Vitreomacular Changes after Intravitreal Gas Injection for Idiopathic Impending or Early Macular Hole: An Optical Coherence Tomography Study

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Keywords

Vitreomacular traction · Macular hole · Intravitreal gas · Optical coherence tomography

Abstract

Purpose: To study the early changes of vitreomacular microstructure by optical coherence tomography (OCT) after intravitreal gas injection for the treatment of idiopathic impending or early full-thickness macular hole (FTMH). **Methods:** A retrospective, interventional case series. **Results:** A total of 21 eyes were included. In the impending macular hole, 8/8 achieved vitreomacular traction (VMT) release, while a macular hole developed in 1 case. On postoperative day 1, the vitreomacular configuration by OCT showed either a flattening ($n = 3$) or elevation ($n = 1$) pattern. In early FTMH, vitreomacular separation was achieved in 10/13 cases, but macular hole closure was only observed in 3 cases. On postoperative day 1, only flattening of the vitreomacular configuration was observed ($n = 5$). Enlargement of the macular hole was found in 4 cases. **Conclusions:** VMT separation can be achieved with intravitreal gas injection by mechanically stretching the posterior vitreous cortex, causing either flattening or steepening of the vitreomacular configuration. However, it did not always result in macular hole closure.

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Introduction

Pars plana vitrectomy (PPV) is the standard treatment for idiopathic full-thickness macular hole (FTMH). For impending macular hole (MH) and early-stage MH, some studies have shown that intravitreal gas might facilitate the separation of vitreomacular traction (VMT) and promote hole closure [1–8]. However, the dynamic changes of the foveal structure after gas injection have not been studied in detail. Recently, ocriplasmin has been shown to induce VMT release and obtain normalization of the macular structure in selected cases [9–12]. After ocriplasmin injection, changes in vitreomacular interface (VMI) and outer sensory retina have been reported [13–17]. Although both intravitreal gas and ocriplasmin are capable of inducing vitreomacular separation, the underlying mechanisms for the release of VMT may be different. In the present study, we described the dynamic changes of the VMI and the outer retinal structures during and after intravitreal gas injection. By studying the early structural changes after gas injection, the mechanisms of how intravitreal gas treatment induces vitreomacular separation may be better understood.

Methods

Patients and Baseline Assessment

This is a retrospective, interventional case series that includes consecutive cases of patients who received intravitreal gas injection for the treatment of idiopathic impending MH or early FTMH at the National Taiwan University Hospital during the period from January 1, 2009 to May 31, 2016. All patients gave full informed consent. The study was in compliance with the Declaration of Helsinki and was permitted by the IRB of the National Taiwan University Hospital.

All patients received comprehensive preoperative examination, including Snellen best-corrected visual acuity (BCVA), slit-lamp biomicroscopic examination, and optical coherence tomography (OCT). The OCT was performed under dilated pupils using different commercially available systems, including Cirrus OCT™ (Carl Zeiss Meditec, Inc., Dublin, CA, USA) or RTVue 100 OCT (Optovue, Inc., CA, USA). All patients had OCT-visible vitreous adhesion to the fovea, causing disruption of macular structure. The staging of FTMH was a modified version of the classification described by Gass [18], based on the recent classification for diseases of vitreomacular interface by the International Vitreomacular Traction Study Group [19], and OCT-based classification system for focal VMT designed by Steel et al. [20]. We defined impending MH as a focal VMT (<1,500 μ m) associated with inner foveal cysts, cavitation, with or without outer retinal changes or foveal detachment by OCT, as well as the presence of foveal yellow dot or ring on biomicroscopy. Only those cases that presented with outer retinal dehiscence involving the ellipsoid zone (EZ) and external limiting membrane, or those with foveal detachment were included for the treatment. Those eyes with only inner retinal changes or focal outer retinal abnormality without dehiscence or subretinal fluid were not chosen for gas injection. FTMH was defined as a full-thickness anatomical defect of neurosensory retina tissue from the internal limiting membrane (ILM) to the EZ with or without operculum by OCT. The hole size was measured according to the method described by the International Vitreomacular Traction Study group [20], using the OCT caliper function at the narrowest aperture parallel to the retinal pigment epithelium layer. We chose the maximum measurement in multiple radial scans; the area of operculum was not included in the measurement. FTMHs with focal VMT and hole size of less than 400 μ m were included. We defined FTMHs with this configuration as stage 2 FTMHs or early FTMHs. The detailed features of the vitreomacular relationship were also recorded, including the area of attachment between the posterior hyaloid and the fovea, the vitreofoveal angle, and the height of retinal elevation. To assess the vitreofoveal angle, we measured the height between the detached posterior hyaloid and the ILM at a distance of 1,000 μ m from the fovea center after adjusting for the horizontal and vertical magnification of individual OCT instruments, and calculated the vitreofoveal angle by trigonometric functions. The largest angle among nasal, temporal, superior, and inferior aspects was selected as the vitreofoveal angle of the specific case. The height of retinal elevation was defined as the perpendicular distance between retinal pigment epithelium surface and the lowest point of vitreomacular adhesion. Cases that had significant epiretinal membrane with cellophane membrane or striation on the retinal surface on biomicroscopy associated with distinct hyperreflective line on the retinal surface by OCT, pathologic myopia (defined as a spherical equivalent of more than

–6.00 dpt, or an axial length of longer than 26.5 mm), retinal vascular diseases, or MH due to other secondary causes were excluded. Cases were also excluded if peripheral retinal degeneration, including lattice degeneration or retinal breaks, was identified during preoperative examination.

Surgical Procedures

Pars plana intravitreal injection with 0.10–0.20 ml of 100% sulfur hexafluoride (SF₆) or perfluoropropane (C₃F₈) using a 27-G needle was performed under topical anesthesia after proper disinfection and anterior chamber paracentesis. The type and volume of gas used for each patient are shown in Tables 1 and 2. Patients were asked to keep a prone or face-down position for at least 5 days after injection. Standard 3-port PPV was arranged if the MH did not seal.

Follow-Up OCT Assessment

The first postoperative OCT was performed within 1 month after surgery in all cases. To evaluate the early changes of the VMI, OCT was performed at day 1 postoperatively in certain cases. The VMT was defined as primary release if the posterior hyaloid was completely detached from the macula within 1 month postoperatively. Primary success was defined as primary closure of MH within 1 month postoperatively, and secondary success was defined as MH closure spontaneously after 1 month postoperatively, or MH closure after PPV. For those cases in which VMT did not release on day 1 postoperatively, a change of vitreomacular configuration was recorded. The change of the vitreomacular configuration was defined as flattened if the height of retinal elevation decreased, and was defined as elevated if the height of retinal elevation increased, while any change within 10% of baseline was defined as insignificant. We also recorded the changes in vitreofoveal angle in the cases of persisted vitreomacular adhesion on postoperative day 1. Furthermore, other microstructural changes at the vitreomacular interface detected by OCT were also documented, including the presence of subretinal fluid pocket and the restoration of EZ integrity.

Results

A total of 21 eyes of 20 patients were included (15 females, median age of 58 years, range 47–76 years). Eight eyes had VMT with impending MH, and the other 13 had early FTMH with diameters of less than 400 μ m. The mean of initial BCVA was 0.80 ± 0.38 logMAR. The baseline characteristics and clinical data before and after intravitreal gas injections are shown in Tables 1 and 2.

Impending MH

In this group, VMT release within 1 month after gas injection was noted in all cases, and MH closure was achieved in 7 of 8 cases (primary success rate: 87.5%). FTMH developed in 1 case even after VMT resolution, and was sealed after surgical vitrectomy with ILM peeling. The mean BCVA improved from 0.63 ± 0.34 logMAR

Table 1. Baseline characteristics and clinical data of the patients before and after intravitreal expansile gas injections in the impending MH group

Case	Age, years	Sex	Eye	Gas used, mL	BCVA, logMAR			Height of retinal elevation, μm		Vitreofoveal angle, degree		Primary VMT release	Primary MH closure
					pre-gas	post-gas	post-PPV	pre-gas	POD1	pre-gas	POD1		
1	63	M	OD	C ₃ F ₈ 0.15	0.30	0.05	N/A	443	320	21.8	R	Yes	Yes
2	52	F	OS	SF ₆ 0.2	0.40	0.52	0.15	343	351	15.6	10.8	Yes	No
3	57	M	OS	SF ₆ 0.2	0.52	0.00	N/A	300	268	25.7	R	Yes	Yes
4	49	F	OS	C ₃ F ₈ 0.15	0.30	0.05	N/A	306	256	28.9	3.4	Yes	Yes
5	61	F	OS	C ₃ F ₈ 0.15	1.30	0.05	N/A	470	490	40.5	45.1	Yes	Yes
6	54	F	OS	C ₃ F ₈ 0.2	0.30	0.10	N/A	254	233	10.8	0.7	Yes	Yes
7	68	F	OS	C ₃ F ₈ 0.2	1.00	0.15	N/A	283	199	16.1	R	Yes	Yes
8	68	F	OD	C ₃ F ₈ 0.2	1.00	0.15	N/A	211	200	24.8	R	Yes	Yes

MH, macular hole; BCVA, best-corrected visual acuity; PPV, pars plana vitrectomy; POD1, postoperative day 1; VMT, vitreomacular traction; R, VMT released; N/A, not applicable.

Table 2. Baseline characteristics and clinical data of the patients before and after intravitreal expansile gas injections in the early FTMH group

Case	Age, years	Sex	Eye	Gas used, mL	BCVA, logMAR			Hole size, μm	Height of retinal elevation, μm		Vitreofoveal angle, degree		Primary VMT release	Primary MH closure
					pre-gas	post-gas	post-PPV		pre-gas	POD1 ^a	pre-gas	POD1 ^a		
9	62	F	OS	C ₃ F ₈ 0.2	1.30	0.70	N/A	120	428	N/A	17.3	N/A	Yes	Yes
10	58	F	OD	C ₃ F ₈ 0.2	1.30	1.00	N/A	291	448	345	24.7	R	Yes	No
11	65	F	OS	C ₃ F ₈ 0.2	0.70	0.82	0.40	226	364	N/A	16.7	N/A	Yes	No
12	56	F	OS	C ₃ F ₈ 0.2	1.30	0.00	N/A	236	440	220	21.8	R	Yes	Yes
13	47	F	OD	C ₃ F ₈ 0.2	0.40	0.70	0.00	341	494	417	17.2	1.7	No	No
14	50	F	OD	C ₃ F ₈ 0.2	0.70	0.30	0.05	271	362	362	25.2	R	Yes	Re-open
15	61	F	OD	C ₃ F ₈ 0.1	0.82	0.82	0.00	194	339	N/A	15.9	N/A	Yes	No
16	72	F	OS	C ₃ F ₈ 0.1	1.52	1.52	0.00	394	365	262	20.6	0.3	No	No
17	54	M	OD	C ₃ F ₈ 0.2	1.30	2.00	0.10	355	404	314	28.4	9.1	Yes	No
18	49	F	OS	C ₃ F ₈ 0.2	0.70	0.82	N/A	219	332	320	23.3	13.0	Yes	No
19	53	F	OD	C ₃ F ₈ 0.2	0.52	0.52	0.10	179	388	N/A	25.9	N/A	Yes	No
20	64	M	OD	C ₃ F ₈ 0.15	0.70	0.82	0.40	288	337	N/A	21.0	N/A	Yes	No
21	61	M	OS	SF ₆ 0.15	0.70	0.70	N/A	116	251	273	17.7	16.3	No	Yes

FTMH, full-thickness macular hole; BCVA, best-corrected visual acuity; PPV, pars plana vitrectomy; POD1, postoperative day 1; VMT, vitreomacular traction; MH, macular hole; R, VMT released; N/A, not applicable. ^a Certain eyes did not receive OCT examination on the first postoperative day, so the data was not applicable in these cases.

to 0.08 ± 0.06 logMAR in the primary success cases. The treatment course of the impending MH group is summarized in Figure 1.

All 8 cases in the impending MH group received OCT examination on postoperative day 1, and 4 cases already had VMT resolution (Fig. 2). In the 4 cases where VMT

persisted, the vitreofoveal angle became flattened in 3 cases (Fig. 3), and became elevated in 1 case (Fig. 4). The postoperative change in the vitreofoveal angle was consistent with the change in the height of retinal elevation except in 1 case, which showed minimal change in the height of retinal elevation (from 343 to 351 μm , or 2.3%

Fig. 1. Schematic diagram on the treatment course of the impending macular hole group. MH, macular hole; IVI, intravitreal injection; VMT, vitreomacular traction; PPV, pars plana vitrectomy.

of baseline), compared with the change in the vitreofoveal angle (from 15.6 to 10.8°, or 30.8% of baseline). The pre- and postoperative OCT features are summarized in Table 1. Furthermore, we observed that the preoperative vitreofoveal angle was steeper in the elevated case than that in other cases. Increased height of foveal detachment and transient subfoveal fluid pocket were noted after gas injection in the elevated case. Overall, restoration of EZ integrity was achieved in 7 cases (medium time to restoration: 2 months; range: 0.5–6 months).

Early or Stage 2 FTMH

The mean MH diameter was $248.5 \pm 82.4 \mu\text{m}$. In this group, 10 out of 13 cases (76.9%) had VMT resolution after intravitreal gas injection, and 3 cases had MH closure subsequently. However, 1 case developed rhegmatogenous retinal detachment and recurrent MH 4 months after gas injection (Fig. 5). In 3 cases of persistent VMT, 1 case showed loosening of the traction, and MH spontaneously closed on postoperative day 4 (Fig. 6). The primary success rate was 3/13 (23.1%). The mean size of MH was significantly smaller in the primary success cases compared with the other cases (157.3 ± 39.4 vs. $275.8 \pm 22.8 \mu\text{m}$, $p = 0.0283$ by t test). Surgical vitrectomy was performed in 7 cases of persisted MH and 1 case of recurrent MH with rhegmatogenous retinal detachment. MH was sealed in all cases after vitrectomy, and the mean BCVA was improved from 0.92 ± 0.35 to 0.17 ± 0.23 log-MAR in primary and secondary success cases. The treatment course of the early FTMH group is summarized in Figure 7.

Fig. 2. Serial optical coherence tomography images of case 7 before and after the intravitreal injection of C_3F_8 . **a** Focal vitreomacular traction (VMT) with outer and inner retina dehiscence was observed preoperatively. **b** On postoperative day 1, VMT released with the flattening of retinal configuration and decreased central foveal thickness was noted. **c** At 2 weeks postoperatively, minimal intraretinal cyst and mild ellipsoid zone separation were still observed. **d** At 3 months postoperatively, improvement of ellipsoid zone integrity and foveal contour were noted.

Eight cases in the early FTMH group were evaluated with OCT on postoperative day 1. Three cases had VMT resolution, and 5 cases presented with persistent VMT. Of these 5 cases, all showed flattening of the vitreomacu-

Fig. 3. Serial optical coherence tomography images of case 4 before and after the intravitreal injection of C_3F_8 . **a** Vitreomacular traction (VMT) with intraretinal cysts, impending macular hole, and mild foveal detachment were observed preoperatively. **b** On postoperative day 1, flattening of the posterior vitreous cortex and reattachment of the foveal floor were noted. **c** On postoperative day 10, VMT was released with only mild intraretinal cysts and ellipsoid zone disruption. **d, e** Restoration of normal foveal contour and ellipsoid zone integrity were achieved during follow-up.

Fig. 4. Serial optical coherence tomography images of case 5 before and after the intravitreal injection of C_3F_8 . **a** Vitreomacular traction (VMT) with intraretinal cysts, impending macular hole, and foveal detachment were observed preoperatively. **b** On postoperative day 1, elevation of VMT and rise of foveal detachment were noted. **c** On postoperative day 14, VMT release and fovea detachment resolved. **d, e** Restoration of normal foveal contour and ellipsoid zone integrity were achieved. Epiretinal membrane became more apparent during the follow-up period.

Fig. 5. Serial optical coherence tomography images of case 15 before and after the intravitreal injection of SF₆. **a** Vitreomacular traction (VMT) with small full-thickness macular hole (MH) and intraretinal cysts were observed preoperatively. **b** On postoperative day 1, VMT was released and vitreomacular configuration became flattened. **c** On postoperative day 8, MH had sealed and residual subfoveal fluid pocket was observed. **d** At 3 months postoperatively, restoration of ellipsoid zone integrity and normal foveal contour were achieved. In this case, recurrent MH with rhegmatogenous retinal detachment developed at 4 months postoperatively, and MH sealed after subsequent pars plana vitrectomy with internal limiting membrane peeling.

lar configuration (Fig. 8). The changes in vitreofoveal angle and height of retinal elevation on postoperative day 1 are listed in Table 2. Four of the 5 cases had later separation of VMT, and 1 showed spontaneous MH closure. During the course of spontaneous MH closure in the 3 cases, residual subfoveal fluid pockets were observed, and the restoration of EZ on OCT images was achieved in all

Fig. 6. Serial optical coherence tomography images of case 21 before and after the intravitreal injection (IVI) of SF₆. **a** Vitreomacular traction (VMT) with small full-thickness macular hole (MH) was observed preoperatively. **b** On postoperative day 1, flattening of posterior vitreous cortex was noted. **c** On postoperative day 4, VMT was not released but MH sealed spontaneously. **d** Fifteen days after IVI gas, VMT persisted despite MH closure.

cases. On the other hand, progression of MH was found in 4 cases even after VMT resolution. Surgical vitrectomy was performed in these cases and all MHs were sealed successfully.

Discussion

Our study indicated that intravitreal gas injection was able to induce VMT separation and the subsequent normalization of foveal configuration in an impending MH.

Fig. 7. Schematic diagram on treatment course of the early full-thickness macular hole (FTMH) group. FTMH, full-thickness macular hole; IVI, intravitreal injection; VMT, vitreomacular traction, MH, macular hole; PPV, pars plana vitrectomy.

Overall, 18 of 21 cases (85.7%) in our study had release of VMT within 1 month after intravitreal gas injection. We performed gas injection to treat impending MH only in those with definite outer retinal abnormalities, such as foveal detachment or outer lamina disruption. We excluded eyes with only inner retinal changes or minor outer retinal abnormality because such subtle changes may be subject to individual judgement, and these cases tend to be stable over time and may go through spontaneous resolution [21]. Our results were compatible with other studies as summarized in Table 3 [1–8]. Rodrigues et al. [2] analyzed the pretreatment SD-OCT features associated with a higher VMT resolution rate, and found that eyes with a lower horizontal length of vitreomacular adhesion, lower maximum foveal thickness ($<500\ \mu\text{m}$), and lower vitreous face reflectivity had higher success rates. The treatment was less effective in VMT associated with age-related macular degeneration or diabetic macular edema than idiopathic VMT. Our series only included cases of idiopathic VMT, and all eyes had focal VMT with maximal foveal thickness $<500\ \mu\text{m}$ and low vitreous face reflectivity. We demonstrated that VMT release could be achieved in a high percentage of cases, regardless of foveal thickness. Recently, Claus et al. [7] reported a high VMT release rate by intravitreal C_2F_6 or SF_6 injection, with 1 out of 20 eyes developed FTMH subsequently.

Fig. 8. Serial optical coherence tomography images of case 18 before and after the intravitreal injection of C_3F_8 . **a** Vitreomacular traction (VMT) with small full-thickness macular hole (MH) and intraretinal cysts were observed preoperatively. **b** On postoperative day 1, flattening of the posterior vitreous cortex was noted. **c** On postoperative day 8, VMT was released but MH enlarged. **d** One month after surgical vitrectomy, MH was sealed.

They concluded that the type of gas used has only a minor influence on the result. In our study, we also found that there is no difference in the results between C_3F_8 and SF_6 .

We observed that the resolution of VMT does not necessarily contribute to the closure of FTMH, and the progression of MH may continue even after VMT release. In our series, 1 case in the impending MH group developed FTMH after VMT resolution, and 4 cases in the early FTMH group had enlarged MH sizes after the release of

Table 3. Outcome of intravitreal gas injection for macular holes (review of recent literature)

Reference	VMT release rate	MH closure rate ^a	Other comments
Chan et al. [6] 1995	18/19 (94.7%)	IMH: 10/11 Stage 2 FTMH: 3/6 Stage 3 FTMH: 0/2	No major complications
Jorge et al. [5] 2006	6/6 (100%)	Stage 2 FTMH: 5/6	Residual hyporeflective area beneath the fovea
Mori et al. [4] 2007	19/20 (95%)	Stage 2 FTMH: 10/20	Inclusion criteria: initial VA >20/40, size <200 µm
Chen et al. [3] 2012	6/12 (50%)	Stage 2 FTMH: 3/12	FTMH re-opened in 1 case, RRD in 2 cases
Day et al. [1] 2016 (Studies below only included eyes with IMH)	5/9 (55.6%)	Stage 2 FTMH: 2/2	Decreased mean central subfield thickness
Rodrigues et al. [2] 2013	6/15 (40%)	Normalization of foveal contour: 7/15 (47%) Decreased maximal foveal thickness in success cases	
Steinle et al. [8] 2017	25/30 (83.3%)	EZ changes on SD-OCT in 1 case 5/6 (83.3%) eyes with concurrent ERM had VMT released	
Claus et al. [7] 2017	17/20 (85.0%)	Stage 2 FTMH developed in 1 case	

VMT, vitreomacular traction; MH, macular hole; IMH, impending macular hole; FTMH, full-thickness macular hole; VA, visual acuity; RRD, rhegmatogenous retinal detachment; EZ, ellipsoid zone; SD-OCT, spectral domain optical coherence tomography; ERM, epiretinal membrane. ^a The staging of the macular hole was according to the Gass classification.

traction. Similar findings were also observed by other intravitreal gas studies [2–4]. Our results showed unfavorable outcomes of MH closure with a primary success rate of only 23.1%. Mori et al. [4] demonstrated a higher closure rate (10 out of 20 stage 2 FTMHs) in eyes with baseline vision better than 0.3 logMAR and a hole diameter <200 µm. We observed a similar finding regarding the hole size. Yet, we did not see a relationship between baseline vision and MH closure rate ($p = 0.3554$ by t test), probably because the preoperative BCVA of our early FTMH group was poor (mean of 0.92 ± 0.35 logMAR), which might partially explain the poor outcomes in our study. Paradoxically, MH closure may be achieved even under persistent VMT. The exact relationship between VMT and MH still needs to be further established.

In this study, we found two patterns of changes after gas injection: the flattening and steepening of the vitreomacular configuration. When the gas bubbles were in the vitreous cavity, assuming a face-down position might push the gas against the posterior hyaloid in the macular area, thus promote the flattening of the vitreomacular

configuration. The cause for the steepening of the vitreomacular configuration was more difficult to understand. We noticed that the baseline vitreofoveal angle was steeper in the case that had elevated vitreomacular configuration after gas injection than that in the cases with flattened patterns. It was possible that the higher separation of the posterior hyaloid and the retina left some room for some of the gas bubbles to enter the mid-peripheral subhyaloid space, instead of staying only in the intravitreal space. This condition in turn increased the anterior-posterior vitreous traction on the fovea, resulting in the steepening of the configuration. Regardless of the patterns, the configuration change indicated a disturbance of the vitreomacular interface, and predisposed the eye to the release of VMT. Furthermore, the elevated pattern likely increased traction on the fovea more than the flattening pattern did, which may potentially cause more disruption on macular structure and lead to the development and progression of FTMH. In the early FTMH group, 8 out of 13 cases had OCT done on postoperative day 1. Three cases already presented with VMT separation. The other

5 cases showed unanimous flattening of the foveal contour. Does this mean that the flattening pattern is more likely to occur than the elevation pattern? Our small number of cases makes it difficult to arrive at a definite answer. One alternative explanation is that an elevation pattern may be more likely to lead to an enlargement of the hole and thus, progression of the MH.

Recently, intravitreal ocriplasmin, a chemical vitreolysis agent, has been introduced for the treatment of VMT syndrome, with a 26.5% VMT resolution rate and 40.6% nonsurgical MH closure rate as shown by the MIVI-TRUST Group [12]. In contrast, treatment of early FTMH with intravitreal gas injection seems discouraging in our study. Steel et al. [22] recently showed that MHs with a narrower base configuration relative to the minimum linear diameter had a higher closure rate when treated with ocriplasmin. Due to the small number of cases, we could not verify the relationship between the MH configuration and success rate in the current study. Similar to our study, the MIVI-TRUST Trials also observed MH closure in eyes with persisted VMT after ocriplasmin treatment [11] and vice versa, i.e., VMT resolution does not assure the closure of MH in either treatment. Chatziralli et al. [15] found that the vitreofoveal angle increased initially in the first week after ocriplasmin injection before release of the VMT. Narrowing of the area of vitreomacular adhesion [23, 24] and gradual contraction and loosening of the hyaloid in SD-OCT [16] have also been noticed after ocriplasmin injection. These were different from the effect of intravitreal gas in which both flattening and steepening of the foveal configuration could be observed. Besides the changes at the vitreomacular interface, several alterations of the outer retina in SD-OCT after ocriplasmin treatment have also been described, including a transient attenuation or disruption of the EZ, and an accumulation

of subfoveal fluid that extends to the parafoveal area [13, 14, 16, 17, 24–26]. These OCT findings are evidence of the proteolytic activity of ocriplasmin against the adhesion molecules within the vitreoretinal structures, whereas the mechanical force may be the major mechanism of VMT release with the use of gas.

The limitations of our study include the small number of cases and the short follow-up periods for some cases. However, instead of focusing on the efficacy of gas in the treatment of impending or early idiopathic MH, which has already been well documented by other studies, we focused on the early vitreomacular changes after gas injection in order to better understand the possible mechanism of VMT resolution. We noticed that the vitreomacular configuration might be elevated or flattened before traction was released, and we proposed that this disturbance of the vitreomacular interface predisposed the eye to the mechanical release of VMT. We proposed that, early after gas injection, the traction on macula transiently increases, especially in eyes that show the elevated pattern. Caution should be taken especially in the eyes with steeper baseline vitreofoveal angle. In conclusion, because of the high success rate of gas injection for impending MH, we suggest that intravitreal gas may be a useful option as an initial treatment. Unfortunately, the same conclusion cannot be reached for early FTMH, since we found that the release of VMT did not guarantee the closure of early FTMH, especially with a hole size >200 μm . Therefore, we do not suggest performing intravitreal gas injection for the treatment of early FTMH.

Disclosure Statement

The authors have no financial interest in any materials or equipment used in the study.

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