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Original Article

QUANTITATIVE ANALYSIS OF ANTERIOR CHAMBER CHANGES AFTER PARS PLANA VITRECTOMY WITH SILICONE OIL TAMPONADE. A SCHEIMPFLUG IMAGING STUDY

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Abstract

Purpose: *To highlight the anterior chamber parameters changes after pars plana vitrectomy with silicone oil tamponade by Scheimpflug imaging.* ***Methods:*** *A prospective observational study was conducted on 20 patients (20 eyes) who had PPV for various indications. Using Scheimpflug imaging, all participants were assessed before PPV with Silicone oil tamponade and 1 week after the surgery to demonstrate the changes in AC parameters. The primary outcome measure was the change in central AC depth, while the secondary outcome measures were the changes in peripheral AC depth, AC volume, and anterior chamber angle.* ***Results:*** *There was a statistically significant reduction in CACD and Average PACD compared with the preoperative values (P=0.013 and <0.001, respectively). Moreover, there was a significant moderate positive correlation between AvPACD difference and preoperative AvPACD (r=0.512, P-value<0.001). There was a significant reduction in mean ACV compared with the preoperative value (P=0.010). There was a significant, strong positive correlation between ACV difference and preoperative ACV (r=0.742, p value <0.001). The mean ACA was 36.96°±12.89° preoperatively and decreased to 33.90°±8.44° one week postoperatively. However, this change was not statistically significant (P=0.293). There was a statistically significant strong positive correlation between ACA difference and preoperative ACA (r=0.781, p-value<0.001).* ***Conclusion****: Silicone oil tamponade with PPV induces significant short-term alterations in anterior chamber parameters, particularly a reduction in anterior chamber depth and volume. A comprehensive understanding of these parameter variations is essential for effective postoperative management.*

Keywords: *Anterior chamber depth, Pars plana vitrectomy, Scheimpflug imaging, Silicone oil tamponade.*

1. Introduction

Pars plana vitrectomy (PPV) is a surgical procedure involving the removal of the vitreous gel from the eye. It is mainly indicated in rhegmatogenous retinal detachment, vitreomacular traction, vitreous hemorrhage, retained lens fragments after cataract surgery, endophthalmitis, epiretinal membrane, macular hole, and intraocular foreign bodies [1]. The improvement of surgical techniques and instruments in PPV has increased the anatomical and functional success in treating various vitreoretinal disorders. However, postoperative changes of the anterior segment parameters may result in postoperative complications and refractive changes affecting the functional outcome and the quality of vision [2,3]. Such complications may include glaucoma resulting from narrowing of the anterior chamber angle (ACA), shallowing of the anterior chamber, and ciliary body detachment [4-7]. Scheimpflug imaging, Anterior Segment Optical Coherence Tomography (*AS*-OCT), and Ultrasonic Biomicroscopy (UBM) have provided quantitative evaluation of the morphological changes of the anterior segment, including swelling and anterior rotation of the ciliary body, forward shifting of the lens–iris diaphragm, and narrowing or closure of the anterior angle [8,9]. In order to objectively evaluate anterior segment parameters, Pentacam offers sectional spatial planes with a revolving Scheimpflug camera. This enables the assessment and measurement of anterior segment parameters in a three-dimensional model [10]. The aim of this study is to utilize the Scheimpflug camera to analyze the anterior chamber morphological changes in the early postoperative period of patients who undergo PPV with silicone oil tamponade.

2. Methods

2.1. *Study design*

A prospective observational study was conducted between June 2023 and October 2024 under the tenets of the Helsinki Declaration. Informed consent was obtained from all participants after a discussion of the procedure, and the study was approved by the Ethics Committee of the Faculty of Medicine, Assiut University (IRB No. 04-2023-200127).

2.2. *Inclusion and exclusion criteria*

Patients suffering from different vitreoretinal disorders and planned for pars plana vitrectomy and Silicone oil tamponade were included in the study. Vitreoretinal disorders include rhegmatogenous retinal detachment, diabetic vitreous hemorrhage, and diabetic tractional retinal detachment Patients were included regardless of lens status (Phakic or Pseudophakic), provided that pseudophakic patients had undergone cataract surgery at least six months before PPV. Patients were excluded if they had a history of ocular trauma, pre-existing glaucoma, active or chronic anterior uveitis, complicated cataract surgery, IOL-related complications, previous vitreoretinal surgery, visually significant cataract requiring combined phacoemulsification with PPV, significant corneal opacity, development of significant post-PPV complications, and poor signal in Scheimpflug imaging. Patients were also excluded if IOP measurement was beyond 21 mmHg at the end of the surgery or on the 1st postoperative day or the 1st postoperative week follow-up visits.

2.3. *Preoperative evaluation*

A complete medical and ocular history was obtained along with thorough ophthalmological examination, including Best corrected visual acuity (BCVA) (Snellen chart converted into the logarithm of minimum angle of resolution (LogMAR) for statistical analysis), intraocular pressure (IOP) measurement (iCare ® IC100, Finland), Slit lamp biomicroscopic examination of the anterior segment, and fundus examination by + 78 D lens.

2.4. *Scheimpflug camera protocol*

All participants were examined by the Scheimpflug camera (The WaveLight® Oculyzer ™ II diagnostic system, USA) 1 day before surgery and 1 week postoperatively by a single experienced physician. The following Scheimpflug camera parameters were evaluated: central anterior chamber depth (cACD), peripheral anterior chamber depth (pACD), anterior chamber volume (ACV), and anterior chamber angle (ACA).

2.5. *Surgical procedure*

Pupillary dilatation was achieved using cyclopentolate hydrochloride 1% eye drops and tropicamide 1% eye drops within 30 minutes before surgery. All surgeries were performed by a single experienced surgeon (W.S.). A 23-gauge three-port PPV was performed through two superior sclerotomies at 2 o'clock and 10 o'clock with an infusion cannula placed in the inferotemporal quadrant**.** Core vitrectomy and triamcinolone-assisted induction of posterior vitreous detachment were also performed. In retinal detachment cases, retinal flattening was achieved by perfluorocarbon liquids, and retinal breaks were treated with endolaser photocoagulation**.** In proliferative diabetic retinopathy (PDR) cases, fibrous membranes were manipulated by segmentation and delamination techniques, and endo-laser photocoagulation was completed**.** After air–fluid exchange, 2000 centistoke (cSt) Silicone Oil was injected. Sclerotomies were sutured with 7/0 Vicryl suture to avoid SO bubble escape. IOP was checked three times, once at the end of the surgery and re-measured again on the 1st day and 1st week postoperatively to exclude IOP rise due to SO overfilling. All participants received Topical moxifloxacin 5mg/ml four times daily for 3 weeks, in addition to Topical prednisolone acetate 1% was prescribed four times daily for one week, twice daily for one week, and once daily for one week.

2.6. *Study outcome measures*

The primary outcome measure is the mean change in CACD after PPV with SO tamponade. Secondary outcome measures are mean changes in PACD, mean change in PACD in each quadrant, ACV, and ACA.

2.7. *Statistical analysis*

Data analysis was performed using SPSS version 26. Categorical data were presented in the form of frequencies and percentages. Numerical data were assessed for normality using the Shapiro-Wilk test and presented as mean ± standard deviation. Paired Sample T-test was used to compare preoperative and postoperative parameters. Independent Sample T-test was used to compare mean differences between phakic and pseudophakic groups.

3. Results

Demographic characteristics of patients are demonstrated in tab. (1). The study included 20 eyes of 20 patients; all underwent PPV and silicone oil injection. The age of the patients ranged from 10 to 60 years, with a mean of 43.80±14.81 years. There were 17 males (85%) and 3 females (15%).

3.1. *Changes in anterior chamber depth*

There was a statistically significant reduction in CACD, 4-peripheral ACD, and Average PACD compared with the preoperative values (P=0.013, <0.001, 0,004, 0.002, <0.001, and <0.001, respectively). The CACD was 3.49±1.03 mm preoperatively and decreased to 3.20±0.98 mm one week postoperatively. The Average PACD was 2.67±0.57 mm preoperatively and decreased to 2.04±0.50 mm one week postoperatively, tab. (2). There was an insignificant positive correlation between CACD difference and preoperative CACD (r=0.403, P-value = 0.078). On univariate linear regression, there was a proportional CACD increase of 0.148 mm for each 1 mm preoperative CACD. Moreover, there was a significant moderate positive correlation between AvPACD difference and preoperative AvPACD (r=0.512, P-value <0.001). On univariate linear regression, it was significant as an increase in preoperative AvPACD by one mm was associated with an increase in AvPACD difference by 0.338 mm, p-value<0.021, and R2=0.262, tab. (3). & fig. (1). The change in anterior chamber depth in two of the study cases is shown in fig. (2).

3.2. *Change in anterior chamber volume*

There was a significant reduction in mean ACV compared with the preoperative value (P=0.010). The ACV was 185.15±58.02 mm3 preoperatively and decreased to 149. 15±41.17 mm3 one week postoperatively, tab. (2). There was a significant, strong positive correlation between ACV difference and preoperative ACV (r=0.742, p value <0.001). On univariate linear regression, it was significant as an increase in preoperative ACV by one mm3 was associated with an increase in ACV difference by 0.722 mm3, tab. (3). & fig. (1).

3.3. *Change in anterior chamber angle*

The mean ACA was 36.96°±12.89° preoperatively and decreased to 33.90°± 8.44° one week postoperatively. However, this change was not statistically significant (P=0.293), tab. (2). There was a statistically significant strong positive correlation between ACA difference and preoperative ACA (r=0.781, p-value<0.001). On univariate linear regression, it was statistically significant as an increase in preoperative ACA by one degree was associated with an increase in ACA difference by 0.766°, p-value<0.001, and R^2=0.610, tab. (3). & fig. (1).

3.4. *Change in anterior chamber parameters in phakic and pseudophakic patients*

Reduction in CACD and ACV was significant in phakic patients (P value: 0.001 and 0.028, respectively) but not in pseudophakic patients (P value: 0.786 and 0.112, respectively). Moreover, the reduction in AvPACD was significant in both phakic and pseudophakic patients (P <0.001 and 0.025, respectively). However, there was no significant decrease in ACA in both phakic and pseudophakic patients, tab. (4).

Table 1: Demographic characteristics of ***patients***

Age	
▪ ***Mean ± SD (range)***	43.80±14.81 (23-61)
Gender	
▪ ***Males***	17 (85%)
▪ ***Females***	3 (15%)
Lens status	
▪ ***Phakic n (%)***	14/20 (70%)
▪ ***Pseudophakic n (%)***	6/20 (30%)
IOP (Mean ± SD)	
▪ ***Baseline***	13.70±2.27
▪ ***1 day postoperative***	14.8±1.95
▪ ***1 week postoperative***	15.65±2.05
Indications of vitrectomy	
▪ ***RRD, n (%)***	13 (65%)
▪ ***TRD, n (%)***	5 (25%)
▪ ***VH, n (%)***	2 (10%)

RRD: *rhegmatogenous retinal detachment,* ***TRD:*** *tractional retinal detachment,* ***VH:*** *vitreous hemorrhage.*

Table 2: Baseline and postoperative CACD, PACD, ACV, and ACA changes

	Baseline	**1-week postoperative**	**P-value**
Central ACD			
▪ ***Mean ± SD (range)***	3.49±1.03 (2.02-5.69)	3.20±0.98 (1.97-5.39)	0.013
Peripheral ACD			
▪ ***Superior ACD Mean ± SD (range)***	2.60±0.82 (0.82-4.36)	1.84±0.63 (0.40-2.79)	0.001
▪ ***Inferior ACD Mean ± SD (range)***	2.75±0.77 (1.52-4.83)	2.17±0.43 (1.50-2.95)	0.004
▪ ***Nasal ACD Mean ± SD (range)***	2.31±0.70 (1.16-3.98)	1.87±0.49 (0.66-2.76)	0.002
▪ ***Temporal ACD Mean ± SD (range)***	3.00±0.68(1.43-4.10)	2.27±0.62 (0.77-3.31)	0.001

Average Peripheral ACD			
▪ ***Mean ± SD (range)***	2.67±0.57 (1.23-3.83)	2.04±0.50 (0.90-2.95)	0.001
ACV			
▪ ***Mean ± SD range***	185.15±58.02 (75-355)	149.15±41.17 (60-241)	0.010
ACA			
▪ ***Mean ± SD range***	36.96±12.89 (21.8-62.3)	33.90±8.44 (19.0-46.2)	0.293

ACA: *anterior chamber angle,* ***ACD:*** *anterior chamber depth,* ***ACV:*** *anterior chamber volume*

Table 3: Linear regression for AC difference with preoperative CACD

	Difference (pre-post)				
	Correlation		***Univariate linear regression***		
	r	P-Value	R^2	ß (95% CI)	P-value
Preoperative CACD	0.403	0.078	0.109	0.148 (-0.06-0.35)	0.156
Preoperative Average PACD	0.512	<0.001	0.262	0.338 (0.10-0.619)	0.021
Preoperative ACV	0.742	<0.001	0.550	0.722 (0.39-1.04)	0.001
Preoperative ACA	0.781	<0.001	0.610	0.766 (0.46-1.06)	0.001

P value: *is significant if <0.05,* ***r:*** *(correlation coefficient),* R^2*: (R square),* ***ß:*** *beta coefficient; 95% CI: 95% confidence interval (lower-upper),* ***ACA:*** *anterior chamber angle,* ***ACV:*** *anterior chamber volume,* ***CACD:*** *central anterior chamber depth,* ***PACD:*** *peripheral anterior chamber depth*

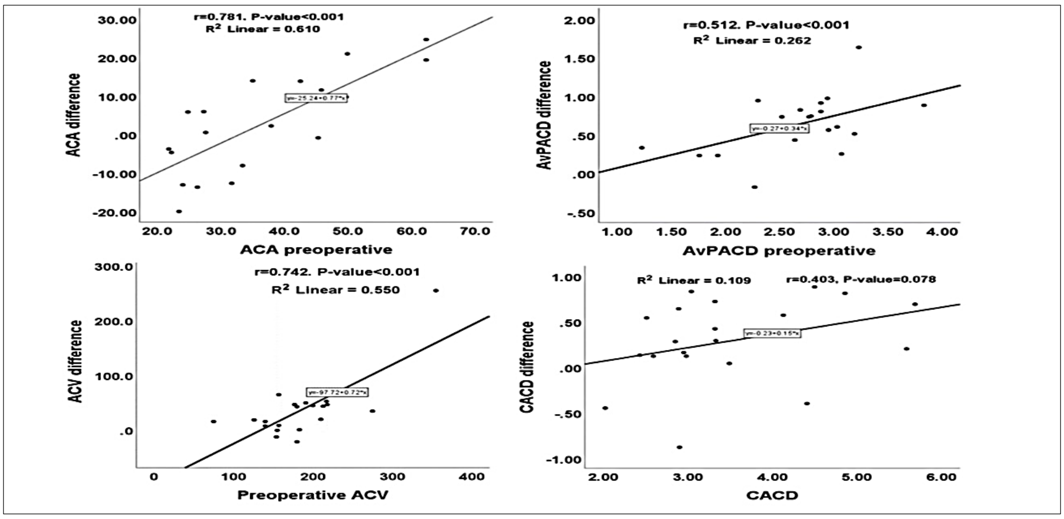

Figure 1: Scatter diagram for correlation between CACD, AvPACD, ACV, and ACA difference with preoperative CACD, AvPACD, ACV, and ACA.

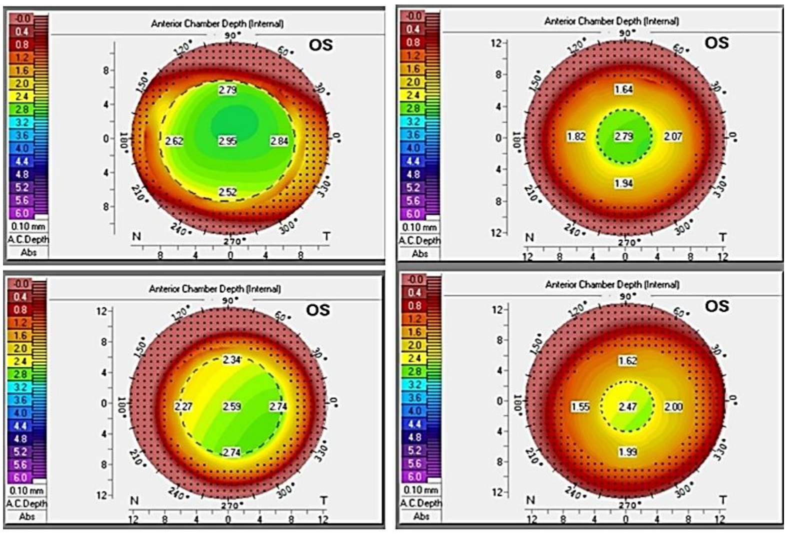

Figure 2: Scheimpflug imaging of AC depth at baseline (left column) and 1-week postoperative (right column) in two of the study cases.

Table 4: Changes in AC parameters in phakic and pseudophakic patients

	Phakic (n=14)	Pseudophakic (n=6)
CACD		
▪ ***Pre***	3.35±1.01 (2.43-5.69)	3.80±1.10 (2.02-4.86)
▪ ***Post***	2.98±1.01 (1.97-5.39)	3.71±0.76 (2.47-4.81)
▪ ***P-Value****	<0.001	0.786
AvPACD		
▪ ***Pre***	2.71±0.51 (1.76-3.83)	2.59±0.73 (1.23-3.19)
▪ ***Post***	1.99±0.44 (1.36-2.95)	2.15±0.64 (0.90-2.68)
▪ ***P-Value****	<0.001	0.025
ACV		
▪ ***Pre***	190.86±61.18 (126-355)	171.83±52.48 (75-218)
▪ ***Post***	147.71±39.65 (93-241)	152.50±48.31 (60-191)
▪ ***P-Value****	0.028	0.112
ACA		
▪ ***Pre***	37.80±13.18 (22.2-62.3)	35.00±13.18 (21.8-49.7)
▪ ***Post***	32.24±8.59 (19.0-44.4)	37.76±7.32 (25.6-46.2)
▪ ***P-Value****	0.116	0.608

*Paired Sample T-test. P value is significant if <0.05. ***SD:*** standard deviation. ***ACA:*** anterior chamber angle, ***AvPACD:*** average peripheral anterior chamber depth, ***ACV:*** anterior chamber volume, ***CACD:*** central anterior chamber depth.

4. Discussion

The increasing anatomical success of pars plana vitrectomy (PPV) has shifted focus to factors influencing functional outcomes, including refractive changes and postoperative complications related to alterations in anterior segment parameters. However, significant controversy exists regarding anterior segment changes following posterior segment surgery. These discrepancies likely arise from variations in lens status, imaging modalities (A-scan, UBM, AS-OCT, Pentacam), the use and type of retinal tamponade (silicone oil or gas), and diverse indications for vitrectomy. In this study, we employed the Pentacam Scheimpflug camera, a non-contact method minimizing pressure-induced artifacts, to evaluate anterior chamber changes. Twenty eyes of twenty patients undergoing 23-gauge PPV with silicone oil injection were examined preoperatively and one week postoperatively to assess short-term changes in anterior chamber depth (ACD), volume (ACV), and angle (ACA). The current study findings demonstrated a significant decrease in central ACD (cACD), average peripheral ACD (AvPACD), and ACV one week after PPV with silicone oil injection. Notably, these changes were more pronounced in phakic eyes compared to pseudophakic eyes. This difference may be attributed to the inherent structural dissimilarity between the crystalline lens and an intraocular lens (IOL). The crystalline lens, with its more convex posterior surface and larger anteroposterior diameter, may amplify the impact of posterior segment configuration changes and the anterior pressure exerted by silicone oil on cACD and AvPACD. The observed postoperative reduction in ACV could be attributed to several factors, including supraciliary effusion, iris congestion, increased lens thickness, and corneal edema. While we observed a greater decrease in postoperative ACA in phakic eyes compared to pseudophakic eyes, the overall change in ACA at one week postoperatively was not statistically significant. This suggests that the crystalline lens, due to its inherent shape, may predispose the angle to narrowing or closure in the presence of supraciliary effusion, iris congestion, silicone oil pressure on the iris-lens diaphragm, or peripheral anterior synechiae. Our findings are consistent with previous studies, Gohari et al. [11] reported a significant decrease in ACD three months after deep vitrectomy with silicone oil tamponade using IOL Master. Similarly, Ünsal FICO et al. [12] found a significant reduction in ACD and trabecular meshwork-iris angle (TIA) in phakic eyes one week after PPV with silicone oil, but not with gas tamponade, using UBM. However, our results diverge from several studies that reported no significant postoperative changes in ACD, ACV, or ACA following vitrectomy with silicone oil [13, 16], Calik et al. [13], using Pentacam, found no significant difference in ACD and ACA one week postoperatively, and even observed an increase in ACV, which they attributed to the cohesive forces of silicone oil, Ünsal et al. [14] reported no significant changes in ACD or TIA in pseudophakic eyes using UBM. Ghomi and Ghassemi [15] reported no significant ACD changes in phakic eyes, attributing it to possible lens subluxation during UBM, Osman et al. [16] found a significant decrease in ACV, but also reported a significant decrease in ACA, and a greater ACD reduction in pseudophakic eyes, which contrasts with our findings, Al Ashry et al. [17] reported no significant ACD changes at any postoperative time point. Furthermore, studies examining anterior chamber changes after vitrectomy without silicone oil also exhibit variability, Neudorfer et al. [18] found a significant ACD decrease with gas tamponade, while Byrne et al. [19] and Marigo et al. [20] reported no significant changes without tamponade. Conversely, Kim et al. [21] found a significant increase in ACD after vitrectomy using swept-source OCT. However, the current study had limitations, including the relatively small sample size, constrained by patient availability and strict inclusion criteria during the study period, which limited the statistical power to detect subtle postoperative changes in anterior chamber parameters. The unequal distribution of phakic and pseudophakic patients hindered meaningful between-group comparisons. Future studies with larger, balanced cohorts are necessary to fully elucidate the impact of lens status on anterior segment changes following PPV with silicone oil. Further research is warranted to explore the relationship between postoperative IOP and ACA. While the Pentacam Scheimpflug camera is reliable for corneal and ACD/ACV assessment, its accuracy in ACA imaging is limited, showing a relatively low correlation with gonioscopy. Finally, future research should investigate the influence of varying silicone oil viscosities on anterior segment changes. Additionally, it would be beneficial to correlate the anterior segment changes with the different vitrectomy indications.

5. Conclusion

PPV with silicone oil tamponade induces significant short-term alterations in anterior segment characteristics, particularly a decrease in anterior chamber depth and volume. These changes may contribute to postoperative complications, especially elevated intraocular pressure. A comprehensive understanding of these parameter variations is essential for effective postoperative management. A thorough understanding of the effects of vitrectomy on anterior segment morphology will enable surgeons to better anticipate and manage the postoperative course of patients with silicone oil tamponade.

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