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Changes in Anterior Segment Parameters Following Pars Plana Vitrectomy Measured by Ultrasound Biomicroscopy (UBM)

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ABSTRACT

Despite being a posterior segment ocular surgery, pars plana vitrectomy (PPV) may also affect anterior segment parameters. We aimed to investigate anterior segment alterations following PPV using ultrasound biomicroscopy (UBM) to visualize the structural anatomy of the eye.

In this study, we enrolled phakic patients undergoing PPV (as the sole procedure). The anterior chamber depth, crystalline lens anterior-posterior (AP) diameter, anterior chamber angle, ciliary body dimensions, and integrity of the ciliary zonules and posterior capsule were assessed using UBM before and at least 3 months after PPV. Seven eyes from seven patients were included in the study. The indications for PPV were rhegmatogenous retinal detachment (57%), epiretinal membrane (29%), and macular hole (14%). The mean age of the patients was 57.86 ± 6.56 years, and they were followed up for a mean of 131.57 ± 29.99 days.

The crystalline lens AP diameter was the only parameter that changed significantly following PPV ($p = 0.042$). Thus, increases in the crystalline lens AP diameter, without significant changes in the anterior chamber depth, can be expected after PPV due to the development of nuclear sclerotic cataracts.

KEY WORDS

Anterior Segment Parameters; Pars Plana Vitrectomy; Ultrasound Biomicroscopy (UBM); Anterior Chamber Depth; Crystalline Lens; Anterior Chamber Angle; Ciliary Body Dimensions

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INTRODUCTION

Pars plana vitrectomy (PPV) is one of the most common vitreoretinal surgeries, and it is carried out to treat pathologies such as macular hole, vitreous hemorrhage, and retinal detachment (1). There are numerous complications associated with PPV, including cataracts, exacerbation of cystoid macular edema, and retinal detachment (2) while the most common complication reported in the literature is the progression of nuclear sclerosis (2-5). The mechanisms behind the development of cataract following PPV have been discussed extensively. First, vitrectomy may disrupt homeostasis in the posterior segment, and thus disturb the natural equilibrium. Second, prolonged exposure to a high concentration of oxygen during the surgery leads to production of reactive species and, hence, oxidative stress. The postoperative inflammation in the anterior and posterior chambers may also contribute to further opacification of the crystalline lens. In addition, the tamponade that is used to replace the vitreous may have cataractogenic effects. Another explanation for the development of post-vitrectomy cataract is related to the trauma caused by intraocular devices, which can lead to the formation of posterior subcapsular cataracts (3-6). Furthermore, age has been found to be a risk factor, while post-vitrectomy cataract almost always occurs in patients aged over 50 years as the anti-oxidative capacity of the lens is diminished in these individuals (4).

Apart from anatomical changes, phacoemulsification in previously vitrectomized eyes can sometimes be challenging. Unusual fluctuations in anterior chamber depth and zonular instability are examples of these challenges (7). The posterior capsule can also be damaged due to insults during vitrectomy, which can lead to serious intraoperative complications and even a dropped nucleus. Careful examination of the anterior chamber anatomy prior to phacoemulsification may be beneficial in these situations (9). However, for a thorough assessment of the structural anatomy, additional workups may be necessary, including the use of various imaging modalities for accurate visualization of the anterior segment. The two most popular techniques for anterior segment imaging are anterior segment optical coherence tomography (AS-OCT) and ultrasound biomicroscopy (UBM) (10).

The development and application of UBM, which involve high-frequency (40–100 MHz) ultrasound imaging, have allowed detailed anterior and posterior chamber imaging (11-12). UBM is a relatively safe and non-invasive procedure, but it is important to note that it has limitations regarding the production of images at greater depths, as the effective penetration of high-frequency ultrasonic waves is restricted to less than 5 mm from the entry site (13). The purpose of this study was to detect changes in anterior chamber morphometry following PPV using UBM.

METHODS

This prospective study involved seven phakic eyes from seven patients who were assessed using UBM before PPV and 3–6 months following PPV (which was the only surgery that each patient underwent). The study was conducted at Farabi Eye Hospital, Tehran, Iran, from Jan. 2013 to Dec. 2014. It was approved by the ethics committee of Tehran University of Medical Sciences. Informed consent was obtained from each of the subjects. The exclusion criteria were significant discomfort during UBM, history of intraocular surgery, poorly controlled diabetes mellitus or hypertension, PPV for the treatment of trauma-related damage, combined PPV and phacoemulsification, and other complicated surgeries.

The preoperative diagnoses comprised four eyes with rhegmatogenous retinal detachment, two with epiretinal membrane, and one with a macular hole. All the surgeries were carried out by the same surgeon (F. Gh.) using similar surgical protocols.

One week prior to surgery, UBM was performed using a commercially available unit (Eye Cubed; Ellex Inc., Osaka, Japan) with a 20-MHz probe. Following the administration of a topical ophthalmic solution of 0.5% tetracaine (Sina Darou Lab, Tehran, Iran), the patients laid down in a supine position. The imaging was carried out by means of an immersion technique using a scleral shell filled with an artificial tear formulation (which was used as a coupling agent). The anterior chamber depth, crystalline lens anterior-posterior (AP) diameter, anterior chamber angle, ciliary body length and thickness according to the scleral spur, and integrity of the ciliary zonules and posterior capsule were evaluated in the axial, longitudinal, and transverse sections. The quantitative analysis was based on the mean values. The morphometric measurements were repeated at 3–6 months (mean: 132 ± 30 days; range: 103–186 days) after PPV by the same operator (F. GH.) to avoid interobserver discrepancies (14). In addition, slit-lamp examinations of the crystalline lens were carried out preoperatively and at the postoperative follow-up examination for each patient.

The mean preoperative and postoperative measurements were compared using the Wilcoxon signed-rank test with IBM SPSS Statistics for Windows version 20.0 (IBM Corp., Armonk, NY, USA).

RESULTS

Four women (57.1%) and three men (42.9%) were included in this case series. The mean age of the participants was 57.86 ± 6.56 years. There were four right eyes (57.1%) and three left eyes (42.9%). Table 1 demonstrates the pre- and postoperative anterior chamber measurements as well as the results of the postoperative slit-lamp examination of the crystalline lens for each patient. As shown, there was a significant increase in the lens thickness after PPV ($p = 0.042$). The slit-lamp examinations indicated that there was an increase in the opacity of the crystalline lens (mostly due to the initiation or progression of nuclear sclerosis) following PPV in five of the seven patients (71.4%). There were no significant changes due to PPV in any of the other parameters. In addition, there was no sign of direct zonular disruption or posterior capsule rupture in any of the patients. Representative examples of pre- and postoperative UBM images are shown in Figure 1.

DISCUSSION

Our study revealed a significant increase in crystalline lens thickness at a mean of 3 months after PPV. This finding is consistent with reports in former studies of nuclear sclerosis progression due to the intraocular tamponade used in PPV (3-4). There were no significant changes in the other anterior segment morphometric parameters. In addition, none of patients exhibited signs (assessed using UBM) of direct zonular disruption or posterior capsule rupture.

Neudorfer et al. investigated anterior segment morphometry before and immediately after vitrectomy with gas tamponade. They reported that there was a significant decrease in the anterior chamber depth, but no significant difference in the lens diameter (15). In contrast, we did not find a significant change in the anterior chamber depth. This discrepancy might be explained by the 3-month mean postoperative follow-up period in our study (in place of immediate examinations) and the use of silicone oil tamponade for the majority of our patients.

Marigo et al. used UBM to measure the angle-opening distance at 500 µm from the scleral spur, ciliary body thickness, central anterior chamber depth, and distance between the trabecular meshwork and the ciliary process before and 8 weeks after PPV without using an internal tamponade (16). In contrast to our findings, Marigo et al. found no significant difference between the pre- and postoperative parameters (16). The main difference between our study and that conducted by Marigo et al was that we enrolled patients who were undergoing PPV with an intraocular silicone oil tamponade. In addition, the relatively short follow-up period in their study (92 ± 33 days) could have reduced the possibility of detecting long-term changes, especially cataract formation. However, the previous study's findings of no changes in anterior segment parameters such as the anterior chamber depth and angle-opening distance are in line with our findings. The lack of a significant reduction in the anterior chamber depth (despite the increase in the crystalline lens thickness) in our study may be due to the disruption of the hyaloid face and the substitution of the vitreous with a substance with distinct hydrodynamic characteristics. Given the supine position of the subjects during the postoperative UBM, the lenses of some of the subjects (which can be affected by zonular instability after PPV) could have undergone posterior subluxation, which may have led to an underestimation of the anterior chamber depth (17). As discussed previously, detailed information about intraocular anatomy can help surgeons to overcome challenges encountered during cataract surgery in vitrectomized eyes (1,5,7,9). For example, preoperative awareness of posterior capsule damage can result in better management of the issue and the prevention of catastrophic complications. In addition, awareness of possible zonular loss can lead surgeons to utilize capsular tension rings before proceeding with the phacoemulsification.

Table 1. Pre- and postoperative measurements of anterior segment parameters

Demographic and surgical variables						Anterior segment measurements										Postoperative slit-lamp examination of crystalline lens	
No.	Age (y)	Gender	Indication of surgery	Tamponade	Post-op follow-up period (d)	ACD (mm)		LAPD (mm)		CBL (mm)		CBW (mm)		Angle (°)		Cataract grading	
						Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op
1	52	Male	RRD	Silicone oil	107	3.335	3.26	3.80	3.76	1.800	1.85	1.51	1.75	47.24	42.88	Clear	NS 1+
2	56	Female	RRD	Silicone oil	106	2.91	2.70	3.98	3.99	1.810	2.30	1.70	1.99	38.26	40.02	Clear	Clear
3	66	Male	ERM	Silicone oil	148	2.39	2.36	4.38	4.72	1.950	2.10	1.94	1.81	30.14	52.33	NS 1+	NS 2+
4	49	Female	RRD	Silicone oil	141	2.32	2.58	3.65	3.82	2.230	2.39	1.31	1.45	28.00	31.13	Clear	NS 1+
5	55	Male	MH	None	103	2.53	2.43	4.29	4.46	2.320	2.17	1.32	1.30	31.13	30.49	Mild PSC	Mild PSC
6	62	Female	RRD	Silicone oil	186	2.46	2.475	4.03	4.32	2.660	2.34	1.37	1.10	33.35	30.29	Clear	NS 2+ PSC
7	65	Female	ERM	Gas	130	2.415	2.70	3.82	3.90	2.060	2.22	1.45	1.52	31.10	33.26	NS 1+	NS 2+
Mean					131.57	2.625	2.664	3.993	4.138	2.118	2.19	1.51	1.56	34.17	37.20		
SE					29.99	0.37	0.31	0.26	0.36	0.30	0.18	0.23	0.30	6.59	8.30		
P						0.735		0.042		0.351		0.499		0.612			

ACD: anterior chamber depth; CBL: ciliary body length; CBW: ciliary body width; ERM: epiretinal membrane; LAPD: lens anterior-posterior diameter; MH: macular hole; NS: nuclear sclerosis; PSC: posterior subcapsular cataract; RRD: rhegmatogenous retinal detachment; SE: standard error

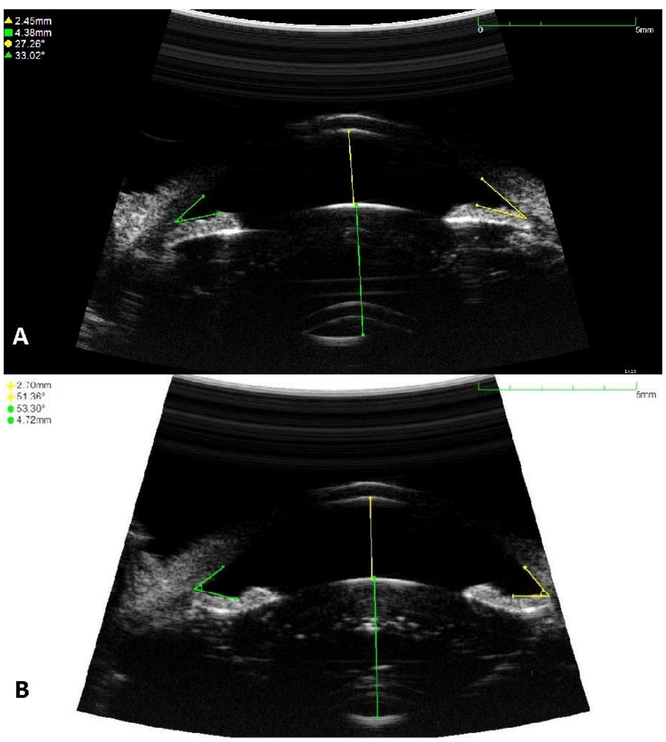

Figure 1. (A) UBM image of a patient prior to PPV. (B) UBM image of the same patient 5 months after the PPV, showing an increase in the crystalline lens thickness (represented by the green line) and the development of nuclear sclerosis. PPV: pars plana vitrectomy; UBM: ultrasound biomicroscopy.

Our study had several limitations. The small sample size led to low statistical power to detect postoperative differences. Another drawback is the small number of cases in each intraocular tamponade subgroup, which prohibited between-group comparisons. In addition, the absence of complete ophthalmic examination data for each patient restricted the possible comparisons that could be carried out. Further studies with large samples sizes would be beneficial to illuminate the potential changes in other anterior chamber morphometric parameters due to PPV.

In conclusion, our investigation demonstrated the ability of UBM to detect very small anterior segment changes following PPV. Despite the limitations of the study, we speculate that apart from increases in the crystalline lens AP diameter (due to development of nuclear sclerosis), uncomplicated PPVs have no long-term effects on other anterior chamber parameters.

DISCLOSURE

Conflicts of Interest: None declared. Current study was approved by the ethics committee of Tehran University of Medical Sciences (86100138-1).

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