

Long-term outcome of pathologic myopic foveoschisis treated with posterior scleral reinforcement followed by vitrectomy

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Abstract

• **AIM:** To report the long-term outcome of posterior scleral reinforcement (PSR) followed by vitrectomy for pathologic myopic foveoschisis (MF).

• **METHODS:** The records of 27 patients (44 eyes) treated with posterior scleral reinforcement (PSR) followed by vitrectomy for pathologic MF were retrospectively reviewed. The best-corrected visual acuity (BCVA), refractive error, axial length, and spectral-domain optical coherence tomography findings and complications were analyzed.

• **RESULTS:** Forty-four eyes of 27 patients were included in this study. The follow-up period was 47.98 ± 18.23 mo (24-83 mo). The mean preoperative BCVA (logMAR) was 1.13 ± 0.63 , and the mean postoperative BCVA was 0.30 ± 0.33 at the last visit. There showed a significant improvement in BCVA postoperatively ($P < 0.001$). Postoperative BCVA in 41 eyes (93%) was improved compared with the preoperative one. Forty-two eyes (95.45%) got total resolution of the MF after surgery. The remaining two eyes (4.55%) got partial resolution of foveoschisis. The preoperative foveal thickness was 610.45 ± 217.11 μ m and the postoperative foveal thickness at the last visit was significantly reduced to 177.64 ± 55.40 μ m ($P < 0.001$). The preoperative axial length was 29.60 ± 1.71 mm, and the postoperative axial length was 29.74 ± 1.81 mm at the last visit. There was no significant increase in axial length within 47.98 ± 18.23 mo of follow-up ($P = 0.562$). There was no recurrence of foveoschisis or occurrence of full-thickness macular hole during the whole follow-up period.

• **CONCLUSION:** For pathologic MF, PSR followed by vitrectomy is an effective procedure to improve the visual

acuity and the anatomical structure of macula. It can also stabilize the axial length for a long time.

• **KEYWORDS:** myopic foveoschisis; posterior scleral reinforcement; vitrectomy

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INTRODUCTION

Myopic foveoschisis (MF) can lead to significant decline in visual acuity in patients with pathologic myopia. The incidence of MF was about 9% to 34% in eyes with pathologic myopia^[1-5]. MF is characterized by splitting of the layers of the neurosensory retina in macular region. Actually, MF is a slowly progressive condition. Most patients retain relatively good vision. However, a small number of cases (30%) will develop into more serious complications, such as foveal detachment (FD), vitreomacular traction (VMT), full-thickness macular hole (MH), and macular hole retinal detachment (MHRD). Once these above serious complications occur, visual acuity decreases significantly^[6]. In these cases, surgical intervention is often necessary to prevent anatomical and functional deterioration. At present, the surgical strategies we adopt for MF are posterior scleral reinforcement (PSR) and vitrectomy^[7-10]. PSR can reduce the foveal thickness and stabilize the axial length. However, PSR was not enough for MF accompanied by a premacular structure. In this condition, vitrectomy is a relatively more suitable surgical strategy, which can remove the posterior vitreous cortex and abnormal vitreomacular traction. On the other hand, for significant axial elongated eyes, especially combined with posterior scleral staphyloma, vitrectomy alone is not enough to for foveoschisis relief and macular reattachment^[11-13]. In our previous study, we compared the surgical outcome of PSR followed by vitrectomy and vitrectomy alone on MF of extremely pathologic myopic eyes. The results showed that PSR followed by vitrectomy had

a better best-corrected visual acuity (BCVA) improvement^[14]. In our clinical experience, we usually use PSR followed by vitrectomy to treat MF, especially in markedly axially elongated eyes. To date, only one article has studied the one-year follow-up results after PSR followed by vitrectomy for MF^[15], and there are no data on long-term follow-up after PSR combined with vitrectomy for MF. Moreover, their surgical technique of PSR is different from ours, and our surgical technique is relatively easier to master and implement^[15]. We hope to explore whether PSR followed by vitrectomy can improve BCVA, relieve foveoschisis, and stable axial length in the long-term. Therefore, in this study, we evaluated our long-term results of PSR followed by vitrectomy for MF, including functional and anatomic outcomes, to determine whether this surgical procedure can obtain a good prognosis in a long run.

SUBJECTS AND METHODS

Ethical Approval This study was approved by the Medical Ethics Committee of the Beijing Tongren Hospital. This study was a retrospective interventional case series. Patients with pathologic MF who underwent PSR followed by vitrectomy at Beijing Tongren Eye Center from 2012 to 2018 were included in this study. We obtained informed consents from all patients before surgery.

Subjects The inclusion criteria were axial length no less than 26.0 mm; refractive error of the phakic eye ≤ -6 D; with foveoschisis; completed more than two years of follow-up. The exclusion criteria were foveoschisis with MH (lamellar or full-thickness); and history of vitrectomy or PSR.

Examination All patients underwent a routine ophthalmologic examination preoperatively and at every follow-up visit postoperatively. The following data were collected: age, sex, optical coherence tomography (OCT) findings, BCVA (Snellen chart), refractive error, axial length, postoperative complications and follow-up time. BCVA was measured using a Snellen chart. Refractive error was measured with streak retinoscopy (Heine Optotechnik GmbH & Co. KG, Herrsching, Germany). Axial length was measured with IOL Master (Carl Zeiss Meditec). If cataract was obvious, axial length was measured with A-scan and color doppler flow imaging (Esaote mylab twice, Italy). Spectral-domain OCT (Cirrus high-definition OCT; Carl Zeiss Meditec, or Heidelberg Engineering, or Optovue) centred through the fovea was performed before and after surgery to observe the macular microstructures and measure the central foveal thickness. A cross-scan for Stratus OCT and a 5-line raster scan for Cirrus OCT were performed. The Snellen BCVA was converted into the logarithm of the minimal angle of resolution (logMAR) for statistical analysis.

Main Outcome Measures The OCT images were analysed and measured in a masked fashion by two separate authors (Huang Y and Qi Y). Any discrepancies were resolved from

detailed discussion with the principal investigator (Duan AL). Central foveal thickness was defined as the vertical distance from the inner surface of the sensory retina to the retinal pigment epithelium (RPE) at the highest foveal point of MF. After determining the internal and external points, the thickness was manually measured on the horizontal OCT scan using the OCT software.

Surgical Procedures All patients got PSR firstly. The surgical procedure of PSR was as described in our previous study^[15]. A scleral buckle of donor sclera with a width of 6 to 10 mm was placed to the scleral surface of the macula. The superior end of the sclera buckle was sutured to the sclera surface to the nasal side of sclera surface near the insertion of superior rectus muscle, and the inferior end of the scleral buckle was sutured to the nasal side of sclera surface near the insertion of inferior rectus muscle. The location and scleral indentation were checked after placing the scleral buckle. It is necessary to make sure that the buckle did not compress the optic nerve.

One week after PSR, a conventional 23-gauge or 25-gauge 3-port vitrectomy was performed by a single experienced surgeon (Duan AL). Phacoemulsification with posterior chamber intraocular lens (IOL) implantation was performed simultaneously on eyes with cataracts. After vitrectomizing the core vitreous, triamcinolone acetonide (0.1-0.2 mL in a concentration of 40 mg/mL) was injected into the vitreous cavity to visualize the vitreous. The posterior hyaloid membrane was completely removed from the macular surface to get complete posterior vitreous detachment (PVD). The inner limiting membrane (ILM) was not peeled. Fluid-gas exchange was performed with tamponade of 16% perfluoroethane (C₂F₆), 12% perfluoroethane (C₃F₈), or air according to surgeon's decision. After surgery, the patients were asked to stay in a facedown position for at least 1wk depending the type of tamponade.

Follow up One day and one week after operation, visual acuity, intraocular pressure (IOP) and ocular examination were recorded. Postoperative follow-up examinations, measurements of OCT, foveal thickness, BCVA, refractive error, and axial length were routinely performed. All patients completed more than 24 months' follow-up. All Short-term and long-term postoperative complications were recorded.

Statistical Analysis Statistical analysis was performed using SPSS for Windows (version 19.0; IBM-SPSS, Chicago, IL, USA). The results are expressed as the means \pm standard deviation (SD). A paired *t*-test was used to compare the preoperative and postoperative BCVA, axial length, refractive error, and foveal thickness. The independent samples *t*-test was used to analyse the above parameters between patients with or without preoperative FD. The sex of patients with or without preoperative FD was analysed using the corrected Chi-square test. Differences were considered significant at $P < 0.05$.

RESULTS

Baseline Characteristics Forty-four eyes of 27 patients were included in this study. The demographics and clinical data of the patients are presented in Table 1. The mean age was 53.3±12.6y (range 35-78y). The mean preoperative BCVA, refractive error, axial length and foveal thickness are shown in Table 1. The mean preoperative foveal thickness was 610.45±217.11 µm. The mean preoperative axial length was 29.60±1.71 mm and the mean preoperative refractive error in phakic eyes was -16.26±4.71 D. The follow-up period was 47.98±18.23mo (range 24-83mo).

Anatomical Outcomes After PSR followed by vitrectomy, the postoperative foveal thickness was significantly reduced compared with the preoperative thickness ($P<0.001$, 177.64±55.40 µm, 610.45±217.11 µm, respectively; Table 2). At the last follow-up visit, complete resolution of the MF was achieved in 42 eyes (95.45%). The remained two eyes (4.55%) got partial resolution. OCT imaging showed the macula had obvious foveoschisis and FD before surgery (Figure 1A). After surgery, the allogeneic scleral strip was just below the macular fovea area. The allogeneic scleral strip had a good reinforcing effect on the macular area (Figure 1B).

Best-Corrected Visual Acuity and Refractive Error The mean preoperative BCVA was 1.13±0.63 logMAR. The mean postoperative BCVA at the last visit was 0.30±0.33 logMAR, which was significantly improved compared with the preoperative BCVA ($P<0.001$; Table 2). Before surgery, the Snellen BCVA was <20/200 in 17 eyes (39%), 20/50 to 20/200 in 24 eyes (55%) and ≥20/50 in 3 eyes (6%). While the Snellen BCVA was <20/200 in 3 eyes (7%), 20/50 to 20/200 in 6 eyes (13%) and ≥20/50 in 35 eyes (80%; Figure 2A). At the last visit, the Snellen BCVA was improved in 41 eyes (93%), no change in 1 eye (2%), and decreased in 2 eyes (5%). Among the improved eyes, 36 eyes (82%) showed a 3-line improvement in BCVA (Figure 2B). Among the two decreased eyes, both had pathologic myopic choroidal neovascularization (CNV) that were treated with intravitreal ranibizumab and had scar formation.

The mean postoperative refractive error at the last visit (-4.70±5.34 D) was obviously lower than the preoperative value (-16.26±4.17 D; $P<0.001$). Such a significant difference is mainly because most patients underwent cataract surgeries combined with IOL implantation. Except for those who underwent cataract surgeries, the mean postoperative refractive error of the remaining patients was -14.53±3.13, which was not significantly different from the preoperative refractive error ($P=0.356$; Table 2).

In our previous study, we found that FD had a significant impact on postoperative visual prognosis^[16]. Therefore, we divided the patients into FD and non-FD groups. There were

Table 1 Baseline characteristics in patients who underwent PSR combined with vitrectomy for high MF mean±SD

Characteristics	Values
No. of patients (eyes), <i>n</i>	27 (44)
Age (y)	53.3±12.6
Sex (F/M)	20/7
Follow-up period (mo)	47.98±18.23
Preop. axial length (mm)	29.60±1.71
Eye, <i>n</i> (%)	
Right	22 (50)
Left	22 (50)
Preop. BCVA (logMAR)	1.13±0.63
Preop. refractive error in phakic eyes (D)	-16.26±4.17
Preop. lens status, eyes (%)	
Phakic	44
Pseudophakic	0
OCT finding, eyes (<i>n</i>)	
FS without FD	24
FS with FD	20
Posterior staphyloma, eyes (<i>n</i>)	
Present	42
Absent	2
Preop. FT (µm)	610.45±217.11

PSR: Posterior scleral reinforcement; MF: Macular foveoschisis; SD: Standard deviation; F: Female; M: Male; BCVA: Best-corrected visual acuity; logMAR: Logarithm of the minimum angle of resolution; D: Diopter; FS: Foveoschisis only; FD: Foveoschisis with foveal detachment; FT: Foveal thickness.

Table 2 Comparisons of BCVA, refractive error and foveal thickness between pre- and post-PSR combined with vitrectomy for myopic foveoschisis

Parameters	Preop.	Postop.	<i>P</i> ^a
BCVA (logMAR)	1.13±0.63	0.30±0.33	<0.001
Axial length (mm)	29.60±1.71	29.74±1.81	0.562
Refractive error (D, total)	-16.26±4.17	-4.70±5.34	<0.001
Refractive error (D, phakic eye)	-16.42±3.34	-14.53±3.13	0.356
Foveal thickness (µm)	610.45±217.11	177.64±55.40	<0.001

BCVA: Best-corrected visual acuity; PSR: Posterior scleral reinforcement; logMAR: Logarithm of the minimal angle of resolution; ^aWithin the group, paired *t*-test was used to compare the preoperative and postoperative parameters.

24 eyes without FD and 20 eyes with FD according to the preoperative OCT images. The preoperative BCVA of non-FD eyes were 0.96±0.50 logMAR, and were 1.34±0.73 logMAR in FD eyes ($P=0.048$). The postoperative BCVA in the non-FD group was 0.17±0.15, which was better than the BCVA in the FD group (0.45±0.42 logMAR; $P=0.011$). The preoperative CFT was 492.54±81.90 µm in the non-FD group and 751.95±240.08 µm in the FD group; the difference between these 2 groups was statistically significant ($P<0.001$). At the

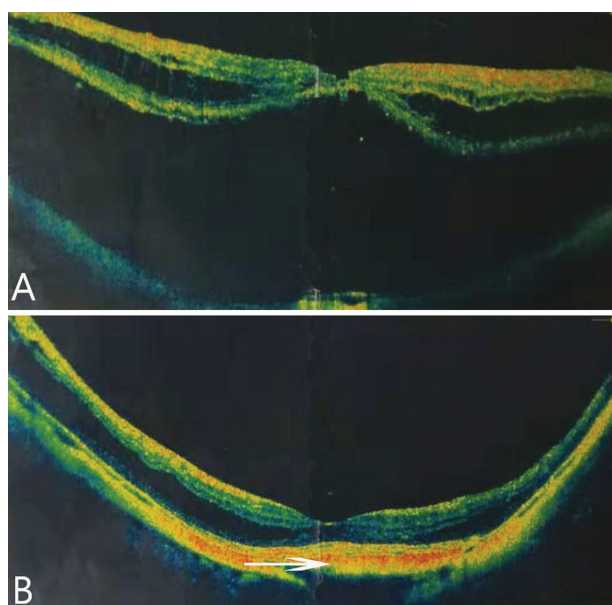


Figure 1 Representative OCT findings before and after PSR followed by vitrectomy A: Preoperative OCT showed MF with significant FD; B: OCT showed complete resolution of MF and FD 26mo postoperatively. Arrow indicated posterior scleral buckle with flattening of the scleral staphyloma and foveoschisis. OCT: Optical coherence tomography; PSR: Posterior scleral reinforcement; FD: Foveal detachment; MF: Myopic foveoschisis.

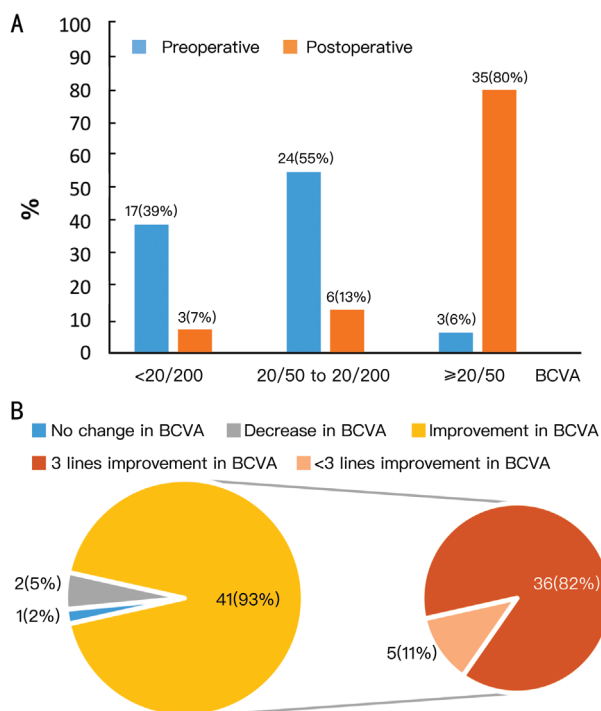


Figure 2 Comparison of BCVA at the last visit and baseline BCVA A: At the last visit, the Snellen BCVA was improved in 41 eyes (93%), had no change in 1 eye (2%), and decreased in 2 eyes (5%); B: Among the improved eyes, 36 eyes (82%) showed more than 3-line improvement in BCVA. BCVA: Best-corrected visual acuity.

last visit, there was no significant difference in CFT between the FS and FD groups (190.71±55.26 and 161.95±52.67 μm,

Table 3 Comparison of preoperative and postoperative characteristics of MF patients in non-FD and FD groups

Parameters	Non-FD (n=24)	FD (n=20)	P
Age (y)	55.92±13.02	52.20 ±8.58	0.281 ^a
Gender (n)			0.364 ^b
Male	14	8	
Female	10	12	
Preop. axial length (mm)	29.14±1.52	30.15±1.82	0.492 ^a
Axial length at last visit (mm)	29.48±1.75	30.04±1.91	0.309 ^a
Preop. refractive error (D)	-15.72±3.25	-17.42±4.14	0.094 ^a
Preop. CFT (μm)	492.54±81.90	751.95±240.08	<0.001 ^a
CFT at last visit (μm)	190.71±55.26	161.95±52.67	0.086 ^a
Preop. BCVA (logMAR)	0.96±0.50	1.34±0.73	0.048 ^a
Postop. BCVA (logMAR)	0.17±0.15	0.45±0.42	0.011 ^a

MF: Myopic foveoschisis; FS: Foveoschisis only; FD: Foveoschisis with foveal detachment; CFT: Central foveal thickness; BCVA: Best-corrected visual acuity. ^aIndependent samples *t*-test; ^bCorrected Chi-square test.

P=0.086). There was no significant difference between these two groups in age, sex, preoperative/postoperative axial length, or preoperative refractive error (Table 3).

Axial Length The preoperative mean axial length was 29.60±1.71 mm. After PSR followed by vitrectomy, the postoperative mean axial length was 29.74±1.81 mm at the last visit. There was no significant difference between the preoperative and postoperative axial lengths (*P*=0.562; Table 2). Through PSR surgery, there was no significant increase in axial length within 47.98±18.23mo of follow-up.

Complications The IOP of the two eyes (4.55%) after surgery were 25 mm Hg. One appeared at 1wk postoperatively, and the other appeared at the 1-year postoperatively. After treatment of cataprolol hydrochloride eye drops for 3-5d, both IOPs returned to normal (16-17 mm Hg). Myopic CNV developed at approximately 2y postoperatively in two eyes (4.55%) and was treated by intravitreal injection of ranibizumab. Two eyes (4.55%) developed cataracts approximately 1-2y postoperatively and underwent phacoemulsification and IOL implantation. No serious postoperative complications, including MH, peripheral retinal breaks, or retinal detachment, developed during the whole follow-up period.

Representative Cases Case 1: A 47-year-old woman with MF in her left eye received PSR in December 2013. One week after PSR, this patients got vitrectomy with phacoemulsification and IOL implantation. During the surgery, we did not peel the ILM. Because there was VMT in the macular area without obvious epiretinal membrane, we only did complete PVD without ILM peeling and used C₂F₆ as tamponade. Before surgery, the MF was obvious in her left eye (Figure 3A). The preoperative BCVA was 20/50 and the refractive error was -22.0 D. The preoperative central foveal thickness was 550 μm. The preoperative axial length was 31.5 mm. One month after

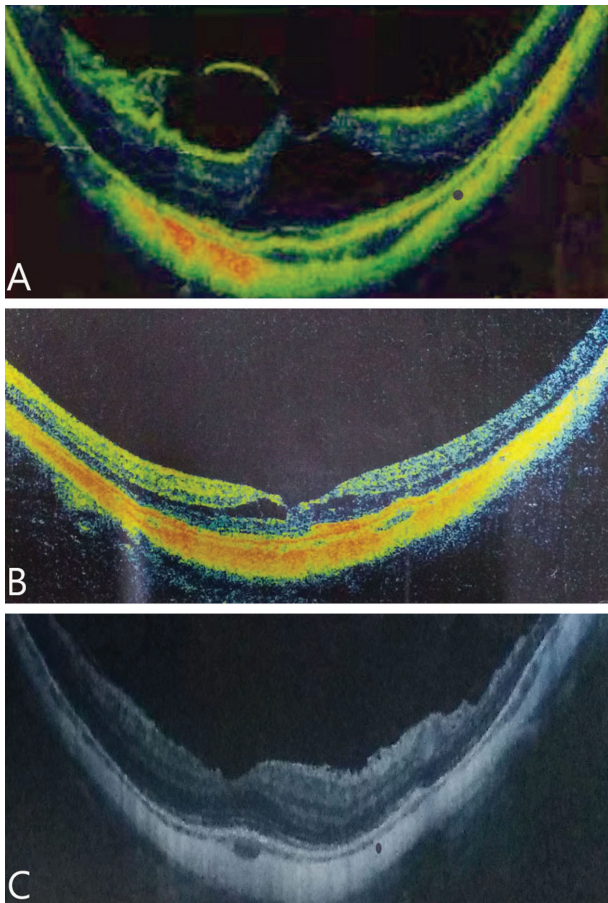


Figure 3 Representative OCT findings of case 1 A: Preoperative OCT of the macula showed MF with VMT. The central foveal thickness was 550 μm . B: The foveoschisis partially resolved one month after surgery, with residual retinoschisis in the inner retina. C: The MF got complete resolution 3mo postoperatively and maintained to 5y postoperatively. The central foveal thickness decreased to 264 μm at the last visit. VMT: Vitreomacular traction; OCT: Optical coherence tomography; MF: Myopic foveoschisis.

surgery, the BCVA improved to 20/30 and the refractive error was -3.75 D. The MF got partial resolution (Figure 3B). The MF got complete resolution 3mo postoperatively and the central foveal thickness decreased to 264 μm (Figure 3C). The BCVA was improved to 20/25 and the refractive error was -2.0 D one year after surgery and continued to 5y postoperatively. The preoperative axial length at the last visit was 31.5 mm.

Case 2: A 38-year old man with MF and FD in his left eye (Figure 4A). PSR with vitrectomy was performed on his left eye on September 2014. The preoperative BCVA was 20/200 and the refractive error was -15.0 D. The preoperative central foveal thickness was 675 μm . The preoperative axial length was 28.72 mm. One month after surgery, the BCVA improved to 20/30 and the MF got complete resolution and maintained until the last visit more than 5y postoperatively (Figure 4B). The refractive error was -15.5 D, the central foveal thickness was 140 μm and the axial length was 29.34 mm at the last visit.

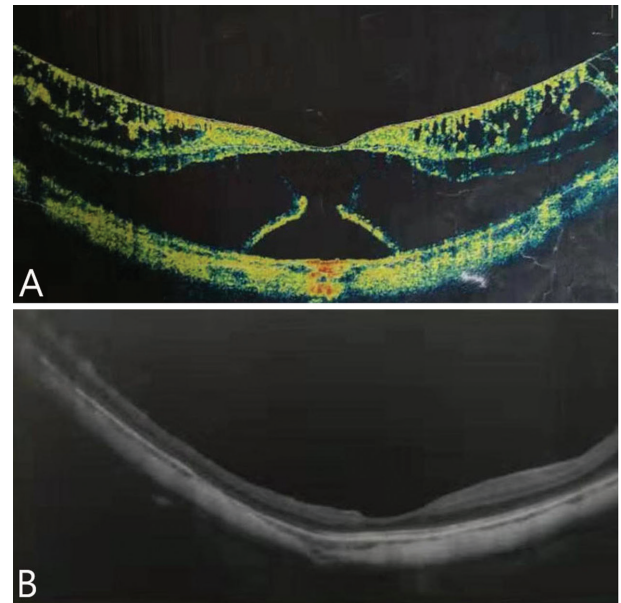


Figure 4 Representative OCT findings of case 2 A: Preoperative OCT of the macula showed myopic foveoschisis with FD. The preoperative central foveal thickness was 675 μm . B: After posterior scleral reinforcement combined with vitrectomy, OCT of the macula showed complete resolution of myopic foveoschisis and FD at the last visit. The central foveal thickness was decreased to 140 μm . FD: Foveal detachment; OCT: Optical coherence tomography.

DISCUSSION

In our current study, we performed PSR followed by vitrectomy to treat patients with MF, who were followed for a long term. The follow-up period was 47.98 ± 18.23 mo (range 24-83mo). Our long-term outcomes showed that PSR followed by vitrectomy can effectively restore the anatomical structure of macula and improve the BCVA of MF patients. It was reported that vitrectomy alone could improve BCVA in 80%-84% of MF eyes^[15,17], and PSR alone could improve BCVA in 66%-75% of MF eyes at the end of follow-up^[18-19]. While in our current study, up to 41 eyes (93%) achieved significant improvement in BCVA at the last follow-up visit. In our study, after PSR followed by vitrectomy, OCT showed that 95.45% of MF eyes achieved complete resolution of the MF, and the remaining 4.55% of MF eyes achieved partial resolution. While only 61.0%-80.0% of eyes achieved total resolution of foveoschisis after PPV alone^[17,20-21], and only 83.33% of eyes achieved complete resolution of foveoschisis after PSR alone^[18]. Our current study showed that PSR followed by vitrectomy got better BCVA improvement and MF resolution than that of PSR or vitrectomy alone. PSR followed by vitrectomy can achieve the goal of internal and external combination. PSR can relieve posterior scleral staphyloma from the outside and stabilize the axial length. Vitrectomy can release the vitreoretinal traction from the inside, and the surface tension of gas tamponade can produce an additional pressure on foveoschisis, so as to

further promote the resolution of foveoschisis and improve the BCVA. In our previous study, we also found that PSR followed by vitrectomy in extreme cases (axial length ≥ 30 mm) of MF had a greater improvement in BCVA than those treated with vitrectomy alone^[14]. In our study, no full-thickness MH or recurrence of foveoschisis occurred during the follow-up period, while these two postoperative complications were reported as previously reported^[17-18]. That's why we chosen the surgical scheme of PSR followed by vitrectomy. This surgical scheme can not only remove the internal vitreo-retinal traction due to vitreofoveal adhesions but also release the antero-posterior stretching effect due to posterior staphyloma. Why didn't we choose to do PSR and vitrectomy simultaneously? At first, we did PSR and vitrectomy at the same time, but the postoperative reaction was relatively heavy. Therefore, we improved to do PSR first and vitrectomy later.

As for whether ILM should be removed during vitrectomy, it is still controversial. During vitrectomy, we only removed the posterior hyaloid membrane completely without peeling ILM. No full-thickness MH or MHRD occurred in our study. As previously reported^[8-9,22], the prevalence ranged from 7.5% to 21.4% in ILM peeling cases. Therefore, for pure MF eyes without obvious epimacular membrane, we do not think it is necessary to peel the ILM during vitrectomy. Without peeling ILM may reduce the risk of intraoperative and postoperative complications and shortening operation time.

During the natural course of extensive high myopia, the axial length elongated 2.05 ± 0.91 mm, and the refractive error increased 3.02 ± 1.57 D after 4-5y of follow-up^[23]. Previous studies confirmed that PSR had a positive effect on visual acuity, refractive error, macular appearance, and axial length in pathologic myopic eyes^[18,23-27]. In MF eyes, vitrectomy alone can only remove the internal vitreoretinal traction, while it cannot control the elongation of the axial length. Therefore, it may not be sufficient to improve the fovea anatomical situation, especially in markedly axially elongated eyes with posterior scleral staphyloma. In Zhang *et al*'s study^[17], through vitrectomy alone, 40% of eyes had persistent residual foveoschisis after long-term follow-up. In our current study, we performed PSR associated with vitrectomy. A total of 95.45% of eyes achieved complete resolution of MF, and no full-thickness MH or recurrence of foveoschisis occurred during the whole follow-up period. The preoperative axial length was 29.60 ± 1.71 mm, while the postoperative axial length was 29.74 ± 1.81 mm after the long-term follow-up period (47.98 ± 18.23 mo). Axial length remained stable for a long time after PSR association with vitrectomy in our study. When patients with obvious preoperative cataract, A-ultrasound was used to measure the axial length. At this time, if the patient had FD, the measured value of axial length

would be shorter than the actual one. In our study, there were 20 eyes (45.45%) with FD. Therefore, the preoperative actual axial length should be longer than 29.60 ± 1.71 mm. It showed that our surgical scheme can shorten the axial length to a certain extent. This may explain why in our study, PSR with vitrectomy had a better outcome than vitrectomy alone^[14,17]. Li *et al*^[15] have reported the outcome of PSR with vitrectomy on MF patients. However, the operation procedure of Li *et al*'s^[15] PSR is different from ours. Our operation method is much simpler, lower risk of optic nerve injury and relatively much safer. Meanwhile, they had only one-year follow-up data and had no long-term follow-up results.

In our study, the postoperative complications included 2 cases of mildly elevated intraocular pressure, 2 cases of cataracts and 2 cases of myopic CNV. No serious complications occurred in our study. The cataracts were surgically managed with phacoemulsification and IOL implantation and got satisfactory results. Two eye (4.55%) developed CNV during the follow up period. In the natural course of pathological myopia, CNV will occur in about 10% of patients^[28-29], which is higher than the incidence of CNV in our study. Therefore, we believe that the occurrence of CNV is not related to surgery, but related to pathological myopia itself. A total of 4.55% of eyes developed mild glaucoma postoperatively. In a previous study, the rate of secondary glaucoma was 15% after PPV with silicone oil tamponade^[30]. Our rate was much lower than that previously reported, and it was satisfactorily controlled by one antiglaucoma medication. In the current study, we only used air or gas as tamponade while not silicone oil, which led to a lower incidence of secondary glaucoma.

Vitrectomy with gas tamponade for MF has been performed with variable high success rates (75%-100%). Gas tamponade exhibited good outcomes on BCVA improvement or anatomical resolution^[31-32], possibly by inducing retinal repositioning by pushing back the retina. Gas has a larger surface tension and fewer complications than silicone oil; thus, we preferred gas or air for MF, which achieved good surgical results in this study: 95.45% of MF eyes achieved complete resolution of MF. Air or gas is an ideal tamponade for vitrectomy in patients with MF.

In our current study, FD was associated with poor preoperative ($P=0.048$) and postoperative ($P=0.011$) BCVA. However, the postoperative BCVA significantly improved regardless of the presence of FD ($P<0.001$). Therefore, it seems that vitrectomy can improve visual acuity in eyes with or without FD, and the final BCVA was significantly correlated with the preoperative BCVA in both types of patients.

The main limitation of this study is that it is a retrospective study and without a control group. Further prospective studies are needed to study the long term effects of the surgical methods for MF patients in the future.

In conclusion, for pathologic MF, PSR followed by vitrectomy is an effective procedure to improve the visual acuity and the anatomical structure of macula. It can also stabilize the axial length for a long time.

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