr Opin Ophthalmol***. 2011; 22: 137-140.

19. Soliman, M., Eid, M., Shalaby, K., et al. Intravitreal phacoemulsification with pars plana vitrectomy for management of posteriorly dislocated nucleus or lens fragments. ***Eur J Ophthalmol.*** 2010; 20: 115-119.

20. Travis, P., Janice, P., Asima, B, et al. Timing of vitrectomy for retained lens fragments after cataract surgery. ***Retina***. 2014; 34 (10): 1969-1976.

21. Al-Amri, A. Visual outcome of pars plana vitrectomy for retained lens fragments after phacoemulsification. ***Middle East Afr J Ophthalmol*** 2008; 15: 107-111.

22. Merani, R., Hunyor, A., Playfair, T., et al. Pars plana vitrectomy for the management of retained lens material after cataract surgery. ***Am J Ophthalmol.*** 2007; 144 (3): 364-370.

23. Marcus, H., Daniel, M., Noureen, J., et al. Same-day versus delayed vitrectomy with lensectomy for the management of retained lens fragments. ***Retina.*** 2011; 31 (8): 1534-1540.

24. Chan, E., Yang, E., Eldeeb, M., et al. Contemporary outcomes and prognostic factors of 23-gauge vitrectomy for retained lens fragments after phacoemulsification. ***Am J Ophthalmol***. 2020; 219: 271-283.

25. Barthelmes, D., Alexander, S., Mitchell, P., et al. Hybrid 20/23-gauge pars plana vitrectomy for retained lens fragments after cataract surgery. ***Retina.*** 2012; 32 (9): 1749-1755.

26. Chiang, A., Garg, S., Alshareef, R., et al. Removal of posterior segment retained lens material using the OZil phacoemulsification handpiece versus fragmatome during pars plana vitrectomy. ***Retina.*** 2012; 32: 2119-2126.

27. Jang, H., Lee, S., Park, J. Phacoemulsification with perfluorocarbon liquid using a 23-gauge transconjunctival sutureless vitrectomy for the management of dislocated crystalline lenses. ***Graefes Arch Clin Exp Ophthalmol.*** 2013; 251 (5): 1267-1272.

28. Lee, S., Kim, I. & Park J. Management of posteriorly dislocated crystalline lens with perfluorocarbon liquid and fibrin glue-assisted scleral-fixated intraocular lens implantation. ***J Cataract Refract Surg.*** 2013; 39 (3): 334-338.