• Clinical Research •

Differential distribution of fibrovascular proliferative membranes in 25-gauge vitrectomy for proliferative diabetic retinopathy

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Abstract

● **AIM:** To analyze the distribution of fibrovascular proliferative membranes (FVPMs) in proliferative diabetic retinopathy (PDR) patients that treated with pars plana vitrectomy (PPV), and to evaluate the outcomes separately.

● **METHODS:** This was a retrospective and cross-sectional study. Consecutive 25-gauge (25-G) PPV cases operated for PDR from May 2018 to April 2020. According to the FVPMs images outlined after operations, subjects were assigned into three groups: arcade type group, juxtapapillary type group, and central type group. All patients were followed up for over one year. General characteristics, operation-related variables, postoperative parameters and complications were recorded.

● **RESULTS:** Among 103 eyes recruited, the FVPMs distribution of nasotemporal and inferiosuperioral was significantly different (both $P<0.01$), with 95 (92.23%) FVPMs located in the nasal quadrants, and 74 (71.84%) in the inferior. The eyes with a central FVPM required the longest operation time, with silicon oil used in most patients, generally combined with tractional retinal detachment (RD) and rhegmatogenous RD, the worst postoperative best-corrected visual acuity (BCVA) and the highest rates of recurrent RD (all $P<0.05$). FVPM type, age of onset diabetes mellitus, preoperative BCVA, and combined with tractional RD and rhegmatogenous RD were significantly associated with BCVA improvement (all $P<0.05$). Compared with the central type group, the arcade type group had higher rates of BCVA improvement.

● **CONCLUSION:** FVPMs are more commonly found in the nasal and inferior mid-peripheral retina in addition to the area of arcade vessels. Performing 25-G PPV for treating PDR eyes with central FVPM have relatively worse prognosis.

● **KEYWORDS:** proliferative diabetic retinopathy; fibrovascular proliferative membrane; 25-gauge pars plana vitrectomy

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INTRODUCTION

Diabetic retinopathy (DR) is the most common ocular complication of diabetes mellitus (DM), and it is a leading cause of blindness in working-age adults who have jobs and families to maintain[1-2]. Those individuals with DM who have poor command of diabetes care knowledge always consult at an extremely severe stage of proliferative DR (PDR) and unfortunately require surgical treatment mainly due to non-clearing vitreous hemorrhage (VH)[3], so the fundus of most patients were first observed clearly during the operation.

Pars plana vitrectomy (PPV) is the most cost-effective and long-term stabilizing treatment performed in cases with advanced PDR[4]. During the process of this operation, segmentation and removal of the fibrovascular proliferative membranes (FVPMs), which are prone to cause hemorrhage and iatrogenic retinal break (IRB), is the critical point regarding the visual prognosis and postoperative complications[5]. With the development of 25-gauge (25-G) forceps, scissors and directional endolaser probes, the 25-G PPV has been proven effective, safe and with rapid visual recovery when applied to complications of PDR[6-9]. However, due to the diversity of fundus in PDR patients, the postoperative effect must be inconsistent in patients with different types of FVPMs.

In addition to the region of the posterior pole, it has been well documented that neovascularization is more commonly found in the nasal and inferior nasal peripheral retina by fundus imaging techniques[10-11]. To the best of our knowledge, there are no studies focusing on the differential distribution of FVPMs attaching to the retina in operation. In this study, we will analyze the distribution of FVPMs in PDR eyes that required surgical treatment through schematic images sketched by an experienced surgeon after the operations. Most importantly, we will assess the different outcomes of 25-G PPV for managing PDR with different types of FVPM. It will be helpful for the management of expectations and early intervention to investigate the relevance of FVPMs to the anatomy and visual prognosis.

SUBJECTS AND METHODS

Ethical Approval The study was performed in accordance with the tenets of the Declaration of Helsinki and approved by the Institutional Review Board of First Hospital of Qinhuangdao (Approval Number: 2019A044). Written informed consent was obtained from all participants.

In this retrospective study, the medical records were reviewed from all consecutive surgical cases from May 2018 to April 2020 who underwent primary 25-G PPV for complications of PDR, including persistent or recurrent VH, tractional retinal detachment (TRD) threatening or involving the macula, combined tractional and rhegmatogenous RD (TRD/RRD). All surgeries were performed by the same experienced vitreoretinal surgeon. The exclusion criteria were as follows: 1) the follow-up duration was <12mo, 2) with other reasons leading to proliferative vitreoretinal diseases, 3) intraoperative data or follow-up data one year postoperative of the primary vitrectomy were incomplete, 4) without any distinct FVPM in the retina.

Intravitreal Ranibizumab injection (0.05 mL) was performed using a 30-G needle through the pars plana under sterile conditions 4-7d before the PPV. All patients underwent retrobulbar anesthesia. If the patient had a cataract that interfered with the surgeon's observation of the fundus, phacoemulsification was performed through a clear corneal incision before the scleral incision for vitrectomy was made. The Alcon Constellation system (Alcon Laboratories, Inc., Fort Worth, TX, USA) was used to perform 25-G PPV with conventional three-port. Under a non-contact wide-angle viewing system (BIOM 3, Oculus, Inc., Munich, Germany), core vitrectomy was first performed, and subsequently the posterior hyaloid was separated and removed. A suspension of triamcinolone acetonide was injected into the vitreous cavity to mark the posterior cortical vitreous for better visualization. Subsequently, FVPMs were dissected and removed as completely as possible. When required, bimanual technique was applied with vitreoretinal scissors and forceps to remove the FVPMs to relieve traction under the chandelier light. With the aid of scleral indentation, the peripheral vitreous base was shaved. Pan-retinal photocoagulation was applied or supplemented following fluid/air exchange. Intraocular lens implantation was performed before completing the surgery. Balanced salt solution, sterile air or silicon oil tamponade was employed resting with the aspect of the retina. Because of restrictions, sulfur hexafluoride and octafluoropropane used in the operation was prohibited at that time.

When the entry sites displayed leakage through the localized bleb formation, suturing of the sclerotomy sites was performed. Finally, the eye was applied with Tobramycin dexamethasone ophthalmic ointment, patched and shielded. Patients should maintain a face-down position if silicone oil (for 1–2wk) or air infusion (for 5–7d) was employed.

General patient characteristics including sex, age, laterality, age at diabetes onset, diabetes duration, glycated hemoglobin, body mass index, and the presence of nephropathy, ischaemic heart disease and hypertension were recorded. The following ophthalmological parameters were obtained: a best-corrected visual acuity (BCVA) that was assessed using the Snellen chart, lens status and prior pan-retinal photocoagulation treatment.

All FVPM schematic images were completed in the Paint 3D software (Windows, Version 6.2105.4017) by the surgeon after completing the surgeries and verified by assistants using surgery videos. The outline of the FVPMs was sketched on a specific layer, which had a standardized background with a macular centre surrounded by circles representing the equator, ora serrata, and limbus for convenient analysis. If needed, correction of the images was performed in cooperation with the surgeons and assistants. Subsequently, the retinal images of the left eyes were flipped across the vertical axis to be analyzed as the right eyes. All images were superimposed into a map and normalized. Each pixel in the map represented the overlap probability of an FVPM, and was represented by different grey values. The top of the scale represents the maximum rate of FVPM overlapping, and the bottom indicates no FVPM. The location of the FVPM was determined according to its geometric centre. The superior, inferior, nasal and temporal hemispheres were defined by a horizontal and a vertical axis across the fovea.

FVPMs were assigned to three categories[12]: Arcade type: FVPMs were restricted to upper and/or lower arcade vessels, with or without disc involvement; Juxtapapillary type: FVPMs were mainly present nasal to the disk, with less or without arcade vessels involvement; Central type: FVPMs were mainly observed in the macular area, with or without arcade vessels involvement. The macular area was defined as the area with a diameter of approximately 5.5 mm centred on the foveal

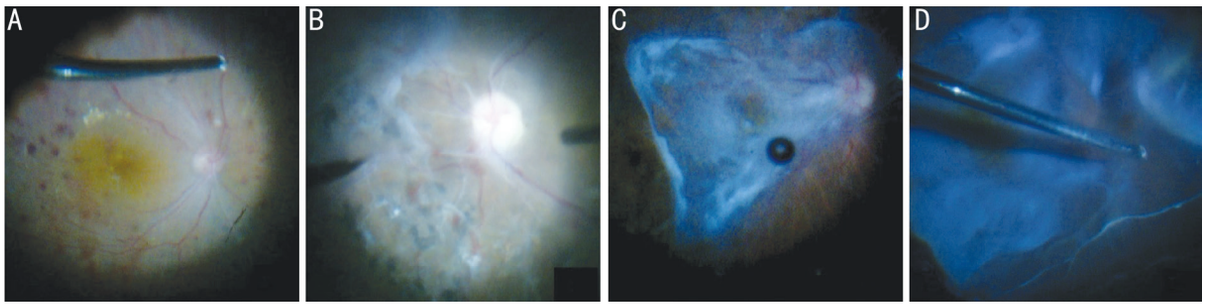

Figure 1 Screenshots from the surgical video showing 3 patterns of FVPMs locations A: Arcade type of FVPMs; B: Juxtapapillary type of FVPMs; C: Central type of FVPMs; D: FVPMs which mixing together that cannot be classified to any group. FVPM: Fibrovascular proliferative membrane.

depression. FVPMs that mix together or distributed irregularly that cannot be classified were not assigned to any group (Figure 1).

Primary outcome measure included BCVA 12mo postoperatively and rates of patients with BCVA improvement by >0.3 logarithm of the minimum angle of resolution (logMAR). The postoperative complications included vitreous rebleeding, which was not absorbed over a month and required a second surgery, recurrent retinal detachment (RD) that required a second operation, the number of patients with IRBs formed in operation, elevated intraocular pressure (IOP) (≥21 mm Hg) for >1wk, hypotony (<6 mm Hg), endophthalmitis and neovascular glaucoma or neovascular iris (NVG/NVI).

To facilitate statistical analysis, the BCVA was converted into the logMAR. We assigned perception of finger counting equivalent to 2.0 logMAR, and hand motion equivalent to 3.0 logMAR. The normal distribution and homogeneity of variance of the parameters in the analysis were preliminarily verified. The Student's *t*-test or analysis-of-variance was applied to evaluate continuous variables. If analysis-of-variance proved positive, post-hoc tests were used between group pairs. The Chi-square test or Fisher's exact test was used to compare categorical variables. Binary logistic regression was used to identify associations between pre-, intra-characteristics and postoperative BCVA improvement. The above statistical analysis was performed using a commercially available statistical software program (SPSS for Mac, version 25.0; IBM/SPSS, Chicago, IL, USA). If the sample size of three group was unbalanced, the bootstrap method will be carried out to resample the data to make the three sample sizes matched. Then the same statistical analysis process will be done again, and we will acquire the new results to verify the original results. A two-tailed *P*-value <0.05 was considered to be statistically significant.

RESULTS

A total of 103 eyes of 103 patients (54 males, 49 females) were included in the study. Thereinto, two patients with FVPMs that involved too extensive, three patients distributed in clusters irregularly and five patients presenting almost the same area between nasal to the disk and arcade vessels involvement were not assigned to any group. The other 93 patients can be clearly assigned to three categories according to the FVPM distribution (53 patients with arcade type FVPM, 29 patients with juxtapapillary type FVPM and 11 patients with central type FVPM).

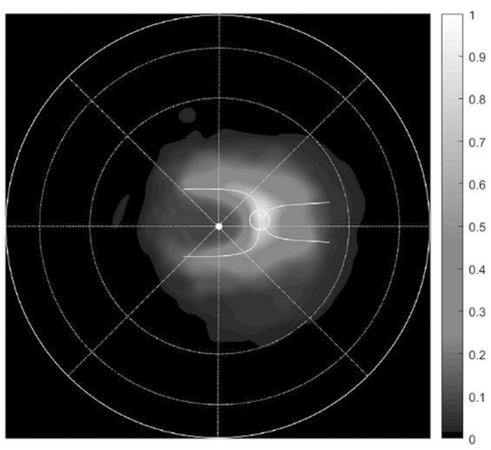

Figure 2 The distribution of the FVPMs represented by the overlapped retinal images The colors on the chart indicate the rate of overlapping FVPM according to the grayscale bar. The top of the bar represents the maximum rate of overlapping FVPMs and the bottom indicates no FVPM. FVPM: Fibrovascular proliferative membrane.

Figure 2 showed the distribution of the FVPMs represented by the overlapped retinal images. They were mostly confined to the equator (103 FVPMs) and mainly along the vascular arcades around the optic disc, with the majority concentrated nasally to the macula. Because 95 (92.23%) were located in the nasal and 8 (7.77%) in the temporal hemisphere, the FVPM centroids had a significant asymmetry between the nasal and temporal distribution (*P*<0.001). Furthermore, the distribution between the superior and inferior hemispheres was 29 (28.16%) and 74 (71.84%), respectively, which was statistically different (*P*<0.001).

Patients' preoperative characteristics were summarized in Table 1. The distribution of patient numbers among the three groups

Table 1 Preoperative, intraoperative, and postoperative clinical characteristics of eyes with FVPM that received 25-G vitrectomy *n* (%)

Characteristics	Arcade type	Juxtapapillary type	Central type	*P*	*P*[a]
No. of patients	53 (33.3)	29 (31.18)	11 (11.83)	<0.001[b]	
Sex, male	26 (49.06)	12 (41.38)	5 (45.45)	0.800[c]	0.838[c]
Age, y, mean±SD	51.45±9.33	52.03±11.98	47.91±8.55	0.503[b]	0.283[b]
Operated eye, right	22 (41.51)	7 (24.14)	7 (63.64)	0.059[c]	0.253[c]
Duration of DM, y, mean±SD	10.58±6.31	11.72±6.23	10.91±6.25	0.776[d]	0.517[d]
Age of onset DM, y, mean±SD	41.25±10.53	40.31±9.33	37.00±7.44	0.432[b]	0.190[b]
HbA1c, %, mean±SD	8.82±2.19	8.73±1.80	10.06±2.37	0.203[d]	0.151[d]
BMI, kg/m^2, mean±SD	25.44±3.60	26.22±4.15	25.04±2.63	0.661[d]	0.210[d]
Nephropathy	10 (18.9)	7 (24.14)	2 (18.18)	0.836[c]	0.601[c]
Dialysis	4 (7.5)	2 (6.90)	1 (9.09)	1.000[e]	0.920[e]
Hypertention	26 (49.1)	13 (44.83)	5 (45.45)	0.927[c]	0.797[c]
Obsolete brain infarction	9 (17.0)	3 (10.34)	1 (9.09)	0.756[e]	0.158[e]
Ischaemic heart disease	5 (9.4)	1 (3.45)	2 (18.18)	0.253[e]	0.029[e]
Patients with VH	43 (81.1)	22 (75.86)	7 (63.64)	0.437[c]	0.141[c]
Patients with pre-photocoagulation	24 (45.3)	18 (62.07)	5 (45.45)	0.326[c]	0.099[c]
Pseudophakic	6 (11.3)	1 (3.45)	0	0.430[e]	0.936[c]
Preoperative BCVA, logMAR, mean±SD	1.62±0.49	1.70±0.39	1.83±0.23	0.484[d]	0.327[d]

DM: Diabetes mellitus; HbA1c: Glycosylated hemoglobin; BMI: Body mass index; VH: Vitreous hemorrhage; BCVA: Best corrected visual acuity; logMAR: Logarithm minimum angle of resolution; FVPM: Fibrovascular proliferative membrane. [a]The statistical results of the re-sampling data; [b]Analysis-of-variance; [c]χ^2 test; [d]Nonparametric test; [e]Fisher exact test.

Table 2 Intraoperative, and postoperative clinical characteristics of eyes with FVPMs that received 25-G vitrectomy *n* (%)

Characteristics	Arcade type	Juxtapapillary type	Central type	*P*	*P*[a]
Operation time, min, mean±SD	65.53±18.61	78.66±28.39[f]	96.00±27.29[f,g]	<0.001[b]	<0.001[b]
Combined with cataract extraction	16 (30.2)	13 (44.83)	6 (54.55)	0.199[c]	0.003[c]
Tamponade					
Gas	14 (26.4)	6 (20.69)	2 (18.18)	0.761[c]	0.415[c]
Silicon oil	7 (13.2)	6 (20.69)	7 (63.64)[f,g]	0.001[c]	<0.001[c]
Patients with TRD	36 (67.9)	18 (62.07)	4 (36.36)	0.145[c]	0.392[c]
Patients with TRD/RRD	8 (15.1)	6 (20.69)	7 (63.64)[f,g]	0.002[c]	<0.001[c]
BCVA 12mo postoperative, logMAR, mean±SD	0.78±0.53	1.09±0.64[f]	1.63±0.91[f,g]	0.004[d]	<0.001[d]
Patients with BCVA improvement by >0.3, logMAR[d]	43 (81.1)	20 (68.97)	5 (45.45)[f]	0.044[c]	<0.001[c]

TRD: Tractional retinal detachment; TRD/RRD: Combined tractional and rhegmatogenous retinal detachment; BCVA: Best corrected visual acuity; logMAR: Logarithm minimum angle of resolution; FVPM: Fibrovascular proliferative membrane. [a]The statistical results of the re-sampling data; [b]Analysis-of-variance; [c]χ^2 test; [d]Nonparametric test; [f]P<0.05 compared with arcade type group; [g]P<0.05 compared with juxtapapillary type group.

was statistically significant (P<0.001). While the patients with central type FVPMs had the youngest mean age and that of DM onset, there was no statistically significant difference. Patients' intra- and postoperative characteristics were summarized in Table 2. The operation time was significantly different among the three groups (P<0.001). The post-hoc tests showed that the operation time of the central type group was significantly longer than that of the juxtapapillary type group (P=0.023) and arcade type group (P<0.001), as well as the juxtapapillary type group versus arcade type group (P=0.009). The rates of silicon oil used as a tamponade in operation and patients with TRD/RRD were significantly different among the three groups (P=0.002 and P=0.004, respectively).

The mean logMAR BCVA of all patients and of those arcade type and juxtapapillary type groups were significantly improved at the final visit compared to that preoperatively (all P<0.001). Only the patients with central type FVPM do not improve significantly (P=0.456). The arcade type group at the final visit had the best BCVA compared with that of juxtapapillary type (P=0.029) and central type (P<0.001) groups. Post-hoc tests also showed that the BCVA of the juxtapapillary type group was significantly better than that of the central type group (P=0.016). The BCVA improved by >0.3 logMAR units, approximately equal to the 15 Early Treatment Diabetic Retinopathy Study (ETDRS) letters, in 43 eyes (81.13%) of the arcade type, 20 eyes (68.97%) of

Table 3 Associations (multivariable logistic regression) between BCVA improvement and FVPM type

Parameters	*B*	SE	Wald	OR (95%CI)	*P*
Age of onset DM	-0.131	0.046	8.226	0.877 (0.802-0.959)	0.004
FVPM type					
Arcade type	3.196	1.204	7.050	24.430 (2.309-258.475)	0.008
Juxtapapillary type	1.342	1.051	1.630	3.826 (0.488-30.014)	0.202
Central type					
Preoperative BCVA, logMAR	3.493	0.902	14.985	32.892 (5.61-192.852)	<0.001
Patients with combined TRD/RRD	-2.235	0.793	7.944	0.107 (0.023-0.506)	0.005

DM: Diabetic mellitus; FVPM: Fibrovascular proliferative membrane; BCVA: Best corrected visual acuity; logMAR: Logarithm minimum angle of resolution; TRD/RRD: Combined tractional and rhegmatogenous detachment. OR: Odd sratio; CI: Confidence interval.

Table 4 Intraoperative and postoperative complications *n* (%)

Complications	Arcade type	Juxtapapillary type	Central type	*P*	*P*[a]
Iatrogenic retinal breaks	6 (11.32)	6 (20.69)	6 (54.55)[f]	0.004[c]	<0.001[c]
Retinal detachment	1 (1.89)	5 (17.24)	3 (27.27)[f]	0.005[e]	0.028[e]
Recurrent vitreous hemorrhage	2 (3.77)	2 (6.90)	0	0.767[e]	0.359[e]
Intraocular pressure evaluation	5 (9.43)	4 (13.79)	4 (36.36)	0.067[e]	<0.001[c]
Neovascularizations (angle and/or iris)	1 (1.89)	2 (6.90)	1 (9.09)	0.237[e]	0.156[e]

[a]The statistical results of the re-sampling data; [c]χ^2 test; [e]Fisher exact test; [f]*P*<0.05 compared with arcade type group.

juxtapapillary type group and five eyes (45.45%) of the central type group. These rates of improvement were significantly different among the three groups (*P*=0.044).

Table 3 showed the associations between pre-, intra-characteristics and BCVA improvement assessed by binary logistic regression. Among the four independent variables included in the model, FVPM type, age of onset DM, preoperative BCVA and combined TRD/RRD were significantly associated with BCVA improvement (all *P*<0.05). The binary logistic regression model was statistically significant (χ^2=48.831, *P*<0.001). Compared with the central type group, the arcade type group had higher rates of BCVA improved by >0.3 logMAR.

In our cohort, there were no cases of endophthalmitis or hypotony, and 10 cases (9.71%) presented with recurrent RD that required a second PPV procedure. IRBs were distinguished by intraoperative endocautery and identified in 20 (19.42%) eyes. There was a significant difference among the three groups regarding the rates of eyes with recurrent RD and IRBs (*P*=0.005 and *P*=0.004, respectively). The rate of recurrent VH that required a re-vitrectomy was 4.85%. High IOP sustained for >1wk presented in 14 (13.59%) patients and NVG/NVI occurred in four (3.88%) eyes. There were no significant differences in the distributions of NVG/NVI and recurrent VH among the three groups. These outcomes were presented in Table 4.

To resolve the problem of imbalanced sample sizes, the bootstrap method was used to resampling the data of juxtapapillary type group and central type group. Then we got the other new *P*-value, recorded at the last row of Tables 1, 2, and 4. Only the issues of high IOP postoperative and combined with cataract extraction intraoperative display the different results.

DISCUSSION

Location variation of FVPMs in PDR eyes will affect the macular structure, which is closely associated with the visual and anatomic prognosis postoperatively[12-13]. In the current report and other studies, approximately 80% of patients require PPV surgery due to a non-clearing or recurrent VH[3,7]. Therefore, the fundus of most patients were first observed clearly during the operation, and the FVPM was the most distinguishable sign that could be detected without any auxiliary equipment. In the current study, we investigated the approximate distributions of FVPMs through the schematic images and evaluated the different outcomes of 25-G PPV for the management of PDR with different FVPM types.

Previous studies showed that microaneurysms mainly occurred around the macular region at the earliest stage of DR[14]. As non-PDR developed, the retinal nonperfusion areas extended to the larger vascular arcades and midperipheral retina[15-16], mainly appearing in the nasal hemisphere[17]. In PDR, it was also reported that the majority of the neovascularization was located in the nasal hemisphere and along the superior vascular arcades[11]. There are four layers of the capillary network together with nerve fiber axons around the optic disc but only three layers in the macula[18], such that the nasal side has relatively abundant blood vessels and is more susceptible to ischemia. This could be the reason that neovascularization induced by ischemia always spreads on the nasal hemisphere of the retina. In the current study, the overlapped fundus map was consistent with previous studies and showed that a large

amount of FVPMs spread along the vascular arcades and nasally to the macular. Because FVPMs are mainly composed of neovascular stromal tissue, their distribution is almost consistent with neovascularization elsewhere. Furthermore, it was also affected by common process of posterior vitreous detachment (PVD). This frequently starts in the foveal areas and extends first in a superior direction. Subsequently, the PVD extends further in the superotemporal and nasal direction and continues in the inferotemporal direction before extending further nasally[19]. The occurrence of neovascularization elsewhere and FVPMs on the retinal surface are based on an appropriate scaffold collagenous material, such that PDR progression is significantly associated with no PVD or partial PVD[20]. This PVD process depicted above may also be a possible reason for the phenomenon that among the three categories of FVPM described here, the rarest was the central type.

In the current study, the distribution of FVPMs was not associated with age, sex, laterality, DM duration or age of onset, glycated hemoglobin or body mass index. Suffering from nephropathy, hypertension, obsolete brain infarction or requiring dialysis or preoperative photocoagulation treatment also did not affect the FVPM distribution. Theoretically, PVD does not initiate in younger patients, who were thus prone to present with a central type FVPM. Although the patients with a central type FVPM had the youngest mean age and DM onset in our study, there was no statistically significant difference among the three groups.

Our results demonstrated that 25-G PPV was safe and effective in the management of PDR complicated with FVPMs, particularly the PDR eyes with arcade or juxtapapillary type FVPM. By comparison, the recruited eyes of the central type group displayed the highest rates of combined TRD/RRD, IRB formation, silicon oil tamponade, recurrent RD and worst BCVA 1y, postoperatively. All of the central type FVPMs involving macular promoted a poor visual prognosis than the other two types, as well as the anatomic results. Therefore, it will raise concern when the fundus photograph or ultrasonography providing insight into the prognosis following vitrectomy to patients indicate that FVPMs are present around the posterior pole. Additionally, early intervention is essential for PDR patients with neovascularization concentrated in the macula with no or partial PVD.

It has been confirmed that the high incidence of IRBs formation was associated with increased postoperative complications, including rebleeding, recurrent RD and NVG, as well as worse postoperative BCVA[5,21-22]. Smaller gauge PPV with high cut rates was reported to display more stable fluidics due to diminished flow and a better ability to preserve the vitreous base that prevents vitreal incarceration and dragging, which will minimize the risk for IRBs[23]. Using 23-G vitrectomy systems, Celik *et al*[24] observed IRBs in 15% of eyes with diabetic FVPM threatening the macula. Using 25-G vitrectomy systems, Mikhail *et al*[6] reported only six IRBs in 109 eyes in the management of diabetic TRDs, and Xiang *et al*[25] reported that the retinal tear formation occurred in 20% of eyes in PDR patients. In the present study, the IRBs incidence was 11.32%, 13.79%, and 54.55% in the eyes of the arcade type group, juxtapapillary type group and central type group, respectively. The incidence of IRB formation during an operation was increased by relatively complex ocular conditions, such as combined TRD/RRD, which will induce retinal atrophy and fragility.

Our study had several limitations. First, we were only able to retrospectively evaluate inaccurate images outlined roughly after the operation because most patients recruited in the current study also displayed VH or opacified vitreous or lens. The inaccurate drawings could not provide the specific size, length or distance from the macula. Second, since this is a cross-sectional study, the imbalance of sample size among three group can't be avoided due to the pathological process mentioned above. Patients with central type FVPM were really rarer compared with the other two types, there must be inevitable bias on the process of statistical analysis although bootstrap method had been used. Case-control studies with large samples are needed for further confirmation. Furthermore, our study included only patients with completed review data in the first year of follow-up. Those patients with a follow-up shorter than 12mo were excluded. The consequences of this bias may have affected the results.

In summary, our study demonstrated that FVPMs were more commonly found in the area of arcade vessels, followed by nasal and inferior mid-peripheral retina. Performance of 25-G vitrectomy proved to be safe in managing complicated PDR and was able to achieve satisfactory anatomical outcomes to preserve or improve vision in a large proportion of cases with complex FVPMs. Given that PDR patients with central type FVPM had a relatively worse visual and anatomic prognosis in comparison, further research into earlier intervention of PDR with central type FVPM is warranted.

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