Diabetes, Metabolic Syndrome and Obesity

Dovepress
open access to scientific and medical research

Open Access Full Text Article

ORIGINAL RESEARCH

Clinical Characteristics and Surgical Outcomes of Complications of Proliferative Diabetic Retinopathy in Young versus Older Patients with Type 2 Diabetes

Meng Zhang[1,2], Gezhi Xu[1,2], Lu Ruan[1,2], Xin Huang[1,2,*], Ting Zhang[1,2,*]

[1]Department of Ophthalmology, Eye & ENT Hospital, Fudan University, Shanghai, 200031, People's Republic of China; [2]Institute of Eye Research, Eye & ENT Hospital, Fudan University, Shanghai, 200031, People's Republic of China

*These authors contributed equally to this work

Correspondence: Xin Huang; Ting Zhang, Department of Ophthalmology, Eye & ENT Hospital, Fudan University, 83 Fenyang Road, Shanghai, 200031, People's Republic of China, Tel +86-21-64377134, Fax +86-21-64377151, Email fd2017huangxin@163.com; tina-chang07@163.com

Purpose: Proliferative diabetic retinopathy (PDR) is a leading vision-threatening disease. In this study, we investigated the clinical features of PDR and the surgical outcomes of its complications in patients with type 2 diabetes (T2D).

Patients and Methods: We retrospectively reviewed the medical data of patients with T2D who underwent vitrectomy for PDR between January 2016 and June 2021. The patients were divided into two groups by age (young patients, < 45 years; older patients, ≥ 45 years).

Results: There were 149 eyes (100 patients) in the young patient group and 315 eyes (256 patients) in the older patient group. The proportion of males and the proportion of patients requiring binocular surgery were much higher in the young patient group than in the older patient group ($P = 0.005$ and $P < 0.001$, respectively). In the young patient group, 26.2% of eyes had active fibrovascular proliferation compared with only 11.4% in the older patient group ($P < 0.001$). The final best-corrected visual acuity (BCVA) was significantly improved relative to the preoperative BCVA in both groups ($P < 0.001$). After surgery, there were no significant differences in the incidence of postoperative neovascular glaucoma (NVG) or recurrent vitreous hemorrhage (VH) between the two groups. The incidence of postoperative recurrent retinal detachment was higher in the young patient group ($P = 0.033$). The risk factors associated with the visual outcomes in the young patient group included preoperative BCVA ($P < 0.001$), renal diseases ($P = 0.001$), postoperative NVG ($P < 0.001$), and recurrent VH ($P = 0.028$).

Conclusion: In this retrospective study, young patients who underwent vitrectomy for PDR had more severe clinical characteristics before vitrectomy. However, vitrectomy (combined with cataract surgery when necessary) achieved better final visual outcomes in young patients than in older patients with T2D.

Keywords: proliferative diabetic retinopathy, vitrectomy, fibrovascular proliferation, risk factors

Introduction

Proliferative diabetic retinopathy (PDR) is a severe complication of diabetes that is characterized by abnormal retinal vascular development, and may lead to vision loss. Recent research has shown a global increase in the prevalence of diabetes, with the International Diabetes Federation projecting up to 642 million diabetic patients by 2040,[1] and the increases will largely occur in developing countries. In a multi-hospital-based diabetic retinopathy (DR) screening program in China, the prevalence of vision-threatening DR was 12.6% in 2016.[2]

More strikingly, the incidence of diabetes mellitus (DM) is rising in numbers of young onset diabetes worldwide.[3–5] The younger the onset age of diabetes is, the longer the duration of hyperglycemia is exposed. Type 2 diabetes also has a more aggressive disease course in youths, with more rapid deterioration of β-cell function and earlier development of

Received: 16 July 2022
Accepted: 24 November 2022
Published: 11 January 2023

diabetes-associated complications compared with older patients, resulting in a greater risk of blindness in working-age individuals.[6–8] Pars plana vitrectomy (PPV) is a major and effective method of treating PDR, with main indications that include severe vitreous hemorrhage (VH), traction retinal detachment (TRD) threatening or involving the macula, combined RRD and severe fibrovascular proliferation. However, the challenges related to surgery for PDR are greater in young patients because active fibrovascular proliferation (FVP) is more severe in that population. Anti-vascular endothelial growth factor (VEGF) drugs have been widely used as a preoperative adjunct before vitrectomy for the treatment of severe PDR.[9,10] Furthermore, young patients have a higher incidence of postoperative adverse complications than older patients, including neovascular glaucoma (NVG), recurrent VH, and retinal detachment (RD).

Many studies have shown that the risk factors for DR progression include poor metabolic control, the duration of diabetes, younger age at diagnosis, and elevated blood pressure.[11,12] Puberty was also shown to be a risk factor for early-onset DR because glycemic control is poor and there are significant changes in hormone levels in this age group.[12] Whether gender and race are risk factors for PDR remains controversial and requires further research.[13,14]

Although extensive studies have examined the epidemiology of diabetes and its association with DR, as well as the general outcomes of surgical treatment of PDR, few studies have focused on the prognosis of surgical outcomes and risk factors in patients with early-onset T2D. Therefore, it is still unclear whether the clinical presentation and the outcomes of vitrectomy, in terms of PDR complications, differ between young and older T2D patients. Therefore, we conducted a retrospective study to compare the clinical features of PDR and the surgical outcomes between young patients and older patients with T2D at a large ophthalmological center in China.

Materials and Methods

Patients

The medical records of consecutive patients with T2D who underwent 25-gauge vitrectomy for PDR complications between January 2016 and June 2021 were retrospectively reviewed. All procedures were performed by a single vitreoretinal surgeon at the ophthalmology department of Eye and ENT Hospital of Fudan University. Exclusion criteria included severe systemic diseases, incomplete medical data, preoperative no light perception, history of vitreoretinal surgery, and other severe ocular diseases. The patients were divided into two groups by age (young patients, < 45 years; older patients, ≥ 45 years) to compare their clinical features and vitrectomy outcomes. All patients were followed-up for at least 6 months after surgery. The study was conducted in accordance with the Declaration of Helsinki, and was approved by the Institutional Review Board of the Eye and ENT Hospital of Fudan University.

Data Collection

The preoperative demographic and ophthalmological data, intraoperative surgical data, and postoperative outcomes were retrieved from the electronic medical records database. The preoperative data included age, gender, ocular examinations, duration of and therapy for diabetes, systemic conditions (blood glucose and hemoglobin A1c (HbA1c) levels, hypertension, cardiovascular disorders, cerebrovascular disorders and renal disorders), and any history of preoperative intravitreal injection of anti-VEGF drugs or panretinal photocoagulation (PRP). The intraoperative data included the surgical procedures and surgical findings. The postoperative clinical characteristics included postoperative complications, best-corrected visual acuity (BCVA), macular thickness from the optical coherence tomography (OCT) and reoperation. Visual acuity was recorded as decimal visual acuity and converted to logarithms of the minimum angle of resolution (logMAR) for statistical analysis. The mean follow-up period after surgery was 19.2 ± 9.9 months (range, 6–38 months).

Surgical Treatment

An anti-VEGF drug was injected intravitreally 3–5 days before surgery in patients with severe active FVP if they were considered at high risk of intraoperative bleeding.

All procedures were performed with the 25-gauge Alcon Constellation Vision System (Alcon Laboratories, Fort Worth, TX, USA) with the Resight Fundus Viewing System (Carl Zeiss Meditec Co., Ltd, Tokyo, Japan). Phacoemulsification was performed first if the presence of cataract significantly affected the surgeon's view of the

fundus during surgery or if the surgeon considered that preserving the lens was not conducive to achieving the surgical objective. During the core vitrectomy, VH was excised to the greatest possible extent. Intraoperative active bleeding was managed by a transient increase in the intraocular perfusion pressure or intraocular endodiathermy. Triamcinolone acetonide was injected in eyes with posterior vitreous detachment. For proliferative preretinal membranes and fibrovascular membranes, membrane peeling with forceps, segmentation with scissors, and delamination were performed. Retinectomy and subretinal surgery were performed in patients with significant extensive unreleasable subretinal proliferation. Depending on the complexity of the membrane, a bimanual technique was used when necessary. Fluid–gas exchange was performed in patients with RD and retinal breaks. PRP was completed as usual. Silicone oil tamponade was used if large or multiple retinal breaks or retinectomies were present to ensure rhegmatogenous confinement and reduce reproliferation.

Statistical Analysis

All data were analyzed using SPSS version 20.0 (IBM Corp., Armonk, NY, USA). Continuous data are expressed as means ± standard deviations (SD). A *t*-test was used to compare the differences between the two groups. Categorical data are presented as percentages. The χ^2 test and Fisher's exact test were used to compare categorical variables. Multivariable linear regression was used to analyze the factors associated with the visual prognosis in the young and older patient groups at 6 months after PPV. In all statistical analyses, $P < 0.05$ was considered to indicate statistical significance.

Results

Patient Demographics

A total of 464 eyes in 356 patients with PDR were included. There were 149 eyes (100 patients) in the young patient group (aged < 45 years) and 315 eyes (256 patients) in the older patient group (aged ≥ 45 years). The mean duration of DM at the time of surgery was shorter in the young patient group than in the older patient group (5.73 ± 4.89 years and 12.69 ± 7.06 years, respectively, $P < 0.001$). The mean age at surgery was 36.24 ± 5.53 years (range 18–44 years) in the young patient group and 57.86 ± 7.53 years (45–80 years) in the older patient group. The proportion of males and the proportion of patients requiring binocular surgery were much higher in the young patient group than in the older patient group ($P = 0.005$ and $P < 0.001$, respectively).

The patients in the older patient group were more likely be treated with insulin combined with other drugs than were the young patients ($P = 0.013$). There was no significant difference in the preoperative glycemic control between the young and older groups (blood glucose, 7.27 ± 2.16 mmol/L and 7.76 ± 2.34 mmol/L, respectively, $P = 0.078$; HbA1c, 7.32 ± 1.41 and 7.30 ± 1.17, respectively, $P = 0.92$). When the systemic diseases in the two groups were compared, the commonest disease was hypertension. The older group had a higher incidence of hypertension, with higher systolic blood pressure, than the young patient group. However, patients in the young group were more likely to have higher diastolic blood pressure than the older patients (82.67 ± 10.37 and 77.55 ± 10.33 mmHg, respectively, $P < 0.001$) and therefore narrower pulse pressure than the older patients. There were no significant differences in the incidence of cardiovascular, cerebrovascular, or renal diseases in the two groups ($P = 0.404$, $P = 0.244$, and $P = 0.997$, respectively). The clinical demographic data were summarized in Table 1.

Surgical Indications and Intraoperative Findings

Preoperative PRP and intravitreal injection of anti-VEGF drugs were performed in 84 eyes (56.4%) and 75 eyes (50.3%) in the young patient group respectively. The proportions of patients treated these interventions were significantly greater in the young patient group than in the older patient group ($P = 0.004$ and $P < 0.001$, respectively).

The medical records showed that the main surgical indication for surgery in the young patient group was VH and TRD combined with tractional rhegmatogenous retinal detachment (RRD). However, VH without other complications was the main reason for older patients to undergo PPV. Active FVP was more frequent in the young patient group (39 eyes, 26.2%) than in the older patient group (36 eyes, 11.4%), and differed significantly between the two groups ($P < 0.001$).

Table 1 The Clinical Demographic Data of the Patients in the Study

Characteristics	Young Patient	Older Patient	*P*-value
Total eyes (patients)	149 (100)	315 (256)	
Both eyes (n, %)	49 (49.0%)	59 (23.0%)	< 0.001
Right eye (n, %)	29 (29.0%)	91 (35.5%)	0.030
Left eye (n, %)	22 (22.0%)	106 (41.4%)	< 0.001
Age at operation (years)	36.24 ± 5.53	57.86 ± 7.53	< 0.001
Gender (n, %)			
Male	67 (67.0%)	129 (50.4%)	0.005
Female	33 (33.0%)	127 (49.6%)	0.005
History (years)	5.73 ± 4.89	12.69 ± 7.06	< 0.001
Therapy (n, %)			
Drugs only	45 (30.2%)	68 (21.6%)	0.044
Drugs and insulin	38 (25.5%)	117 (37.1%)	0.013
Insulin only	64 (43.0%)	125 (39.7%)	0.503
Unknown	2 (1.3%)	5 (1.6%)	1.000
Blood pressure (mmHg)			
Systolic blood pressure	131.50 ± 20.97	142.50 ± 18.80	< 0.001
Diastolic blood pressure	82.67 ± 10.37	77.55 ± 10.33	< 0.001
Blood glucose (mmol/L)	7.27 ± 2.16	7.76 ± 2.34	0.078
HbA1c (%)	7.32 ± 1.41	7.30 ± 1.17	0.920
Systemic diseases (n, %)			
Hypertension	78 (52.3%)	213 (67.6%)	0.001
Cardiovascular disorders	5 (3.4%)	16 (5.1%)	0.404
Cerebrovascular disorders	3 (2.0%)	13 (4.1%)	0.244
Renal disorders	9 (6.0%)	19 (6.0%)	0.997

Cataract surgery combined with vitrectomy was performed intraoperatively in 39 eyes (26.2%) and 245 eyes (77.8%) in the young and older groups, respectively ($P < 0.001$). Retinotomy was performed in 9 (6.0%) eyes in young patient group and 5 (1.6%) eyes in the older group, which differed significantly ($P = 0.020$).

The choice of the tamponade agent was based on the patient's preoperative characteristics and intraoperative findings. Intraoperative silicone oil tamponade was used in a significantly greater proportion of patients in the young patient group than in the older patient group (42.3% and 29.8%, respectively, $P = 0.008$). There was no significant difference in the distribution of gas tamponade or balanced salt solution (BSS) tamponade between the two groups. At the final follow-up, 10 eyes (10 patients) in the young group and 11 eyes (9 patients) in the older group had retained silicone oil tamponade.

The patients treated with silicone oil tamponade had relatively worse preoperative BCVA and more severe FVP and RD than patients treated with gas or BSS tamponade. Among the patients treated with silicone oil, only 30 eyes (19.1%) had a preoperative BCVA of 20/400 or better, whereas 86 eyes (28.0%) had a preoperative BCVA of 20/400 or better in patients treated with gas or BSS tamponade ($P = 0.036$). The surgical indications and intraoperative findings were shown in Table 2.

Visual Acuity and Macular Thickness After Surgery

At the end of the follow-up period, the final BCVA was significantly improved compared with the preoperative BCVA in both groups. The mean BCVA improved significantly from 1.65 ± 0.46 preoperatively to 0.95 ± 0.64 postoperatively ($P < 0.001$) in the young patient group and from 1.61 ± 0.52 to 1.08 ± 0.61 in the older patient group ($P < 0.001$). Compared with the older patients, the young patients generally had worse BCVA before surgery, but better BCVA after surgery (Table 3). The postoperative BCVA at the final follow-up improved 2 or more lines in 113 eyes (75.8%), remained stable in 26 eyes (17.4%), and deteriorated 2 or more lines in 10 eyes (6.7%) in the young patient group. In the older patient group, the postoperative BCVA improved 2 or more lines in 205 eyes (65.1%), remained stable in 75 eyes (23.8%), and deteriorated 2 or more lines in 35 eyes (11.1%).

Table 2 The Surgical Indications and Intraoperative Findings of the Patients in the Study

Characteristics	Young Patient	Older Patient	*P*-value
Pre-operation			
BCVA (LogMAR)	1.65 ± 0.46	1.61 ± 0.52	0.454
PRP (n, %)	84 (56.4%)	132 (41.9%)	0.004
IVI (n, %)	75 (50.3%)	100 (31.7%)	< 0.001
Surgical indication (n, %)			
VH only	44 (29.5%)	123 (39.1%)	0.046
TRD with or without VH	39 (26.2%)	71 (22.6%)	0.390
VH+FVP with or without TRD	22 (14.8%)	23 (7.3%)	0.011
Combined tractional RRD	44 (29.5%)	93 (29.5%)	0.990
with FVP	17 (11.4%)	13 (4.1%)	
Without FVP	27 (18.1%)	80 (25.4%)	
Others	0 (0%)	5 (1.6%)	0.287
Surgical records Vitreous tamponade (n, %)			
Gas	19 (12.8%)	57 (18.1%)	0.146
Silicone oil	63 (42.3%)	94 (29.8%)	0.008
BSS	67 (45.0%)	164 (52.1%)	0.153
Cataract extraction (n, %)	39 (26.2%)	245 (77.8)	< 0.001
Retinotomy (n, %)	9 (6.0%)	5 (1.6%)	0.020

Abbreviations: BCVA, Best corrected visual acuity; PRP, Panretinal photocoagulation; IVI, Intraocular injection; VH, Vitreous hemorrhage; TRD, Tractional retinal detachment; FVP, Fibrovascular proliferation; RRD, Rhegmatogenous retinal detachment; BSS, Balanced salt solution.

After 3 months of follow-up, the mean macular thickness of the young patient group was thinner than that of the older patient group (243.14 ± 82.74 μm and 281.30 ± 107.63 μm, respectively, $P = 0.005$).

Postoperative Complications

The main postoperative complications were NVG, RD, recurrent VH, and epiretinal membrane (ERM). NVG was the most frequent complication in this study. NVG occurred after primary PPV in 7 of 149 eyes (4.7%) in the young patient group, and in 7 of 315 eyes (2.2%) in the older patient group. VH was the second commonest postoperative complication, occurring in 3 (2.0%) eyes in the young patient group and 5 (1.6%) eyes in the older patient group; all of these eyes were treated with vitreous washout. Only two eyes developed significant ERM after primary PPV, and both were in the young patient group. There were no significant differences in the incidence of postoperative NVG, VH, and ERM between the two groups ($P = 0.155$, $P = 1.000$, and $P = 0.103$, respectively). After primary PPV, three eyes in the young patient group developed recurrent RD, whereas no eyes did in the older patient group ($P = 0.033$). These three eyes all had TRD or RRD before primary PPV, and were successfully treated with retinal reattachment surgery. No patient in either group suffered postoperative endophthalmitis. Table 3 showed the postoperative complications in this study.

Analysis of Factors Associated with the Visual Outcome

The multivariable linear regression analysis indicated that the risk factors associated with the visual outcome in the young patient group were preoperative BCVA ($P < 0.001$), renal disorders ($P = 0.001$), postoperative NVG ($P < 0.001$), and recurrent VH ($P = 0.028$). However, there were no significant associations between the visual prognosis and the duration of DM, patient age, hypertension, preoperative PRP, intravitreal injection of anti-VEGF drugs, the presence of FVP, TRD, or RRD, the use of silicone oil, or postoperative RD. In the older patient group, the preoperative BCVA ($P < 0.001$), the duration of DM ($P = 0.002$), and the presence of TRD ($P = 0.019$) were significantly associated with the visual outcome. The other factors were not significantly associated with the visual outcome (Table 4).

Table 3 The Final BCVA and Postoperative Complications of the Patients in the Study

Characteristics	Young Patient	Older Patient	*P*-value
Post-operation			
BCVA (LogMAR)	0.95 ± 0.64	1.08 ± 0.61	0.043
Postoperative complications (n, %)			
NVG	7 (4.7%)	7 (2.2%)	0.155
Recurrent VH	3 (2.0%)	5 (1.6%)	1.000
Recurrent RD	3 (2.0%)	0 (0%)	0.033
ERM	2 (1.3%)	0 (0%)	0.103

Abbreviations: BCVA, Best corrected visual acuity; NVG, neovascular glaucoma; VH, Vitreous hemorrhage; RD, Retinal detachment; ERM, epiretinal membrane.

Table 4 The Linear Regression Analysis of Risk Factors Influencing visual outcome in the Young Patients and the Older Patients

Risk Factors	Young Patient			Older Patient		
	Coefficient	t	*P*-value	Coefficient	t	*P*-value
Age	0.038	0.491	0.624	0.100	1.782	0.076
Gender	−0.024	−0.337	0.737	−0.071	−1.337	0.182
Duration of DM	0.047	0.646	0.519	−0.164	−3.069	0.002
Hypertension	−0.039	−0.530	0.597	0.030	0.558	0.577
Renal disorders	0.274	3.542	0.001	0.051	0.946	0.345
Preoperative BCVA	0.295	4.079	0.000	0.279	5.237	0.000
Preoperative PRP	−0.087	−1.197	0.233	−0.023	−0.429	0.668
Preoperative IVI	−0.034	−0.475	0.636	0.014	0.257	0.797
Preoperative FVP	0.016	0.222	0.825	−0.011	−0.203	0.839
Preoperative TRD	−0.032	−0.421	0.675	0.127	2.364	0.019
Preoperative RRD	0.090	1.213	0.227	0.057	0.910	0.363
Silicone oil tamponade	0.124	1.639	0.103	0.057	0.887	0.376
Postoperative NVG	0.317	4.332	0.000	−0.024	−0.443	0.658
Recurrent RD	0.090	1.213	0.227	0.073	1.372	0.171
Recurrent VH	−0.174	−2.220	0.028	0.069	1.293	0.197

Abbreviations: DM, Diabetes mellitus; BCVA, Best corrected visual acuity; PRP, Panretinal photocoagulation; IVI, Intraocular injection; FVP, Fibrovascular proliferation; TRD, Tractional retinal detachment; RRD, Rhegmatogenous retinal detachment; NVG, Neovascular glaucoma; RD, Retinal detachment; VH, Vitreous hemorrhage.

Discussion

Although the prevalence of diabetes is rising globally, the overall prevalence of DR has been declining in the past 20 years.[15] This trend is mainly attributed to intensive insulin therapy and advances in screening for DR. Nevertheless, PDR is a significant socioeconomic problem for working-age adults, resulting in impaired vision and an inability to work. Vitrectomy is a key method of treating PDR complicated with, for instance, persistent VH, TRD, or RRD. In this study, we compared the clinical features of severe PDR and the outcomes of surgical interventions for the treatment of its complications in young and older patients with T2D.

We analyzed a group of consecutive patients who underwent 25-gauge vitrectomy for PDR complications performed by an experienced vitreoretinal surgeon. Previous research has shown that patients aged < 45 years with diabetes have greater risk of PDR and its serious complications.[16] Therefore, we selected patients aged < 45 years as the young patient group. Consistent with other studies, the mean duration of diabetes at the time of surgery was shorter in the young patients than in the older patients. Two additional findings of this study were that the young patient group comprised a greater proportion of males and a greater proportion of patients requiring binocular surgery than the older patient group.

In a large clinical study conducted by Mehlsen et al, males with PDR had a lower age at PDR diagnosis, more severe retinopathy, and higher blood pressure than females with PDR.[17] These demographic characteristics imply that in young patients, especially in young men, who require vitrectomy for PDR, the disease is more aggressive than in older patients.

Many studies have demonstrated that glycemic control plays a crucial role in the development of PDR, and hyperglycemia or a high HbA1c level is related to the deterioration of PDR. However, we found no significant difference in preoperative glycemic control between the two groups, which may be attributable to the fact that our patients were required to maintain stable blood glucose and HbA1c levels before vitrectomy. In this study, the commonest systemic disease in both groups was hypertension. The older patients had a higher incidence of hypertension, with higher systolic blood pressure, than the young patients. However, the young patients were more likely to have higher diastolic blood pressure and therefore narrower pulse pressure, which is consistent with the results of several other studies.[18,19] Some researchers have also shown a significant association between diastolic blood pressure and PDR. In that analysis, diastolic blood pressure ≥ 90 mmHg was a risk factor for PDR.[20]

The age of DM onset has a major impact on the progression of DR. Young patients with DR often display a more aggressive disease course than older patients. In the present study, the young patient group had more active FVP and more extensive TRD or combined RRD than the older group, despite higher proportions of patients with preoperative PRP and patients with intravitreal injection of anti-VEGF drugs. Therefore, although the surgical success rate was relatively high in both groups when advanced vitrectomy techniques were used, a higher proportion of young patients required retinotomy and silicone oil tamponade than older patients.

The final BCVA was significantly improved relative to the preoperative BCVA in both groups, consistent with other studies.[21,22] Many previous studies have shown that the visual prognosis is worse in young patients than in older patients,[23] which is attributed to the higher rate of recurrent RD and severe FVP in young patients, and the subsequent poor anatomical recovery. However, in our study, the visual prognoses were not consistent with previous findings. We found that although the preoperative BCVA of young patients was worse, their postoperative BCVA was better than that of older patients at the end of the follow-up period. This result may be partly attributable to the following factors. First, all of the surgical procedures in our study were performed by a single vitreoretinal surgeon with excellent surgical skills. Second, the blood supply to the retina is better in young patients than in older patients, and vascular occlusion is less common in young patients. Therefore, once the retina is surgically stabilized, the potential for functional improvement is greater in younger patients than in older patients. Third, in this study, intractable macular edema after surgery was less common in young patients than in older patients.

In this study, NVG was the most frequent complication after vitrectomy. The early onset of DM is considered a risk factor for postoperative NVG, and the presence of NVG is thought to be associated with a poor visual prognosis.[11] Among the seven eyes with postoperative NVG in the young patient group, only one eye had a final BCVA > 0.05. However, in the older patient group, four of the seven eyes with postoperative NVG had a final BCVA > 0.05. VH was the second commonest postoperative complication. The incidence of recurrent VH was 2.0% in the young patient group and 1.6% in the older patient group. The pathogenesis of NVG and VH in PDR involves ocular ischemia and neovascularization. Therefore, adequate intraoperative PRP should be performed and anti-VEGF drugs administered if necessary. However, there were no significant differences in the incidence of postoperative NVG or VH between the two groups. There were three cases of postoperative recurrent RD after vitrectomy, and all three were young patients with RD before vitrectomy. This suggests that young patients with complicated PDR are more likely to develop postoperative recurrent RD.

In this study, we analyzed the risk factors affecting the final visual outcome. Preoperative BCVA correlated significantly with the final BCVA in both groups. Other risk factors for a poor visual outcome were renal disease, postoperative NVG, and recurrent VH in the young patient group, the duration of DM and preoperative TRD in the older patient group. The associations between the final visual outcome after vitrectomy and pre-existing general conditions have been studied by many researchers. DR and diabetic nephropathy are microvascular complications of DM, and have similar microangiopathy. Previous studies have suggested that the duration of DM is a risk factor for the development of DM with microvascular complications. Raczynska et al reported that patients with diabetes for more than 6 years were at high risk of developing DR and diabetic nephropathy.[24] TRD in severe PDR is often caused by contraction of the FVP

membrane. The anatomical structure of the detached retina is damaged. Dissection of the FVP membrane from the detached retina may lead to further damage, which when combined with the poor retinal recovery potential of older patients, may account for the poor final BCVA in the presence of TRD in older patients.

There were some limitations to our research. First, the retrospective design made it difficult to compare the two groups with a rigorous research design. Second, no long-term clinical data were available for some systemic conditions, such as glycemic control, blood pressure, and blood lipid levels. All of the patients included in this study were from a specialized eye hospital. Therefore, for other diabetic complications, only a few major complications were reviewed. Third, this study comprised clinical data from a single hospital, in which all procedures were performed by one experienced vitreoretinal surgeon, so the results cannot be applied to the entire PDR population.

Conclusions

In summary, young patients who underwent vitrectomy for PDR had more severe clinical characteristics before vitrectomy than older patients. However, the final visual outcome after vitrectomy (combined with cataract surgery when necessary) was better in the young patient group than in the older patient group. The presence of postoperative NVG, recurrent VH, and renal disorders was associated with the final visual prognosis in the young patients.

Data Sharing Statement

The data used in this study are available from the corresponding author.

Ethics Approval and Informed Consent

This study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of the Eye and ENT Hospital of Fudan University.

Consent for Publication

All the patients provided written informed consent so that the results could be analyzed for scientific publication.

Acknowledgments

We thank the Retina and Vitreous Department of the Eye and ENT Hospital of Fudan University for their collaboration with the clinical follow-up, as well as their suggestions of our study.

Funding

This work was supported by National Natural Science Foundation for Young Scholar of China (81400410) and National Science Foundation of China (82070975).

Disclosure

The authors report no conflicts of interest in this work.

References

1. Zheng Y, Ley SH, Hu FB. Global aetiology and epidemiology of type 2 diabetes mellitus and its complications. *Nat Rev Endocrinol*. 2018;14(2):88–98. doi:10.1038/nrendo.2017.151
2. Zhang G, Chen H, Chen W, Zhang M. Prevalence and risk factors for diabetic retinopathy in China: a multi-hospital-based cross-sectional study. *Br J Ophthalmol*. 2017;101(12):1591–1595. doi:10.1136/bjophthalmol-2017-310316
3. Dabelea D, Mayer-Davis EJ, Saydah S, et al. Prevalence of type 1 and type 2 diabetes among children and adolescents from 2001 to 2009. *JAMA*. 2014;311(17):1778–1786. doi:10.1001/jama.2014.3201
4. McMahon SK, Haynes A, Ratnam N, et al. Increase in type 2 diabetes in children and adolescents in Western Australia. *Med J Aust*. 2004;180(9):459–461. doi:10.5694/j.1326-5377.2004.tb06023.x
5. Pinhas-Hamiel O, Zeitler P. The global spread of type 2 diabetes mellitus in children and adolescents. *J Pediatr*. 2005;146(5):693–700. doi:10.1016/j.jpeds.2004.12.042
6. Zou W, Ni L, Lu Q, et al. Diabetes onset at 31–45 years of age is associated with an increased risk of diabetic retinopathy in type 2 diabetes. *Sci Rep*. 2016;6:38113. doi:10.1038/srep38113
7. Singerman LJ, Weaver DT. PDR in juvenile onset diabetics: high-risk proliferative diabetic retinopathy in juvenile onset diabetics. *Retina*. 1981;1(1):18–26.

8. Wong J, Molyneaux L, Constantino M, Twigg SM, Yue DK. Timing is everything: age of onset influences long-term retinopathy risk in type 2 diabetes, independent of traditional risk factors. *Diabetes Care*. 2008;31(10):1985–1990. doi:10.2337/dc08-0580
9. Zhang ZH, Liu HY, Hernandez-Da Mota SE, et al. Vitrectomy with or without preoperative intravitreal bevacizumab for proliferative diabetic retinopathy: a meta- analysis of randomized controlled trials. *Am J Ophthalmol*. 2013;156(1):106–15.e2. doi:10.1016/j.ajo.2013.02.008
10. Zhao XY, Xia S, Chen YX. Antivascular endothelial growth factor agents pretreatment before vitrectomy for complicated proliferative diabetic retinopathy: a meta-analysis of randomised controlled trials. *Br J Ophthalmol*. 2018;102(8):1077–1085. doi:10.1136/bjophthalmol-2017-311344
11. Yau JW, Rogers SL, Kawasaki R, et al. Global prevalence and major risk factors of diabetic retinopathy. *Diabetes Care*. 2012;35(3):556–564. doi:10.2337/dc11-1909
12. Wong TY, Cheung N, Tay WT, et al. Prevalence and risk factors for diabetic retinopathy: the Singapore malay eye study. *Ophthalmology*. 2008;115 (11):1869–1875. doi:10.1016/j.ophtha.2008.05.014
13. Forga L, Goñi MJ, Ibáñez B, Cambra K, García-Mouriz M, Iriarte A. Influence of age at diagnosis and time-dependent risk factors on the development of diabetic retinopathy in patients with type 1 diabetes. *J Diabetes Res*. 2016;2016:9898309. doi:10.1155/2016/9898309
14. Kokkonen J, Laatikainen L, van Dickhoff K, et al. Ocular complications in young adults with insulin-dependent diabetes mellitus since childhood. *Acta Paediatr*. 1994;83(3):273–278. doi:10.1111/j.1651-2227.1994.tb18093.x
15. LeCaire TJ, Palta M, Klein R, Klein BE, Cruickshanks KJ. Assessing progress in retinopathy outcomes in type 1 diabetes: comparing findings from the Wisconsin diabetes registry study and the Wisconsin epidemiologic study of diabetic retinopathy. *Diabetes Care*. 2013;36(3):631–637. doi:10.2337/dc12-0863
16. Wu YB, Wang CG, Chen C, Xu LX, Su GF, Zhou XB. Analysis of risk factors for progressive fibrovascular proliferation in proliferative diabetic retinopathy. *Int Ophthalmol*. 2020;40(10):2495-2502. doi:10.1007/s10792-020-01428-y
17. Mehlsen J, Erlandsen M, Poulsen PL, Bek T. Identification of independent risk factors for the development of diabetic retinopathy requiring treatment. *Acta Ophthalmol*. 2011;89(6):515–521. doi:10.1111/j.1755-3768.2009.01742.x
18. Kostraba JN, Klein R, Dorman JS, et al. The epidemiology of diabetes complications study. IV. Correlates of diabetic background and proliferative retinopathy. *Am J Epidemiol*. 1991;133(4):381–391. doi:10.1093/oxfordjournals.aje.a115892
19. Mengyu L, Xiaohong W, Jinguo Y, et al. Characteristics and outcomes of vitrectomy for proliferative diabetic retinopathy in young versus senior patients. *BMC Ophthalmol*. 2020;20(1):416. doi:10.1186/s12886-020-01688-3
20. Lovestam-Adrian M, Agardh CD, Torffvit O, Agardh E. Diabetic retinopathy, visual acuity, and medical risk indicators: a continuous 10-year follow-up study in Type 1 diabetic patients under routine care. *J Diabetes Complications*. 2001;15(6):287–294. doi:10.1016/S1056-8727(01)00167-2
21. Shah CP, Ho AC, Regillo CD, et al. Short-term outcomes of 25-gauge vitrectomy with silicone oil for repair of complicated retinal detachment. *Retina*. 2008;28(5):723–728. doi:10.1097/IAE.0b013e318166976d
22. Cyrus MS, Charu G, Daraius S, Neelam A, Priyanka G, Dutta R. Ranjan Dimanual microincision vitreous surgery for severe proliferative diabetic retinopathy outcome in more than 300 eyes. *Retina*. 2018;38(Suppl 1):S134–S145. doi:10.1097/IAE.0000000000002093
23. Huang CH, Hsieh YT, Yang CM, et al. Vitrectomy for complications of proliferative diabetic retinopathy in young adults: clinical features and surgical outcomes. *Graefes Arch Clin Exp Ophthalmol*. 2017;255(5):863–871. doi:10.1007/s00417-016-3579-4
24. Raczyńska D, Zorena K, Urban B, et al. Current trends in the monitoring and treatment of diabetic retinopathy in young adults. *Mediators Inflamm*. 2014;2014:492926. doi:10.1155/2014/492926