· Clinical Research ·

Clinical observation of vitrectomy combined with endolaser photocoagulation at the edge of posterior scleral staphyloma for macular hole retinal detachment in high myopia

Xiao-Tian Zhang[1,2,3,4], *Jing-Xian Wang*[1,2,3,4], *Song Chen*[1,2,3,4]

[1]Clinical College of Ophthalmology, Tianjin Medical University, Tianjin 300020, China
[2]Tianjin Eye Hospital, Tianjin 300020, China
[3]Tianjin Key Laboratory of Ophthalmology and Visual Science, Tianjin 300020, China
[4]Tianjin Medical University, Tianjin 300070, China

Co-first authors: Xiao-Tian Zhang and Jing-Xian Wang

Correspondence to: Song Chen . Clinical College of Ophthalmology, Tianjin Medical University, Tianjin 300020, China; Tianjin Eye Hospital, Tianjin 300020, China; Tianjin Key Laboratory of Ophthalmology and Visual Science, Tianjin 30020, China; Tianjin Medical University, Tianjin 300070, China. chensong9999@126.com

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Abstract

● **AIM:** To observe the clinical effect of pars plana vitrectomy (PPV) and silicone oil filling surgery combined with intraoperative posterior scleral staphyloma (PS) marginal retinal photocoagulation in the treatment of high myopic macular hole retinal detachment (MHRD) with PS.

● **METHODS:** This was a retrospective clinical study. From May 2017 to March 2020, 62 MHRD patients with PS (62 eyes) were enrolled in the study. Patients were divided into 23G PPV combined with PS marginal retina intraoperative photocoagulation group (combined group) and conventional surgery group (conventional group), with 31 eyes in each. Triamcinolone acetonide and indocyanine green were used to remove the epiretinal membrane and the posterior macular inner limiting membrane (ILM). In the combined group, 2 to 3 rows of retinal photocoagulation were performed on the edge of the PS. The patients were followed up for an average of 8.34±3.21mo. The first retinal reattachment rate, macular hole closure rate, Duration of silicone oil tamponade, best corrected visual acuity (BCVA) and average number of operations were observed and compared between the two groups.

● **RESULTS:** The first retinal reattachment rates of the eyes in the combined group and the conventional group were 96.7% (29/31) and 67.7% (21/31), respectively (χ^2=6.613, *P*=0.010). The macular hole closure rates in the combined group and the conventional group were 74.2% (23/31) and 67.7% (21/31), respectively (χ^2=0.128, *P*=0.721). The Duration of silicone oil tamponade of the patients in the combined group was lower than that of the routine group (*t*=-41.962, *P*≤0.001). Postoperative logMAR BCVA values of patients in the combined group and the conventional group were 1.27±0.12 and 1.26±0.11, compared with the logMAR BCVA before surgery, each group was improved (*t*=19.947, *t*=-19.517, *P*≤0.001, *P*≤0.001). There was no significant difference in the logMAR BCVA between the eyes of the two groups (*t*=-0.394, *P*=0.695). The average numbers of operations on the eyes in the conventional group and the combined group were 2.39±0.62 and 2.06±0.25 times, the combined group had fewer operations on average (*t*=-2.705, *P*=0.009).

● **CONCLUSION:** Intraoperative PPV treatment of MHRD with PS combined with PS marginal endolaser photocoagulation can effectively increase the rate of retinal reattachment after the first operation, reduce the number of repeated operations, and reduce the postoperative duration of silicone oil tamponade.

● **KEYWORDS:** macular hole retinal detachment; high myopia; posterior scleral staphyloma; retinal photocoagulation; vitrectomy

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INTRODUCTION

High myopia macular hole retinal detachment (MHRD) is a blinding complication of high myopia that has a predilection for Asian populations, and the removal of retinal traction, promotion of retinal reattachment, and closure of the macular hole are the mainstays of MHRD treatment. Currently, pars plana vitrectomy (PPV) is the primary surgical procedure used to treat MHRD, but the choice of PPV posterior filler for MHRD is subject to disagreement. For high myopia patients with a long axial length, especially MHRD with posterior scleral staphyloma (PS), the PPV operation is complicated, and the rate of retinal reattachment after surgery is not high[1]. Direct closure of the macular hole by intraoperative laser photocoagulation has previously been suggested to improve MHRD retinal reattachment rates[2], but direct photocoagulation disrupts photoreceptors and retinal neurons around the macular hole, and although retinal reattachment rates are improved, photoreceptor damage can lead to impaired postoperative central vision. In addition, MHRD with PS has more severe retinal pigment epithelium (RPE) and choroidal atrophy, a poor response to laser irradiation, and more difficulty in forming an effective spot, facilitating retinal reattachment[3]. Therefore, our group proposed that in the surgical treatment of MHRD accompanied by PS with laser reinforcement at the edge of the PS performed with PPV. The clinical observations are reported below.

SUBJECTS AND METHODS

Ethical Approval This study was a retrospective clinical study. This research was approved by the Ethics Committee of Tianjin Eye Hospital (approval number: 2021006) and followed the tenets of the Declaration of Helsinki. All subjects were informed about the purpose, modality, and risks of surgery beforehand. The patient and family members signed written informed consent forms.

Sixty-two MHRD patients with PS (62 eyes) who presented to Tianjin Eye Hospital from May 2017 to March 2020 were included in the study, including 19 males (19 eyes) and 43 females (43 eyes).

The inclusion criteria were as follows: 1) patients with high myopia, axial length ≥26.00 mm and/or myopic refraction ≥6.00 D; 2) MHRD diagnosed by indirect ophthalmoscopy, B-mode ultrasound, and optical coherence tomography (OCT; Figure 1); 3) B-mode ultrasound and wide-angle photography of the fundus were accompanied by definite PS, both of which were grade 2 in depth[4], and the typing criteria were all type I (posterior pole)[5]; and 4) no previous vitreoretinal surgery. The exclusion criteria were as follows: 1) retinal detachment due to traumatic macular hole or idiopathic macular hole; 2) the presence of a merging of other fissures in addition to the macular hole resulting in retinal detachment; 3) previous history of ocular trauma or internal eye surgery; 4) severe corneal disease, uveitis, vitreous haemorrhage, glaucoma, retinal vein or artery occlusion, other lesions in the macula such as age-related macular degeneration, macular haemorrhage, *etc*; and 5) no periodic review performed.

All affected eyes were examined by best corrected visual acuity (BCVA), intraocular pressure (IOP), slit lamp microscopy, indirect ophthalmoscopy, B-mode ultrasound, OCT, and axial length measurement. BCVA examinations were performed with a standard logarithmic visual acuity chart, which was converted to the minimum angle of resolution logarithmic (logMAR) visual acuity for statistical purposes.

The patients were assigned to receive PPV plus PS plus intraoperative photocoagulation of the marginal retina (combination therapy group) or conventional surgery (conventional group), with 31 eyes in each group. The baseline data of the 2 groups are shown in Table 1. There were no significant differences in age, sex composition ratio, preoperative logMAR BCVA, refraction (spherical equivalent refraction), axial length, PS depth, retinal detachment range, or posterior vitreous detachment (PVD) status between the 2 groups (P>0.05; Table 2).

A standard three-channel 23G PPV was performed in all patients. The operation was performed by the same experienced physician. Intraoperatively, the central vitreous was removed, and artificial PVD was performed in the absence of complete PVD. Intraoperative use of triamcinolone acetonide with indocyanine green (ICG) staining, denudation of the anterior retinal membrane with the inner limiting membrane (ILM) of the macular region at the posterior pole, intraoperative laser photocoagulation of the peripheral retinal degenerative region, and drainage of the subretinal fluid through the macular hole by gas-liquid exchange, after vitreous cavity silicone oil (Oxane 5700, Bausch & Lomb, Incorporated, USA) filling by gas/air-silicone oil exchange completely reset the retina. The combination therapy group received 2-3 rows of C-shaped or O-shaped photocoagulation (Figure 2), with grade II light flecks, at the PS edge in addition to following the conventional surgical procedures described above; the PS margins in the conventional group were not photocoagulated. Moderate episcleral freezing could be given if there was difficulty with the photocoagulation in the area of degeneration above the periphery. The vitreous cavity of the affected eyes in both groups was filled with silicone oil.

All patients underwent intraoperative posterior capsulotomy in combination with phacoemulsification and intraoperative silicone oil removal. Air-liquid exchange was performed under direct vision at the time of oil removal, the fundus was examined under indirect ophthalmoscopy after oil removal, and freezing or laser light was added as appropriate. If recurrence of retinal detachment occurred before or after silicone oil removal, the affected eye underwent scleral buckle surgery or silicone oil removal, membrane stripping, photocoagulation, retinotomy, and silicone oil refilling as appropriate.

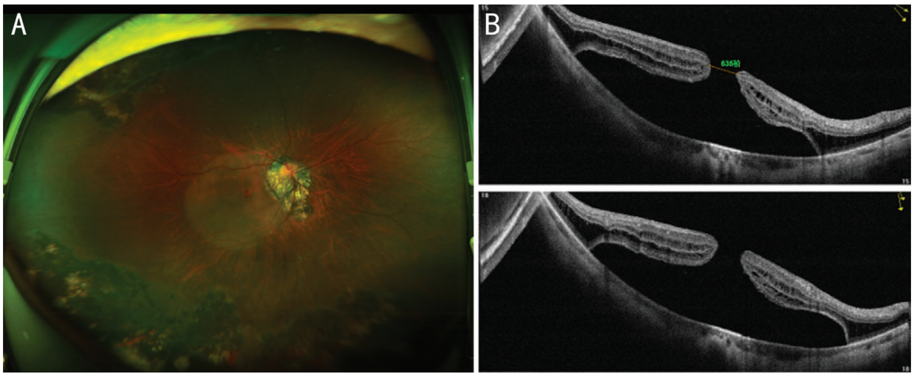

Figure 1 Colour fundus and optical coherence tomography (OCT) images of the right eye in a patient with foveal retinal detachment due to high myopia A: A colour fundus image with retinal detachment in the macular region; B: OCT images depicting extensive detachment of the neuroepithelial layer at the macula and a full-thickness break of the neuroepithelial layer at the fovea to form a hole.

Table 1 Baseline data of the combination therapy and conventional therapy groups mean±SD

Group	Eyes, *n*	Age (y)	M/F	LogMAR BCVA	Dioptres (D)	Axial length (mm)	PS depth (mm)	With PVD
Combination therapy	31	58.16±8.82	9/22	1.88±0.18	-11.56±4.41	27.19±1.10	2.71±0.31	16
Conventional	31	57.87±8.53	10/21	1.86±0.19	-11.66±3.37	27.22±1.06	2.67±0.28	15
Test value		t=0.132	χ^2=0.076	t=0.246	t=-0.093	t=-0.117	t=0.443	χ^2=0.065
P		0.896	0.783	0.806	0.926	0.908	0.569	0.799

SD: Standard deviation; BCVA: Best corrected visual acuity; PS: Posterior scleral staphyloma; PVD: Posterior vitreous detachment.

Table 2 Baseline data of the combination therapy and conventional therapy groups

Group	Eyes, *n*	Range of retinal detachment		
		Posterior pole	Posterior pole and <2 quadrants	Posterior pole and >2 quadrants
Combination therapy	31	5	12	14
Conventional	31	7	11	13
Test value			χ^2=0.414	
P			0.813	

The follow-up period ranged from 7 to 12mo after surgery, with a mean follow-up time of 8.56±2.84mo. The same equipment and methods were used to conduct related examinations before surgery. Treatment outcomes were evaluated by the rate of retinal reattachment, macular hole closure, mean number of procedures, and final BCVA after silicone oil removal surgery. With reference to the criteria in reference[6], loss of the gap between the retinal neuroepithelial layer and the RPE layer was defined as retinal reattachment. The presence of a gap between the retinal neuroepithelial layer and the RPE layer was defined as unreduced retina. The disappearance of the defect in the macular retinal neuroepithelial layer was defined as macular hole closure (Figure 3). The presence of a neuroepithelial layer defect remaining in the macular retina was defined as failure of the macular hole to close.

Statistical Analysis Statistical analysis was performed using SPSS 26.0. The measurement data are presented as the mean±standard deviation (SD). Comparisons of indexes before and after surgery within groups were performed using paired samples t-tests. Count data were compared between the 2 groups using the χ^2 test. Comparisons of measurement data were performed using independent samples t-tests. $P<0.05$ was considered statistically significant.

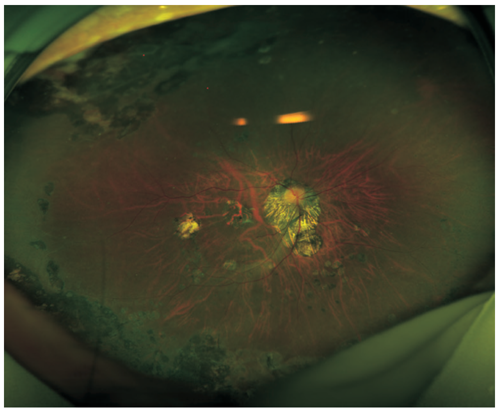

Figure 2 Colour fundus image of the right eye in a patient with foveal retinal detachment with high myopia Three rows of photocoagulation spots can be seen in the posterior pole, which are in the shape of C, located at the edge of PS, and retinal photocoagulation is also performed in the peripheral retinal degenerative area. PS: Posterior scleral staphyloma.

RESULTS

The mean number of procedures per affected eye was 2.39±0.62 and 2.06±0.25 in the conventional and combination therapy groups, respectively. The average number of surgical

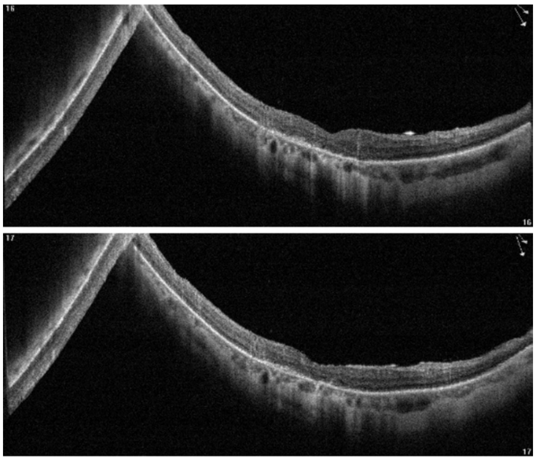

Figure 3 Right eye coherence tomography image in a patient with foveal retinal detachment with high myopia After surgery, the gap between the neuroepithelium and the RPE layer in the macula had disappeared, the original neuroepithelial layer defect had disappeared, and the macular hole was closed. RPE: Retinal pigment epithelium.

procedures was significantly lower in the combination therapy group than in the conventional group (t=-2.705, P=0.009).

After the initial surgery, retinal reattachment was achieved in 21 eyes (67.7%, 21/31) in the conventional group, and 10 eyes (32.3%, 10/31) were unreduced. Retinal reattachment was observed in 29 eyes (96.7%, 29/31) in the combination group, and 2 eyes (3.3%, 2/31) were unreduced. The rate of first retinal reattachment in the affected eyes in the combination therapy group was higher than that in the conventional group, with significant differences (χ^2=6.613, P=0.010). At the last follow-up, the retina was restored in all affected eyes in both groups, and the reduction rate was 100%.

At the last follow-up, macular hole closure was observed in 21 (67.7%, 21/31) and 23 (74.2%, 23/31) eyes in the conventional and combination therapy groups, respectively. There was no significant difference in the rate of macular hole closure between the 2 groups (χ^2=0.128, P=0.721). LogMAR BCVA was 1.27±0.12 and 1.26±0.11 (P≤0.001, P≤0.001), respectively, compared with logMAR BCVA before surgery (t=19.947, t=-19.517). There was no significant difference in the logMAR BCVA values between the affected eyes in the 2 groups (t=-0.394, P=0.695).

In the conventional group, of the 10 patients whose first operation was not reset, five patients had a patent macular hole and open water leak before removal of silicone oil, resulting in a recurrence of retinal detachment at the posterior pole and below. Silicone oil was removed for combined membrane stripping, laser photocoagulation, and retinotomy; the vitreous cavity was filled with silicone oil again; and the retina was reset after surgery. Silicone oil was removed in 3 eyes for retinal reattachment in the anterior macular area, with recurrence of previous retinal detachment in the lower equator. Retinal repositioning was performed after scleral buckle surgery. The macular hole opening was leaky after the first silicone oil removal in 2 eyes, which resulted in a recurrence of peripheral retinal detachment. The membrane was peeled back again, laser photocoagulation was performed, the vitreous cavity was filled with silicone oil, and the retina was reset after surgery. Retinal restoration was good in all affected eyes after the last silicone oil removal surgery.

In the 2 eyes in the combination group in which the first operation was unreduced, the retina was reset in the macular area before removal of the silicone oil, and the previous retinal detachment in the lower equator recurred. Retinal repositioning was performed after a second scleral buckle surgery. The retina was reset well after removal of the silicone oil.

The mean postoperative duration of silicone oil tamponade was 61.66±9.83d and 72.54±6.69d in the combination therapy group and the conventional group, respectively. The silicone oil fill time of the affected eye in the combination therapy group was significantly lower than that in the conventional group (t=-41.962, P≤0.001).

No iatrogenic retinal tears were present during surgery in any affected eye. No serious complications, such as endophthalmitis or intraocular haemorrhage, occurred during the operation. Intraocular pressure >21 mm Hg (1 mm Hg= 0.133 kPa) was noted in 7 eyes before silicone oil removal after surgery. Of these, 2 eyes were in the combination therapy group, and 5 eyes were in the conventional group. Carteolol hydrochloride and brinzolamide eye drops were given, and the intraocular pressure returned to normal within 1wk after treatment. At the time of silicone oil removal surgery, cataract aggravation related to silicone oil occurred in 15 eyes, including 8 and 7 eyes in the combination therapy group and the conventional group, respectively. All patients underwent phacoemulsification combined with intraocular lens implantation at the time of silicone oil removal surgery. At the last follow-up, no other significant visual impairment complications were seen.

DISCUSSION

The use of PPV combined with gas filling in the postoperative prone position for the treatment of high myopic MHRD was first proposed by Converse and Machemer in 1982[7]. Today, PPV has become the most predominant surgical modality for the treatment of MHRD. However, for MHRD patients with abnormal anatomy of high myopia, such as retinochoroidal atrophy, PS, and axial growth, there is great surgical difficulty, the visual prognosis of patients is poor, and the rate of anatomical retinal reattachment is low. The main causes of postoperative recurrence of PPV in MHRD patients are failure of the macular hole to close and water leakage through the reopening[8].

Laser photocoagulation to seal retinal tears is one of the important methods for the treatment of RRD. Previously, some scholars treated MHRD patients by directly photocoagulating the macular hole, using circular photocoagulation with moderate energy to act on the basal part of the macular hole, stimulating RPE proliferation to make the retina adhere to the choroid, and achieving a better reduction rate of the retina[9]. The thermal coagulation reaction generated by laser photocoagulation makes the choroid adhere to the retinal scar while effectively sealing the retinal fissure, stimulating RPE cells to secrete growth factors, releasing fibronectin to form matrix deposited in the extracellular space, acting as a temporary tamponade of the hole. Furthermore, laser photocoagulation can stimulate the RPE pump, promote subretinal effusion to be absorbed, and promote retinal reattachment[10]. While laser photocoagulation promotes retinal resetting, it directly damages central vision by destroying photoreceptors and neurons around the macular hole, while photocoagulation using low energy does not guarantee that significant RPE hyperplasia will occur and does not produce a strong enough scar to close the hole. In addition, RPE and choroidal atrophy are severe in highly myopic eyes, especially for cases with more severe RPE and choroidal atrophy in the macular area, and the poor response to laser photocoagulation makes it difficult to form an ideal photocoagulation spot and challenging to achieve the expected effect. Scholda *et al*[3] found that photocoagulation to close the macular hole did not improve anatomical reduction.

Therefore, in order to give full play to the reliable local fixation effect of laser while avoiding the above-mentioned problems, we innovatively propose PS edge photocoagulation to treat pathological high myopia with PS MHRD. The edge of the scleral staphyloma is treated with 2-3 circles of laser photocoagulation, that is, the PS is treated as a huge retinal tear. The laser spot is far away from the macular area to reduce the impact on the central vision. It improves the safety of the laser. It avoids the severe retinal atrophy at the posterior pole and improves the effectiveness of the laser. This photocoagulation is essentially equivalent to the rearward movement of the serrated edge to strengthen the laser. The retina, without damaging the central vision, resists the traction caused by the residual posterior vitreous cortex and epiretinal membrane to the greatest extent. The laser energy should not be too large, and it is enough to reach the level II spot response, because the high myopia is atrophy and thinning of the retina, and the laser energy is too high to easily form iatrogenic retinal tears.

PS is a special structure in eyes with pathological high myopia, and PS is present in approximately 12%-51% of eyes with high myopia[11]. Curtin[5] classified PS into 10 types, with types I-V as pure and types VI-X as complex; types I-II and VI-X involve the macular area, with type I (posterior pole) being the most prevalent (76.0%). PS typing of all affected eyes in this study was type I, suggesting that type I PS has the highest incidence in MHRD. The ILM is tightly adherent to the retina at the edge and macular region of the PS, and the retina is incompletely tractable by denudation[12], at which point laser reinforcement can antagonize the traction of the epiretinal remnant membrane and thereby improve the rate of retinal reattachment. In addition, some scholars found that the choroid in highly myopic eyes gradually thinned from the periphery to the PS edge and gradually rethickened from the PS edge to the backward pole direction, leading to the weakening of retinal adhesion at the PS edge, which suggested the necessity of laser reinforcement in this area[4-5]. In this study, we used individualized laser therapy in different patients and performed a C-shaped or O-shaped laser ring to avoid important structures in the posterior pole, such as the macular fibre bundles of the optic disc, and to minimize functional damage as much as possible.

The results of this study showed that the first surgical retinal reattachment rate of the affected eye in the combination therapy group was higher than that in the conventional group, and the difference was statistically significant. However, there was no significant difference in the final BCVA after surgery between the 2 groups, suggesting that PS edge photocoagulation can effectively improve the retinal reattachment rate without damaging visual acuity. The macular hole closure rates were 62.5% and 76.0% of eyes in the conventional group and the combination therapy group, respectively, which was higher in the combination therapy group than in the conventional group, but the difference was not statistically significant. All patients in the two groups achieved retinal reduction at the last follow-up. Previous studies[6-7] have shown that the retinal reduction rate of PPV combined with ILM stripping is 69%-95.9%, and the macular hole closure rate ranges from 42.9%-70.5%. The results of this study are consistent with them, which further confirms the positive effect of ILM stripping on macular hole closure and retinal reduction. The recurrence of retinal detachment in the 2 groups was caused by water leakage through the macular hole opening before and after silicone oil withdrawal in 5 eyes in the conventional group, whereas this was not the case in the combination therapy group. The results suggest that photocoagulated PS margins, although not obviously useful for macular hole closure, used for posterior pole retinal overall reinforcement can obviously reduce the recurrence of retinal detachment caused by leaking with macular hole reopening.

Recently, with the continuous updates of ILM treatment techniques such as ILM flap, tamponade and autologous ILM transplantation, it has been possible to improve the rate of macular hole closure after MHRD surgery[8,10]. However, in practice, the thin and brittle ILM in high myopia increases the risk of iatrogenic injury associated with the difficulty of manipulation and the risk of making, inverting, and accurately filling the ILM flap, and the stability of the ILM flap during and after surgery also needs to be improved. Achieving a good result in high myopia with a longer axial length is challenging for the surgeon[13-14]. In addition, the ICG stain has toxic effects on the retina, and the tamponade of the ILM flap that may trap remnant ICG in the macular hole that can directly contact the retina at the base of the macular hole, which increases the risk of retinal toxic effects from ICG and can potentially harm vision[8,13]. Yuan *et al*[15] showed that ILM flaps did not improve postoperative BCVA compared with that of ILM dissection. Therefore, this study did not focus on revolutionizing ILM handling. The ILM of the macular region was routinely denuded in both groups, and no forced applanation of the retina with heavy water was employed, reducing the potential for heavy water use itself to carry a range of risks, such as the entry of heavy water into the subretina and the potential for intraocular toxicity[16-17]. Ultimately, the results of this study confirm that PS edge photocoagulation combined with conventional ILM decortication improves MHRD PPV retinal reattachment rates with fewer surgical procedures.

In terms of intraocular filler selection, there is still no consensus at this time. Some scholars suggested[18] that inert gas filling after PPV combined with ILM decortication would be better for MHRD patients with shorter disease duration, limited range of retinal detachment, and no proliferative vitreoretinopathy. Other scholars believe that the action time of MHRD silicone oil filling is long, the top pressure is large, and it can act as a scaffold and stimulus for gliosis to promote macular hole closure[19-20]. Because inert gas use was limited in mainland China during the time that this study was conducted, silicone oil was used to fill both groups. The results showed that silicone oil filling did not lead to major postoperative complications for MHRD patients and that the phacoemulsification procedure combined with cataracts at the time of silicone oil removal resolved the lens opacity. Very few patients developed postoperative ocular hypertension, and all were being controlled well by short-term topical ocular hypotensive medication at the time of silicone oil withdrawal.

Silicone oil use has the potential to cause a series of complications, such as cataracts, corneal damage, ocular hypertension, endophthalmitis, and emulsification of silicone oil[21], and the longer the postoperative duration of silicone oil tamponade is, the higher the associated risk. We considered that ocular hypertension was related to the amount of silicone oil infused, the patient's postoperative maintenance of the face in a downward prone position, and the use of Triamcinolone acetonide. In this study, laser treatment of the PS margin while using silicone oil filling, employing laser photocoagulation to promote retinal resetting, reduced the time that the silicone oil was filled in the eye, and the corresponding combination therapy group had fewer cases of intraocular hypertension caused by postoperative silicone oil than did the conventional group.

There are several limitations to this study: 1) the sample size was small, and only patients with a single type of PS were observed, which means that comparisons could not be made between MHRD cases with PS of other types (types II, VI-X) with different types of macular involvement to observe the differences in outcomes; 2) only silicone oil was used as an intraocular filler, so the effect of different intraocular fillers, represented by inert gas, on the study results could not be observed; and 3) the postoperative visual function observation index was singular and did not involve electrophysiology, micro optic field, *etc*.

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