• Investigation •

Vitreoretinal surgeons' experience and time interval from pars-plana vitrectomy to cataract extraction

Yan-Xin Xu, Liang-Ping Liu, Jian-Bing Li, Huan-Huan Cheng, Min Hou, Lin Lu, Ming-Xing Wu

State Key Laboratory of Ophthalmology, Zhongshan Ophthalmic Center, Sun Yat-sen University, Guangzhou 510060, Guangdong Province, China

Co-first authors: Yan-Xin Xu and Liang-Ping Liu

Correspondence to: Ming-Xing Wu. State Key Laboratory of Ophthalmology, Zhongshan Ophthalmic Center, Sun Yat-sen University, Guangzhou 510060, Guangdong Province,China. wumingx@mail.sysu.edu.cn

Received: 2020-08-14 Accepted: 2020-10-10

Abstract

● **AIM:** To identify the association of the vitreoretinal surgeons' experience with the time interval between pars-plana vitrectomy (PPV) and cataract extraction (CE).

● **METHODS:** Eyes with prior PPV and following CE were included in this retrospective cohort study. The years of practice and the annual case volume were used to describe the surgeons' experience. Multivariable linear regression analysis was used to investigate the relationship between surgeons' experience and the time interval adjusted for the patients age, gender, intraocular tamponade, and case complexity.

● **RESULTS:** Of 132 430 eyes, 1445 eyes were included in this study. In multivariable linear regression analysis, cases performed by surgeons with >20 practice years had longer time intervals compared with surgeons with <10 practice years after adjusted for other variables (β=0.329, 95%CI: 0.113 to 0.549, P=0.003). No difference in time interval was detected for comparing the lowest with the highest volume groups (β=0.089, 95%CI: -0.164 to 0.343, P=0.343). The surgeons' practice years were not directly with the volume. For complicated surgery, the higher-practice-year surgeons had longer time interval than lower-practice-year surgeons.

● **CONCLUSION:** The time intervals from PPV to CE is longer in higher-practice-year surgeons. The surgeons' practice years may have a greater effect on the time interval than annual case volume in high-complexity cases. Matching the complexity of vitreoretinal diseases with the surgeons' practice year should be considered.

● **KEYWORDS:** pars-plana vitrectomy; cataract; time interval; experience; annual case volume

DOI:10.18240/ijo.2021.01.17

Citation: Xu YX, Liu LP, Li JB, Cheng HH, Hou M, Lu L, Wu MX. Vitreoretinal surgeons' experience and time interval from pars-plana vitrectomy to cataract extraction. *Int J Ophthalmol* 2021;14(1):120-126

INTRODUCTION

With the continuous evolution of instrumentation and techniques, pars-plana vitrectomy (PPV) has been extensively applied in the treatment of vitreoretinal disorders. Cataract formation is a frequent late postoperative complication, with up to 80%[1-2] of cases developing cataracts within 2y and of these almost 100%[3-4] developing nuclear sclerotic cataract. Phacoemulsification with intraocular lens (IOL) implantation is the most common treatment for cataracts, but there are many surgical challenges in vitrectomized eyes[5]. Patients with vitreoretinal diseases are generally young, and the eye is unable to accommodate after cataract extraction (CE), which brings many inconveniences to life and work, and increases the health-care costs and financial burden to families and societies. The exact cause of cataract development after PPV remains unclear; some predisposing factors have been proposed, such as patients' age[6-7], the use of silicone oil (SO) or intravitreal gas[7-8], lens injury during PPV[9], the complexity of vitreoretinal disease[5], diabetic retinopathy[5,10], and duration of surgery[11]. The time interval from PPV to CE is determined largely by the speed of progression of cataract after vitrectomy, with more rapid progression indicating shorter time intervals.

The cataract surgeon's grade and annual case volume are related to better visual acuity outcomes and a lower complication rate[12]. However, any association between vitreoretinal surgeons' experience and the time interval from PPV to CE has rarely been reported. A previous study found that post-vitrectomy cataract progression is not associated with surgeons' experience[13], but the study was limited by its sample size, and no further studies have been conducted.

The primary aim of this study was therefore to identify the associations between vitreoretinal surgeons' experience and the time interval from PPV to CE.

SUBJECTS AND METHODS

Ethical Approval The study was performed in accordance with the Helsinki Declaration and approved by the Zhongshan Ophthalmic Center Ethical Committee.

Data Extraction and Patient Selection All patients who underwent CE at Zhongshan Ophthalmic Center, Guangzhou, China from January 1, 2012 to June 30, 2018 were enrolled in an electronic medical record system.

Patients aged 18y or older with prior PPV who underwent phacoemulsification and IOL implantation in the hospital were included. Eyes that underwent phacovitrectomy were excluded. Eyes with a history of ocular diseases that could cause cataract formation or progression, including corneal disease, glaucoma, uveitis, endophthalmitis, optic nerve disease, and blunt or penetrating trauma, and eyes that had multiple intraocular procedures other than SO removal were also excluded. Patients whose records showed incomplete data were excluded. For patients in whom surgery was bilateral, only one eye was randomly selected in the final analyses.

Data were extracted from patient records and included the patient's age, gender, diabetics status, the gauge of PPV, duration of surgery, the intraocular tamponade, the complexity of vitreoretinal diseases, the surgeon's number of years as a practicing surgeon (years in practice) and annual case volume, and the dates of the PPV and CE surgeries. The time interval from PPV to CE was defined as the date of CE minus the date of PPV and recorded accurately to the nearest month.

Surgeons' Experience To describe the experience of each surgeon, the number of years of practice in vitreoretinal surgery and the annual case volume were both considered. Years in practice were determined by subtracting the year of PPV from the year of residency completion of the PPV surgeon and recorded as the practice years of the surgeon which was updated annually as the study progressed. Surgeons were categorized according to the number of practice years into three subgroups: ≤10y (junior), 11-20y (mid-level), and >20y (senior). For each patient case, the surgeon's annual case volume was defined as the number of cases performed by the surgeon during the same year as surgery performed in that case. Annual case volume was categorized into five subgroups: <400, 400-599, 600-799, 800-999 and ≥1000 cases/year.

Complexity of Vitrectomy For analysis, complexity of PPV surgery was categorized into 4 levels as described in a previous study[5]: Level 1, vitreous opacities: including vitreous opacity caused by various vitreoretinal diseases except for proliferative diabetic retinopathy (PDR). Level 2, vitreoretinal interface diseases: including macular membrane, macular hole, and vitreomacular traction. Level 3, rhegmatogenous retinal detachment (RRD): including RRD with proliferative vitreoretinopathy (PVR) grade C1 or less. Level 4, complex vitrectomy: including PDR with epiretinal membrane and retinal detachment with PVR over grade C1.

Duration of Surgery The duration of surgery was defined as the time from the opening to the closing of the scleral incision, and it was recorded by the operating room staff using an electronic timer.

Statistical Analysis All statistical analyses were performed using SPSS software version 19.0 (Stata CorpLP, College Station, TX, USA). Variables are described by type as proportions or medians with interquartile ranges (IQR) or mean±standard deviations (SDs) as appropriate. Because the time interval data were non-normal, Mann-Whitney *U* or Kruskal-Wallis *H* Wilcoxon tests were used to determine significance. After mean square root transformation, time interval data were approximately normally distributed. Univariate linear regression analysis was used to assess the effects of various variables on the time interval from PPV to CE. All covariates reaching significance with no multicollinearity between them were included in the multivariate linear regression analysis. A Chi-square test was used to compare cases complexity between annual case volume subgroups. A *P*-value <0.05 was considered statistically significant. For multiple tests, the *P*-value was corrected using the Bonferroni method.

RESULTS

A total of 132 430 cataract surgeries were performed during the study period, and of these 2.4% (3285) cases had simultaneous or prior vitreoretinal surgeries. Among them, 78.2% (2571) cases had phacoemulsification with prior PPV, and data from 1445 eyes met the inclusion criteria and were analyzed (Figure 1). Among the 1445 eyes, there were vitreous opacities in 119 eyes (8.3%), vitreoretinal interface diseases in 393 eyes (27.2%), retinal detachment in 732 eyes (50.6%), and PDR in 201 eyes (13.9%). The patients with intraocular gas tamponade were positioned face down after operation for 1 to 3wk. And the patients with SO tamponade were positioned face down for 3d to 3mo. At the time of CE, the type of cataract was recorded as nuclear sclerosis (86%), posterior subcapsular (7.8%), or cortical (6.2%).

Patients' Characteristics The median time interval was 13mo (IQR 8-19). The baseline characteristics and time intervals of all variables are shown in Table 1. The average age of the patients was 55.25±10.51y (mean±SD), and slightly more than half of the patients were men (54.7%). The median time intervals for men and women were 12mo (8-19) and 13mo (8-20), respectively (*P*>0.05). Most of the patients (85.9%) were without diabetes, and the median time interval for patients without and with diabetes was similar, at 12mo (*P*>0.05).

Gauge of PPV Two thirds (65.5%) of patients underwent 23-gauge (G) PPV, and only 1.2% of patients underwent 27-G PPV. The number of patients who received 20-G and 25-G PPV was similar. From 20-G to 23-G PPV, the time interval increased with reduced gauge size, while the interval for

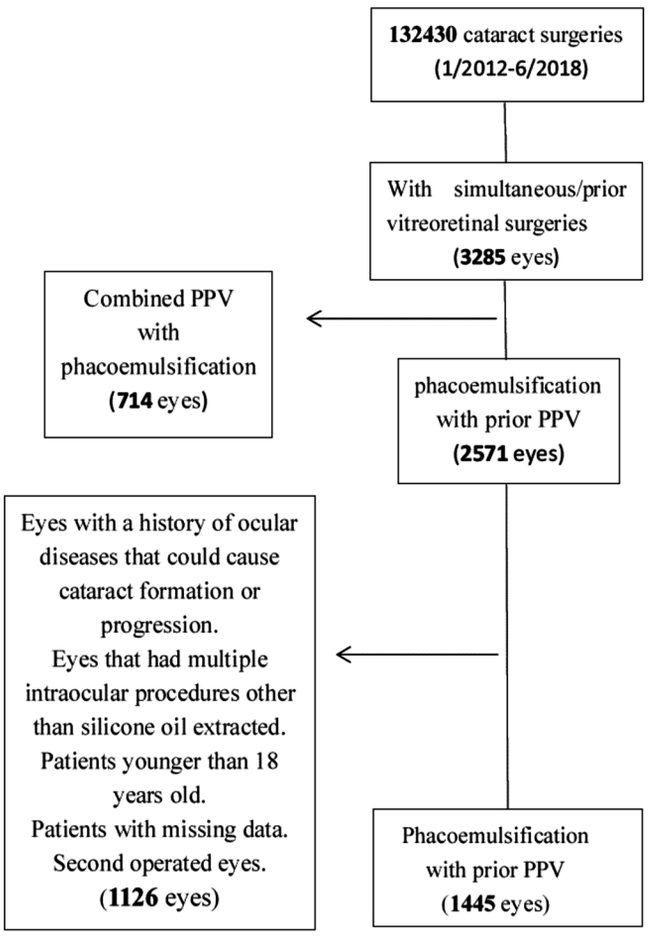

Figure 1 Flowchart showing the filtering process of the study population.

patients with 27-G PPV was similar to that of patients with 23-G PPV (P>0.05).

Intraocular Tamponade Eyes with C3F8 tamponade had the longest time interval [median: 14mo (IQR 9-23)], and eyes with balanced salt solution (BSS), air and SO tamponade had a similar time interval (13mo). For patients with SO tamponade, 23.5% underwent SO extraction with simultaneous CE (SO+CE), and these patients had the shortest time interval [7mo (6-10)] (P<0.05).

Duration of Surgery The median surgery duration was 50min, and the time interval for patients requiring less than or more than 50min to perform the PPV was similar (12mo, P>0.05).

Complexity of Vitrectomy The complexity of surgery is classified into four levels from low to high. Cases with complexity at level 4 had the shortest time interval [12mo (8-17)], while the remaining complexity subgroups had similar intervals (P<0.05).

Surgeons' Experience The median practice years of surgeons was 20y (IQR 14-26). Among all the included cases, those performed by senior surgeons had the longest time interval [13mo (9-20)], followed by mid-level surgeons [12mo (7-18)], and junior surgeons [11mo (5-18)] (P<0.05).

Table 1 Baseline characteristics and the time interval

Variables	Mean±SD, *n* (%)	Time interval, median (IQR)
Age (y)	55.25±10.51	-
Gender		
M	790 (54.7)	12 (8-19)
F	655 (45.3)	13 (8-20)
Diabetic status		
Nondiabetics	1241 (85.9)	12 (8-19)
Diabetics	204 (14.1)	12 (7-19)
Tamponade		
BSS	240 (16.6)	13 (6-15)
SO	527 (36.5)	13 (10-19)
SO+CE	162 (11.2)	7 (6-10)
C3F8	421 (29.5)	14 (9-23)
Air	95 (6.6)	13 (8-17)
Gauge of PPV		
20 G	293 (20.3)	9 (7-13)
23 G	947 (65.5)	11 (7-18)
25 G	187 (13.0)	12 (8-18)
27 G	18 (1.2)	11 (9-13)
Duration of surgery (min)		
≤50	670 (46.4)	12 (7-19)
>50	775 (53.6)	12 (8-19)
Cases complexity		
Level 1	257 (17.8)	13 (9-20)
Level 2	330 (22.9)	13 (8-21)
Level 3	645 (44.6)	13 (8-19)
Level 4	213 (14.7)	12 (8-17)
Years in practice (y)		
≤10	175 (12.1)	11 (5-18)
11-20	509 (35.2)	12 (7-18)
>20	761 (52.7)	13 (9-20)
Annual case volume (case/y)		
<400	179 (12.4)	11 (7-17)
400-599	352 (24.4)	11 (7-17)
600-799	451 (31.2)	12 (9-19)
800-999	213 (14.7)	12 (8-18)
≥1000	250 (17.3)	11 (7-17)

PPV: Pars-plana vitrectomy; BSS: Balanced salt solution; SO: Silicone oil; CE: Cataract extraction; SO+CE: Silicone oil extracted with simultaneous cataract extraction; IQR: Interquartile range.

The median annual case volume was 667 cases/year (IQR 520-859). Cases performed by surgeons with annual case volumes of 600-799 and 800-999 cases/year had the longest time interval (12mo). The rest of the annual case volume subgroups had the same intervals (P>0.05).

Linear Regression Analysis The linear regression analysis for the time interval is shown in Table 2.

Patients' age was negatively correlated with time interval after

Table 2 Linear regression analysis for the time interval

Variables	Univariate linear regression		Multivariate linear regression	
	β (95%CI)	*P*	*β* (95%CI)	*P*
Age (y)	-0.017 (-0.024 to -0.010)	<0.001[a]	-0.012 (-0.020 to 0.005)	0.020[a]
Gender				
M	Reference		-	-
F	0.031 (-0.123 to 0.186)	0.691		
Diabetic status				
Nondiabetics	Reference			
Diabetics	0.855 (0.630 to 1.116)	0.314		
Tamponade				
BSS	Reference		Reference	
SO	0.077 (-0.144 to 0.298)	0.492	0.147 (-0.082 to 0.376)	0.236
SO+CE	-0.804 (-1.091 to -0.516)	<0.001[a]	-0.449 (-0.723 to -0.174)	<0.001[a]
C3F8	0.557 (0.328 to 0.786)	<0.001[a]	0.486 (0.259 to 0.713)	<0.001[a]
Air	0.030 (-0.406 to 0.466)	0.892	-0.051 (-0.479 to -0.377)	0.850
Gauge of PPV				
20 G	Reference			
23 G	0.021 (-0.176 to 0.218)	0.428		
25 G	0.045 (-0.183 to 0.312)	0.527	-	-
27 G	0.023 (-0.177 to 0.235)	0.625		
Duration of surgery (min)				
≤50	Reference			
>50	-0.025 (-0.067 to 0.018)	0.256	-	-
Cases complexity				
Level 1	Reference		Reference	
Level 2	-0.066 (-0.213 to 0.181)	0.601	-0.108 (-0.332 to 0.117)	0.375
Level 3	-1.116 (-0.335 to 0.102)	0.296	-0.094 (-0.294 to 0.106)	0.451
Level 4	-0.361 (-0.636 to -0.086)	0.010[a]	-0.318 (-0.571 to -0.064)	0.025[a]
Years in practice (y)				
≤10	Reference		Reference	
11-20	0.283 (0.027 to 0.539)	0.039[a]	0.074 (-0.149 to 0.298)	0.512
>20	0.482 (0.237 to 0.728)	<0.001[a]	0.329 (0.113 to 0.549)	0.003[a]
Annual case volume (cases/y)				
<400	Reference			
400-599	0.018 (-0.220 to 0.255)	0.884		
600-799	0.203 (-0.025 to 0.432)	0.081	-	-
800-999	0.040 (-0.222 to 0.302)	0.766		
≥1000	0.089 (-0.164 to 0.343)	0.489		

After mean square root transformation, time interval data were approximately normally distributed. All covariates reaching significance (P<0.05) with no multicollinearity between them were included in the multivariate linear regression analysis. PPV: Pars-plana vitrectomy; BSS: Balanced salt solution; SO: Silicone oil; CE: Cataract extraction; SO+CE: Silicone oil extracted with simultaneous cataract extraction. [a]P<0.05.

controlling for other variables (β=-0.017, 95%CI: -0.024 to -0.010, P<0.001) but no significant association was found between time interval and gender (P=0.691).

Time interval was similar in patients with and without diabetes (β=0.855; P=0.314) and did not differ significantly with PPV gauge (P>0.05) or duration of surgery (P=0.256).

Compared with patients with BSS tamponade, patients with SO+CE had a shorter time interval (β=-0.449, 95%CI: -0.723 to -0.174, P<0.001), and patients with C3F8 tamponade had a longer time interval (β=0.486, 95%CI: 0.259 to 0.713, P<0.001), as determined using multivariate regression analysis controlling for other variables.

High complexity cases (level 2 to level 4) had shorter time intervals compared with low complexity cases (level 1), but the difference was significant only for cases with complexity level 4 (β=-0.318, 95%CI: -0.571 to -0.064, P=0.025) after controlling for other variables in multivariate regression analysis.

Table 3 Years in practice and classification of cases complexity according to surgeons' annual case volume

Parameters	Annual case volume (cases/y)					*P*
	<400	400-599	600-799	800-999	≥1000	
Years in practice, median (IQR)	9 (5-19)	20 (15-25)	26 (12-27)	14 (13-27)	24 (15-27)	0.017[a]
Cases complexity (%)						
Level 1	12.6	19.9	17.6	21.8	17.4	0.069
Level 2	29.8	22.9	21.4	16.2	18.9	
Level 3	47.0	40.2	47.3	48.0	45.3	
Level 4	10.6	16.9	13.7	14.0	18.4	

IQR: Interquartile range. [a]*P*<0.05.

In univariate linear regression analysis, cases performed by mid-level and senior surgeons had longer time intervals compared with that performed by junior surgeons (all *P*<0.05). In multivariate regression analysis, time interval was significantly longer following surgery by senior versus junior surgeons after controlling for other variables (β=0.329, 95%CI: 0.113 to 0.549, *P*=0.003) but did not differ between mid-level and junior surgeons (*P*=0.512).

In univariate linear regression analysis, time interval did not differ significantly with annual case volume (all *P*>0.05, Table 2).

Surgeons' Practice Years and Annual Case Volume For all case complexity classification subgroups, the time interval was prolonged as the surgeons' practice years increased (*P*<0.05 for level 2 and 3 subgroups) except in the level 1 subgroup (Figure 2). Surgeons with fewer than 400 cases/year were the least experienced, with a median of 9y in practice, and those with 600-799 cases/year were the most experienced, with a median of 26y in practice (Table 3). Surgeons performing the highest volume had 24 practice years. Differences in the surgeons' practice years between the annual case volume subgroups were significant (*P*=0.017). However, case complexity was similar between different case volume subgroups (*P*=0.069).

Case volume of junior surgeons did not exceed 800 cases per year, and the time interval showed an upward but not significant tendency as this volume increased within this subgroup (*P*>0.05). The upward tendency was found among senior surgeons (*P*<0.01), but for mid-level surgeons, time interval showed the opposite trend, decreasing with case volume (*P*<0.01; Figure 3).

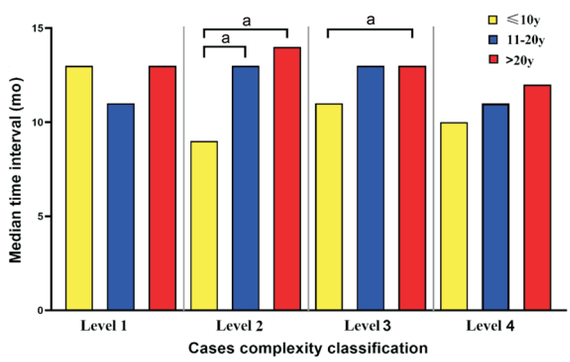

Figure 2 The median time interval of all years in practice subgroups among different case complexity classification [a]*P*<0.05, Kruskal-Wallis *H* test.

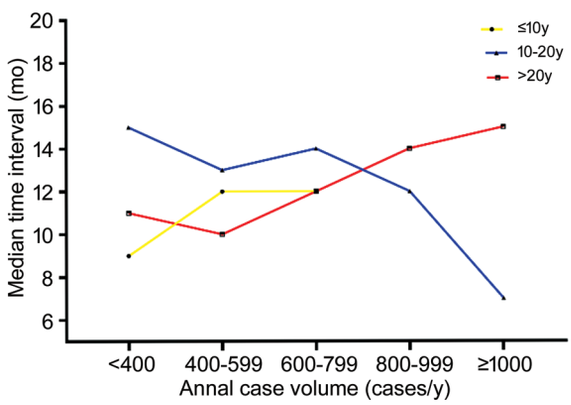

Figure 3 The trends of the time interval of all practice years subgroups as the annual case volume increased.

DISCUSSION

In this retrospective clinical study, the relationship between surgeons' experience and the time interval from PPV to CE was analyzed, controlling for the patients' age, gender, diabetics status, the gauge of PPV, duration of surgery, intraocular tamponade, and case complexity. Number of years in practice was a protective factor for the time interval, but the surgeons' annual case volume had no significant relationship with time interval. In addition, patients' age, SO tamponade, and complicated vitreoretinal surgery were predisposing factors for a shorter time interval. The median time interval between CE and the initial PPV was 13mo (mean±SD, 16±14.6mo), similar to previous reports[5,14-16].

The surgeons' grade was associated with a shorter duration of surgery and lower complication rate in CE[17]. A previous study suggested that vitreoretinal surgeons' experience was associated with the progression of nuclear sclerosis[13] but largely accounted for the differences in the proportions of preoperative nuclear sclerosis and the duration of follow-up. In the present study, surgeons with a higher number of practice years were associated with a longer time interval to CE after PPV compared with surgeons with fewer practice years, after controlling for the patient's age, gender, diabetics status, the

gauge of PPV, duration of surgery, intraocular tamponade, case complexity, and the surgeons' annual case volume. The association may indicate that more experienced surgeons possess particularly fine-tuned surgical skills that further reduce the likelihood of lens damage and other complications.

Volume-outcome studies have shown that surgeons who perform more operations have better patient outcomes than those performing fewer operations[18]. Previous studies have also shown that cataract operations performed by surgeons with high surgery volume have better postoperative visual acuity outcomes and fewer complications[17,12]. However, the present study found no correlation between the surgeons' annual case volumes and the time intervals, and surgeons' practice years were not associated with their annual case volumes. In addition, the proportions of cases complexity in annual case volume subgroups were similar. As the annual case volume increased, the number of complicated surgeries also increased, but the practice years of surgeons did not increase correspondingly. Consequently, the time intervals were shortened when the lower-practice-year surgeons performed complicated surgeries.

A correlation between patient age and cataract progression after PPV has been reported in previous studies[6-7,19-20]. Melberg and Thomas[6] found that the incidence of nuclear sclerosis within two years after vitrectomy was 7% in people under 50 years of age and 79% in those older than 50. In broad agreement with this, the present study found that patient age was negatively correlated to the time interval.

Previous findings indicate a lower rate of CE after vitrectomy in diabetic patients than that in nondiabetic patients, because vitreous oxygen tension was significantly lower in diabetic patients with ischemic retinopathy[10,21]. However, the present study found no difference in the time interval between patients with and without diabetes. The shorter time interval found previously in diabetics may relate to a higher frequency of examinations in those patients and a possible misattribution of poor vision to lens opacity without clinical significance[22]. In addition, patients with diabetes in the present study did not all have ischemic retinopathy.

Small gauge PPV in vitreoretinal surgery has been associated with less postoperative inflammation, lower complication rates, and time savings[23]. In the present study and in one former study[24] the gauge of PPV was not significantly associated with the time interval to CE. Further research is needed to understand why time interval was not affected by the advantages of smaller gauge PPV.

Previous studies have shown that eyes with intraocular gas filling do not show increased cataract progression after vitrectomy[19-20], while other studies have the opposite outcome[1,7]. Eyes with air tamponade were not related to cataract development[5]. In the present study, intraocular tamponade with air was not related to the time interval, but longer time intervals were found in eyes with C3F8 tamponade. A transient posterior subcapsular cataract has been reported after PPV when gas was injected into the vitreous cavity[1], but the long-term effect of gas on the lens is not well understood. Intraocular SO tamponade has been found to increase cataract progression after vitrectomy[25-26]. In the present study, the time interval was shorter in eyes that underwent SO+CE, while eyes with SO tamponade in which SO was removed with delayed CE had similar time intervals to those with other types of tamponade. This finding is in line with those reported in a recent study[5].

It has been reported that light phototoxicity, intraoperative oxidation of lens proteins, and exposure to irrigating solutions are associated with the development of cataracts after PPV[5] but the duration of PPV surgery was not correlated with changes in nuclear sclerosis progression[11,19-20]. Consistent with these findings, no significant difference in time interval was found between patients undergoing PPV within 50min and over 50min in this study.

Time interval was shorter in high complexity cases in this study, in agreement with previous research[5]. In RRD and PDR surgeries, more action was taken to remove peripheral vitreous, which may increase the risks of lens injury and accelerate the development of cataracts.

It is important to consider the clinical significance of the present findings. Although many factors affected lens opacification after vitrectomy, 83% of patients needed CE within 24mo after PPV in this study. Combined phacoemulsification with vitrectomy should be considered.

Study Limitations This study has some limitations. First, this was a retrospective single-center study. However, the Zhongshan Ophthalmic Center has the largest CE volume in China, and the results of this study can therefore be extended to most hospitals. Second, the time interval from PPV to CE was used as an indicator of cataract progression after PPV, and this indicator is affected by subjective factors such as the patient's preference and the individual surgeon's threshold for CE surgery. Third, no detailed information is available about the duration of surgery with patients in prone (face down) position, so its impact on cataract progression cannot be analyzed, and further prospective study is needed to understand this potential factor.

In conclusion, this study found that surgeons with more years in practice were associated with a longer time interval to CE after PPV and more experienced surgeons were associated with longer intervals in complicated cases. The annual case volume of surgeons had no clear relationship with the time interval in non-low-complexity cases. In addition, aging,

SO tamponade, and complicated vitreoretinal surgery were predisposing factors for a shorter time interval. These findings may indicate the necessity of surgery allocation according to the classification of cases complexity in ophthalmic hospitals, particularly in regions with high patient-to-surgeon ratios.

ACKNOWLEDGEMENTS

Authors' contributions: Conception and design: Wu MX, Xu YX; Provision of study materials or patients: Xu YX, Liu LP; Collection and assembly of data: Xu YX, Liu LP; Data analysis and interpretation: Xu YX, Liu LP, Li JB, Cheng HH; Manuscript writing: All authors; Final approval of manuscript: All authors.

Foundations: Supported by the National Key Research and Development Program of China (No.2017YFC1104603); the National Natural Science Foundation of China (No.81770909; No.81970783).

Conflicts of Interest: Xu YX, None; **Liu LP,** None; **Li JB,** None; **Cheng HH,** None; **Hou M,** None; **Lu L,** None; **Wu MX,** None.

REFERENCES

1 Hsuan JD, Brown NA, Bron AJ, Patel CK, Rosen PH. Posterior subcapsular and nuclear cataract after vitrectomy. *J Cataract Refract Surg* 2001;27(3):437-444.

2 Shousha MA, Yoo SH. Cataract surgery after pars plana vitrectomy. *Curr Opin Ophthalmol* 2010;21(1):45-49.

3 Leonard REII, Smiddy WE, Flynn HW Jr, Feuer W. Long-term visual outcomes in patients with successful macular hole surgery. *Ophthalmology* 1997;104(10):1648-1652.

4 Do DV, Gichuhi S, Vedula SS, Hawkins BS. Surgery for post-vitrectomy cataract. *Cochrane Database Syst Rev* 2013(12):CD006366.

5 Soliman MK, Hardin JS, Jawed F, Uwaydat SH, Faramawi MF, Chu CJ, Yang YC, Sallam AB. A database study of visual outcomes and intraoperative complications of postvitrectomy cataract surgery. *Ophthalmology* 2018;125(11):1683-1691.

6 Melberg NS, Thomas MA. Nuclear sclerotic cataract after vitrectomy in patients younger than 50 years of age. *Ophthalmology* 1995;102(10):1466-1471.

7 Thompson JT. The role of patient age and intraocular gas use in cataract progression after vitrectomy for macular holes and epiretinal membranes. *Am J Ophthalmol* 2004;137(2):250-257.

8 Federman JL, Schubert HD. Complications associated with the use of silicone oil in 150 eyes after retina-vitreous surgery. *Ophthalmology* 1988;95(7):870-876.

9 Elhousseini Z, Lee E, Williamson TH. Incidence of lens touch during pars Plana vitrectomy and outcomes from subsequent cataract surgery. *Retina* 2016;36(4):825-829.

10 Smiddy WE, Feuer W. Incidence of cataract extraction after diabetic vitrectomy. *Retina* 2004;24(4):574-581.

11 Cheng L, Azen SP, El-Bradey MH, Scholz BM, Chaidhawangul S, Toyoguchi M, Freeman WR. Duration of vitrectomy and postoperative cataract in the vitrectomy for macular hole study. *Am J Ophthalmol* 2001;132(6):881-887.

12 Cox JT, Subburaman GBB, Munoz B, Friedman DS, Ravindran RD. Visual acuity outcomes after cataract surgery: high-volume versus low-volume surgeons. *Ophthalmology* 2019;126(11):1480-1489.

13 de Bustros S, Thompson JT, Michels RG, Enger C, Rice TA, Glaser BM. Nuclear sclerosis after vitrectomy for idiopathic epiretinal membranes. *Am J Ophthalmol* 1988;105(2):160-164.

14 Cole CJ, Charteris DG. Cataract extraction after retinal detachment repair by vitrectomy: visual outcome and complications. *Eye (Lond)* 2009;23(6):1377-1381.

15 Pinter SM, Sugar A. Phacoemulsification in eyes with pastpars plana vitrectomy: case-control study. *J Cataract Refract Surg* 1999;25(4): 556-561.

16 Cherfan GM, Michels RG, de Bustros S, Enger C, Glaser BM. Nuclear sclerotic cataract after vitrectomy for idiopathic epiretinal membranes causing macular pucker. *Am J Ophthalmol* 1991;111(4):434-438.

17 Nderitu P, Ursell P. Factors affecting cataract surgery operating time among trainees and consultants. *J Cataract Refract Surg* 2019;45(6): 816-822.

18 Halm EA, Lee C, Chassin MR. Is volume related to outcome in health care? A systematic review and methodologic critique of the literature. *Ann Intern Med* 2002;137(6):511.

19 Okamoto Y, Okamoto F, Hiraoka T, Oshika T. Refractive changes after lens-sparing vitrectomy for rhegmatogenous retinal detachment. *Am J Ophthalmol* 2014;158(3):544-549.e1.

20 Iwase T, Yamamoto K, Yanagida K, Kobayashi M, Ra E, Murotani K, Terasaki H. Change in refraction after lens-sparing vitrectomy for rhegmatogenous retinal detachment and epiretinal membrane. *Medicine* 2016;95(32):e4317.

21 Holekamp NM, Bai F, Shui YB, Almony A, Beebe DC. Ischemic diabetic retinopathy may protect against nuclear sclerotic cataract. *Am J Ophthalmol* 2010;150(4):543-550.e1.

22 Bernth-Petersen P, Bach E. Epidemiologic aspects of cataract surgery. III: Frequencies of diabetes and glaucoma in a cataract population. *Acta Ophthalmol (Copenh)* 1983;61(3):406-416.

23 Pielen A, Guerra NIP, Böhringer D, Junker B, Bühler AD, Stahl A, Agostini HT, Ehlken C. Intra- and postoperative risks and complications of small-gauge (23-G) versus conventional (20-G) vitrectomy for macular surgery. *Eur J Ophthalmol* 2014;24(5):778-785.

24 Keyal K, Liao X, Liu G, Yang S, Wang F. Post-vitrectomy cataract acceleration in phakic eyes: a review. *Discov Med* 2017;24(134): 305-311.

25 Titiyal JS, Agarwal E, Angmo DW, Sharma N, Kumar A. Comparative evaluation of outcomes of phacoemulsification in vitrectomized eyes: silicone oil versus air/gas group. *Int Ophthalmol* 2017;37(3):565-574.

26 Antoun J, Azar G, Jabbour E, Kourie HR, Slim E, Schakal A, Jalkh A. Vitreoretinal surgery with silicone oil tamponade in primary uncomplicated rhegmatogenous retinal detachment. *Retina* 2016;36(10):1906-1912.