Vitrectomy with Internal Limiting Membrane Peeling and Gas Tamponade for Myopic Foveoschisis

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Research article

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Abstract

Background

We evaluated the effect of vitrectomy with internal limiting membrane (ILM) peeling and gas tamponade for myopic foveoschisis (MF), and analysed prognosis with different gas tamponade.

Methods

Retrospective, non-randomized study. The records of patients with MF treated by vitrectomy, were reviewed. Patients were followed up postoperatively mean 16.74 months, to record changes of Best-corrected visual acuity (BCVA) and central foveal thickness (CFT).

Results

62 eyes (59 patients) were analysed in total, with mean age of 55.29 ± 10.34 years, 49 females (83.1%). Foveoschisis completely resolved in all eyes at least 6 months post vitrectomy, except for two postoperative full-thickness macular holes (FTMH). Final BCVA improved significantly from 0.69 ± 0.39 to 0.44 ± 0.42 logMAR, and CFT from 502.47 ± 164.78 to 132.67 ± 52.26 μm . Patients were subdivided into three subgroups based on the different endotamponades used (C3F8, C2F6, and air). Baseline BCVA, baseline CFT and foveal detachment (FD) were not significantly different among the three groups. Eyes treated with air tamponade had better visual outcomes than eyes with C3F8 tamponade ($P = 0.009$). Baseline BCVA and FD were significant risk factors for postoperative BCVA ($P < 0.001$ and $P = 0.013$, respectively).

Conclusions

Vitrectomy with ILM peeling and gas tamponade results in good functional and anatomic outcomes in the treatment of MF. Good vision and no-FD pre-surgery are related with good visual prognosis. Air tamponade can provide faster visual recovery and reduce postoperative complications, compared with expansive gas.

Background

Myopic foveoschisis (MF) is considered one of the major causes of visual loss in highly myopic eyes [1, 2]. The estimated morbidity of MF is 8-34% in highly myopic eyes with posterior staphylomas [3, 4]. As recorded, the pathogenesis of MF is the combined effect of introversion traction and extroversion traction. Tangential vitreomacular traction is thought to be a crucial point [1, 4, 5]. Macular retinal detachment and macular hole are likely secondary complications occurring spontaneously following the development of MF, with disrupted ellipsoid zone (EZ).

The surgical options for MF include pars plana vitrectomy (PPV) and ILM peeling with or without gas tamponade, posterior scleral reinforcement alone or with vitrectomy. Moreover, the fovea-sparing ILM peeling technique has been reported to prevent iatrogenic macular holes and result in better anatomical and functional improvement than total ILM peeling [6–8]. Surgical approach, follow-up time, and the operator's surgical skills can affect the surgical result. However, the necessity of gas tamponade or ILM peeling remains controversial [9–23].

In this retrospective study, we evaluated BCVA and CFT changes of PPV with ILM peeling and gas tamponade for MF, and compared surgical outcomes and complications between eyes with different gas tamponade.

Methods

Patients

A retrospective review of 62 eyes of 59 patients who underwent PPV and ILM peeling with gas tamponade for MF was performed at Beijing Tongren Hospital, between March 2012 and August 2018. The inclusion criteria were axial length > 26.0mm, progressive visual loss caused by MF, follow-up $\geq$ 6 months. The exclusion criteria were other pre-existing macular pathologies, a history of ocular surgery other than cataract surgery, low quality OCT scans with insufficient resolution.

Examinations

BCVA was measured by the tumbling E charts and converted to logarithm of the minimum angle of resolution (LogMAR) for statistical analysis. The detailed fundus was examined by indirect binocular ophthalmoscopy. Axial length was measured by IOL-Master. The macular architecture was evaluated using spectral-domain OCT (Cirrus; Carl Zeiss, Dublin, CA). OCT images were accomplished using the 'Macular Cube 512 $\times$ 128' scan. The CFT was defined as the largest vertical distance measured manually between the retinal pigment epithelium and the inner retinal surface at the foveal area on horizontal OCT scan, with or without FD or lamellar hole. Other SD-OCT features were recorded: macular schisis, foveal detachment, epiretinal membranes, vitreomacular traction, lamellar holes. BCVA and OCT were recorded on all visits.

Surgical Techniques

PPV was accomplished using a 23G vitrectomy system (Alcon Constellation Vision System). Combined phacoemulsification with simultaneous intraocular lens implantation was performed on phakic eyes in case of significant cataract. The posterior cortical vitreous was removed gently from the retina after core vitrectomy. After peeling the epiretinal membrane, 0.5 ml of 0.5% ICG was used to stain the ILM, if necessary. The ILM was entirely peeled between the upper and lower vascular arcades. Before June 2017, gas tamponade (18% C2F6 or 14% C3F8) was injected after fluid-air exchange; since June 2017, sterile air was retained in the vitreous cavity. All patients were instructed to maintain prone postoperatively, long-acting gas for 1–2 weeks, air for 5–7 days.

Statistical methods

SPSS version 23.0 software (IBM Corp., Armonk, NY, USA) was performed for statistical analysis. Qualitative data are presented as a value, and quantitative data are expressed as the mean $\pm$ standard deviation. Independent-samples *t*-tests, Fisher's Least Significant Difference test, and chi-square test were used to compare the statistical significance of preoperative and postoperative outcome in BCVA, CFT, and various findings. $P < 0.05$ was considered significant.

Results

Baseline characteristics of 62 eyes of 59 patients (M:F = 10:49) are summarized in Table 1. All patients had undergone PPV and received ILM peeling with gas tamponade. 30 eyes (48.4%) received phacoemulsification and intraocular lens implantation simultaneously with vitrectomy. Significant visual improvement was defined as two lines or more improvement in BCVA (0.3 LogMAR units). At the mean 16.74-month follow-up visit, 43 eyes (69.4%) showed improvement in BCVA, and 31 eyes showed significant visual improvement. 7 eyes (11.3%) had vision decrease, and 12 eyes (19.4%) had no vision change. The mean BCVA improved significantly from 0.69 ± 0.39 logMAR (range 0.1 to 1.5 logMAR) to 0.44 ± 0.42 logMAR (range 0.0 to 2.3 logMAR), and mean CFT improved significantly from 499.20 ± 164.38 μm ($n = 62$) to 132.67 ± 52.26 μm ($n = 60$, eyes without FTMH). (both $P < 0.001$, paired *t*-test).

Table 1
Baseline characteristics of the patients.

Number of patients (eyes)	59 (62)
Age (years)	55.29 ± 10.34 (29 to 75)
Sex (male/female)	10/49
Duration of symptoms(months)	16.76 ± 17.25 (1 to 96)
Baseline axial length (mm)	29.31 ± 1.99 (26.23 to 34.92)
Baseline BCVA (log MAR)	0.69 ± 0.39 (0.10 to 1.52)
Baseline CFT (μm)	502.47 ± 164.78 (200 to 954)
Preoperative IOP	15.64 ± 3.2 (8 to 25)
Preoperative lens status (Phakic / Pseudophakic / Aphakic)	56/5/1
Epiretinal membrane	19 (30.6%)
Vitreous traction	8 (12.9%)
Foveal detachment	20 (32.3%)
Lamellar hole	9 (14.5%)
Mean follow-up period (months)	16.74 ± 9.40 (6 to 24)
BCVA best-corrected visual acuity, log MAR logarithm of the minimum angle of resolution, CFT central foveal thickness, OCT optical coherence tomography, MF myopic foveoschisis.	

The preoperative and postoperative parameters between MF eyes with or without FD are shown in Table 2. The eyes with FD at baseline had a thicker mean CFT (593.85 ± 178.57 vs. 448.36 ± 133.92 μm; $P= 0.001$) and a worse mean BCVA (0.91 ± 0.34 vs. 0.59 ± 0.38 logMAR; $P= 0.002$) preoperatively, compared to those without FD at baseline. Both groups had significant improvement in CFT reduction and BCVA. However, eyes with FD at baseline had a thinner mean CFT (113.60 ± 55.36 vs. 144.86 ± 47.68 μm; $P= 0.031$) and a worse mean BCVA (0.60 ± 0.36 vs. 0.37 ± 0.44 logMAR; $P= 0.045$) postoperatively.

Table 2
Parameters before and after surgery between eyes of myopic foveoschisis with or without foveal detachment

Findings	MF without FD (n = 42)	MF with FD (n = 20)	<i>t</i>	<i>P</i> value
Baseline BCVA (log MAR)	0.59 ± 0.38	0.91 ± 0.34	-3.17	0.002
Post-op BCVA (log MAR)	0.37 ± 0.44	0.60 ± 0.36	-2.05	0.045
Change BCVA (log MAR)	-0.23 ± 0.48	-0.31 ± 0.29	0.71	0.481
Baseline CFT (μm)	448.36 ± 133.92	593.85 ± 178.57	-3.45	0.001
Post-op CFT (μm)	144.86 ± 47.68	113.60 ± 55.36	2.22	0.031
Change CFT (μm)	297.23 ± 128.99	480.25 ± 192.18	-4.22	0.000
BCVA best-corrected visual acuity, log MAR logarithm of the minimum angle of resolution, CFT central foveal thickness, FD foveal detachment.				
Independent-Samples t-test				

Three categories grouped based on the different endotamponades used (C3F8, C2F6, and air) are shown in Table 3. 33 eyes (53.2%) used C3F8 tamponade, 13 eyes (21.0%) C2F6 tamponade, and the remaining 16 eyes (25.8%) air tamponade. There were no statistically significant differences in age, axial length, CFT, FD, baseline BCVA or cataract treatment in these three groups. However, postoperative BCVA was statistically different among these three groups ($P = 0.009$, Least Significant Difference test). Eyes treated with air tamponade had better visual outcome than eyes with C3F8 tamponade, with P value of 0.006 (Least Significant Difference test). Postoperative BCVA was not statistically different between groups treated with C2F6 and C3F8 tamponade and between C2F6 and air tamponade ($P = 0.03$, $P = 0.72$, respectively, Least Significant Difference test).

Table 3
Characteristics of patients treated with different gas tamponades

Parameters	C ₃ F ₈ (n = 33)	C ₂ F ₆ (n = 13)	Air (n = 16)	P value
Age (years)	53.85 ± 10.33	57.00 ± 11.20	56.88 ± 9.84	0.51
Sex (M/F, eyes)	9/24	0/13	2/14	
Axial length (mm)	29.58 ± 2.43	29.19 ± 1.24	28.86 ± 1.36	0.49 ^a
Baseline CFT (μm)	511.06 ± 164.71	495.62 ± 190.28	487.00 ± 147.45	0.90 ^a
Postoperative CFT (μm)	123.70 ± 48.05	130.33 ± 49.80	162.25 ± 57.80	0.09 ^a
Baseline logMAR BCVA	0.76 ± 0.40	0.64 ± 0.31	0.61 ± 0.42	0.41 ^a
Postoperative logMAR BCVA	0.59 ± 0.46	0.30 ± 0.26	0.24 ± 0.33	0.009 ^a
Foveal detachment	12	5	3	0.45 ^b
Cataract treatment	14	6	10	0.46 ^b
CRT: Central retinal thickness; logMAR: Logarithm of the minimum angle of resolution; BCVA: Best corrected visual acuity. All values are shown as the mean ± standard deviation				
^a Fisher's Least Significant Difference test				
^b χ^2 test				

Factors affecting the change in BCVA using multiple linear regression analysis are shown in Table 4. Better postoperative BCVA had a high correlation with better baseline BCVA and absence of FD ($P < 0.001$, 0.013 , multiple linear regression analysis), whereas age, duration of symptoms, axial length, baseline CRT, phacoemulsification, epiretinal membrane, vitreous traction and Lamellar hole were not correlated with final visual outcome. Baseline BCVA ($\beta = 0.579$) had greater effect on postoperative BCVA than foveal detachment ($\beta = 0.316$).

Table 4
Correlation between preoperative factors and final postoperative BCVA

Preoperative factors	<i>P</i>	β
Age	0.617	0.073
Duration of symptoms(months)	0.517	-.086
Axial length	0.311	0.120
Baseline BCVA	¹ <0.001	0.579
Baseline CFT (μ m)	0.336	-.123
Phacoemulsification	0.226	-.161
Epiretinal membrane	0.644	0.057
Vitreous traction	0.608	0.065
Foveal detachment	¹ 0.013	0.316
Lamellar hole	0.799	0.033
BCVA: Best-corrected visual acuity; CRT: Central foveal thickness. ¹ Statistically significant (multiple linear regression, stepwise)		

Complications

FTMH developed in 2 eyes (3.2%). One eye with C2F6 tamponade maintained stable postoperative vision without macular detachment or the macular hole progression in one year follow-up. Another eye with C3F8 tamponade, complicated with retinal detachment in the 11th month after surgery, underwent reoperation with silicone oil tamponade. One eye developed secondary glaucoma with axial length of 34.92mm and with C3F8 tamponade (1.6%), recovered with anti-glaucoma medication. Of the 32 eyes in which the lens showed clear preoperatively, cataract developed in 18 eyes (56%), 14 eyes were cured by cataract removal during the follow-up period. The remaining four eyes with postoperative vision deterioration are still under observation. For these 18 eyes, 12 eyes were with C3F8 tamponade, 4 eyes with C2F6 tamponade, and 2 eyes with air tamponade.

Discussion

Our study showed that patients with MF may obtain anatomical and functional improvement from 23-gauge vitrectomy with ILM peeling at least 6 months following ($p < 0.001$). Many earlier studies confirmed that PPV with ILM peeling results in better BCVA and anatomic outcomes compared with PPV alone [6, 9, 10, 14, 15, 24–26]. However, some researchers hypothesized that total ILM peeling could increase the risk of developing a FTMH, macular shift and inner retinal dimples [6, 27]. 'Fovea-sparing ILM peeling' method was raised by Ho[8] and Shimada[6] to prevent the formation of FTMH and to reduce the damage to the

structure of macular after vitrectomy. Although it's extremely challenging to preserve a small size of spared-fovea ILM with long axial length. If the size is not small enough or the margin is not sharp, the preserved ILM itself may cause a late contraction [6].

In our study, the eyes with FD had a thicker baseline mean CFT and a thinner postoperative mean CFT, compared with those without FD, probably due to EZ disruption preoperatively related to the foveoschisis and FD. This disruptive change may bring about worse preoperative VA and postoperative VA, compared with those eyes without FD at baseline [28]. Our study showed that a better baseline BCVA and absence of FD were significantly correlated with a better visual prognosis ($p < 0.001$), similar to the results by Lee et al.[29] and Al-Badawi et al.[30]. Nonetheless, even eyes with FD achieved as much improvement in vision and macular structure as eyes without FD from baseline. Therefore, when the central fovea is affected, with vision decline, it is effective to take surgical treatment of vitrectomy in time to restore the foveal configuration and prevent macular hole and retinal detachment. For eyes with FD with long-term low vision, surgery is still an effective way to improve VA.

Whether or not to use gas tamponade and which gas is more suitable for tamponade has been controversial [15, 21, 31]. We insist on the application of gas tamponade to achieve more rapid MF resolution to protect macular function. Jiang et al.[32] considered that C3F8 was more effective in patients than air. Hwang et al.[19] reported that there was no significant difference in postoperative BCVA between air tamponade group and C3F8 group. In this study, air, C2F6 and C3F8 tamponade were divided into three groups according to different tamponade material. There was no significant difference in FD and combined cataract surgery between the three groups ($P = 0.45$ and $P = 0.46$), which could exclude the effect of both on the statistical results. All eyes of the three groups showed significant visual improvement after vitrectomy. The air tamponade group showed a greater improvement in postoperative BCVA compared with the C3F8 tamponade group. This disparity can be explained to some extent by the expansion and long retention time in eyes, which may lead to lens opacity and high intraocular pressure [15]. The postoperative complications showed that 1 case of secondary glaucoma and 12 cases of complicated cataract were with C3F8 tamponade, 2 cases of complicated cataract with air tamponade. The results indicated that air tamponade was more effective than C3f8 tamponade, with fewer side effects. Compared with C3F8, air tamponade can provide faster visual recovery and reduce the occurrence of postoperative complications.

FTMH is a common complication after PPV with ILM peeling for MF, with an incidence of about 12.5%–27.3%. ILM peeling, gas tamponade, and preoperative ellipsoid disruption may be risk factors [14–16, 21, 23, 28, 33]. In our study, 2 of 62 eyes (3.2%) developed FTMH with total ILM peeling, similar to the incidence of PPV without ILM peeling studies and fovea-sparing ILM peeling studies [34–36]. It has been reported that postoperative FTMH is more common in MF with FD [2, 37, 38]. Preoperative lamellar MH was observed in the two cases of our study that developed postoperative FTMH (one case with C3F8 tamponade, the other one with C2F6 tamponade). Tian's research showed that the only risk factor for development of postoperative FTMH was preoperative outer lamellar MH [36]. We hypothesized that the foveal tissue with lamellar MH or EZ defect is fragile and is more easily damaged, regardless of the

surgical procedure selection, fovea-sparing or total ILM peeling. How to reduce the occurrence of postoperative MH requires further study.

There are several limitations to this study. First, although our surgical technique was standardised, the decision to use either air or expansive gas intraocular tamponade depended on the surgical period (by June 2017) and the surgeon's experience rather than being driven by particular guidelines. Second, we didn't note EZ disruption in the study, because some OCT scans were of poor quality caused by lens opacity and extreme axial length. Third, the sample size was not enough, and the patients were not randomized into groups.

Conclusions

Our study demonstrated that a better baseline BCVA and absence of FD were strongly correlated with a better visual prognosis in the treatment of MF. Patients with MF may obtain anatomical and functional improvement from vitrectomy with ILM peeling and gas tamponade, regardless of whether FD is present at baseline. Compared with expansive gas, air tamponade could provide better visual recovery with fewer side effects.

Abbreviations

ILM: Internal limiting membrane; MF : Myopic foveoschisis; BCVA : Best-corrected visual acuity; CFT : Central foveal thickness; FTMH : Full-thickness macular holes; FD : Foveal detachment; EZ: Ellipsoid zone; PPV: Pars plana vitrectomy; LogMAR : Logarithm of the minimum angle of resolution

Declarations

Ethics approval and consent to participate

The study protocol was approved by the ethical review committee of Beijing Tongren Hospital, Capital Medical University.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

LW and ZJY designed the whole study. ZJY and YYP collected all the data and conducted data analysis with DDS. ZJY drafted the manuscript and revised with LW and YYP. All authors read and approved the final manuscript.

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