Original Article

Outcomes of Light Silicone Oil Tamponade for Failed Idiopathic Macular Hole Surgery

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Abstract

Purpose: To study the outcomes of redo macular hole surgery using light silicone oil tamponade.
Methods: In this study, medical charts of consecutive patients who underwent redo pars plana vitrectomy, extended dye-assisted internal limiting membrane peel, and light silicone oil tamponade for failed previous macular hole surgery (from January 2010 to June 2014) were retrospectively reviewed. Best spectacle corrected visual acuity and anatomical closure rates were regarded as outcome measures.
Results: Overall, data from 13 patients was recorded and analyzed. The mean (±SD) age of patients was 66 ± 7 years, and four (30.7%) were male. Mean interval between the primary and redo surgeries was 3.7 ± 2.0 months (range, 1 to 8 months). During redo surgeries, 11 (84.6%) subjects underwent additional internal limiting membrane peeling. Mean interval between the redo surgery and silicone oil removal was 5.9 ± 2.1 months (range, 3 to 10 months). After silicone oil removal, patients were followed for 21.8 ± 14.2 months (range, 3 to 51 months). Mean best spectacle corrected visual acuity improved from 20/452 before redo surgery to 20/121 in the last follow-up examination ($P < 0.001$). Anatomical success was achieved in 11 (84.6%) patients: nine (69.2%) macular holes were closed and two (15.4%) were flat-open.
Conclusions: Redo pars plana vitrectomy with light silicone oil tamponade is an effective method for restoration of macular anatomy and function in patients with persistent macular holes.

Keywords: Internal Limiting Membrane Peeling; Macular Hole, Pars Plana Vitrectomy; Silicone Oil; Surgery

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INTRODUCTION

Pars plana vitrectomy (PPV) combined with fluid-gas exchange has been successful in the management of full thickness macular holes (MH).[1] Vital dye-assisted internal limiting membrane (ILM) peel and/or tamponade with medium- to long-acting gases such as sulfur hexafluoride (SF6) and perfluoropropane (C3F8) contributed to the increase in the success rate of the procedure.[2] Despite remarkable advances in surgical techniques and instruments, a proportion of cases of MH (particularly those with larger or more chronic holes) fails to close after the initial surgery. This issue is important, because without anatomical success, the visual outcome will remain poor.[3]

After MH surgery with gas tamponade, patients are typically instructed to remain in the prone position

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for seven to ten days. Prone positioning may be very inconvenient or even impossible for some patients such as elderly, obese, or arthritic patients, or those with lumbar or cervical spine problems. Inaccurate or inadequate positioning in the early postoperative period may contribute to some cases of failure, particularly for larger holes.[4] Optimal tamponade of MH is less compromised by inappropriate postoperative position in cases with silicone oil-filled vitreous cavity than those who receive long-acting gases such as SF6 or C3F8;[5] hence, silicone oil (SO) may have an advantage over gas in cases of surgery that failed secondary to presumed noncompliance with positioning. In addition, effective long-term tamponade is only possible with SO, which does not lose volume over time. Taken together, SO tamponade may be a useful alternative to gas in MH redo cases. The aim of the present study was to evaluate the anatomical and visual outcome of SO injection in failed MH surgery cases.

METHODS

Study Population

In this single-center retrospective interventional case series, the medical charts of 13 patients who underwent redo surgery with injection of light SO for failed MH surgery from January 2010 to June 2014 were reviewed. Only patients with persistent open idiopathic MH and uncomplicated primary surgery were included. Eyes with re-opening of initially successfully closed MHs were excluded. All included patients had at least 3 months of follow-up after SO removal. Subjects with other types of MH (ex, myopic, or traumatic), or concomitant ocular disorders other than cataract (such as glaucoma, diabetic retinopathy, uveitis, or corneal disorders) were excluded. Patients were operated on by multiple vitreoretinal surgeons in the same hospital. Informed consent was obtained from all subjects before operation. The study protocol was approved by the Ethics Committee at Shiraz University of Medical Sciences.

Surgical Technique

The primary surgical technique included a sutureless 23-gauge PPV, membrane peeling (if present), and ILM peeling to at least one disc diameter from the edge of the hole. ILM was stained with Brilliant Blue G (using either Brilliant Peel [Geuder AG, Heidelberg, Germany] or ILM Blue [DORC International, Zuidland, Netherlands]) and peeled with Eckhardt end-gripping ILM forceps (DORC International). Fluid–air exchange was then performed, and the vitreous cavity was replaced with 20% SF6 or 14% C3F8. Phacoemulsification with posterior chamber intraocular lens insertion was performed in all phakic eyes, regardless of the clarity of the lens.

Redo MH surgery consisted of a second PPV (sutureless 23-gauge in 12 eyes and standard 20-gauge in one eye), extended ILM peeling (up to the arcade vessels) using the same method (in 11 eyes), and light SO tamponade (Oxane 5700 or 1300 [Bausch & Lomb, Kingston-upon-Thames, UK]). In this study, light SO 5700 centistokes (cSt) was used in ten eyes and light SO 1300 cSt was used in the remaining three eyes. The selection of different viscosities of the light SO was based on the availability of the light SO type in the operating room. In the setting of 23-gauge PPV, light SO 1300 cSt was preferred (which takes considerably less time to inject); if light SO 1300 cSt was not available, light SO 5700 cSt was used.

All patients were instructed to maintain a prone position for one week after operation, and to avoid supine position thereafter until SO removal, which was performed by pars plana approach at least 3 months after redo surgery.

Outcome Measures

Best spectacle corrected Snellen visual acuity (BSCVA) was recorded at baseline, after primary surgery (and before redo surgery), and at final examination. The anatomical outcome of redo surgery was classified as flat-closed MH (with apposition of MH edges), flat-open MH (flat edges without apposition), or elevated-open MH (with elevated edges and cuff of retinal detachment around the hole).[6] Flat-closed and flat-open MHs were considered as successful anatomical outcomes.

Statistical Analysis

Data were analyzed using SPSS software version 17 (SPSS Inc., Chicago, IL). For statistical evaluation, BSCVA values were converted into logarithms of the minimum angle of resolution (logMAR) equivalents. The Kolmogorov-Smirnov test confirmed the normality of logMAR BSCVA data. Measurements obtained from different time points were compared using repeated measures analysis of variance (ANOVA) and the Bonferroni multiple comparison test. A P value of <0.05 was considered statistically significant.

RESULTS

Data of 13 eyes of 13 patients who underwent redo PPV with light SO injection for failed MH surgery were recorded and analyzed. Mean (±SD) age of patients was 66 ± 7 years (range, 56 to 78 years), and four (30.7%) were male.

Demographic and baseline characteristics of the study cohort are presented in Table 1. At baseline, two patients (15.4%) had stage 2 MH, seven (53.8%) had stage 3, and four (30.8%) had stage 4. The primary surgery comprised of phacoemulsification combined

Table 1. Demographic and baseline characteristics of the study cohort

Patient	Sex	Age, y	Eye	MH stage[a]	Lens status	VA (1)[b]	Gas	VA (2)[c]	Interval, m[d]
1	Female	56	Right	3	Phakic	20/400	SF6	20/1200	6.0
2	Male	66	Right	2	Phakic	20/200	C3F8	20/100	4.5
3	Male	78	Right	3	Pseudophakic	20/240	C3F8	20/600	3.0
4	Female	69	Right	3	Pseudophakic	20/240	C3F8	20/400	2.5
5	Male	77	Right	4	Phakic	20/300	C3F8	20/800	8.0
6	Female	65	Right	3	Phakic	20/1200	SF6	20/800	4.0
7	Female	73	Left	4	Phakic	20/600	C3F8	20/600	3.5
8	Male	64	Left	4	Pseudophakic	20/600	SF6	20/1200	1.0
9	Female	59	Right	2	Phakic	20/300	SF6	20/400	1.0
10	Female	59	Left	3	Phakic	20/240	C3F8	20/400	5.5
11	Female	67	Left	4	Phakic	20/200	SF6	20/200	3.5
12	Female	65	Right	3	Phakic	20/200	SF6	20/200	4.0
13	Female	63	Left	3	Phakic	20/240	SF6	20/400	2.0

[a]According to Gass classification. [b]Best spectacle corrected visual acuity at baseline. [c]Best spectacle corrected visual acuity after the failed surgery and before silicone oil injection. [d]The time between the first surgery and redo surgery. MH, macular hole; m, month; VA, visual acuity; y, year

with 23-gauge PPV, ILM peeling and gas injection in ten (76.9%) phakic patients, and 23-gauge PPV, ILM peeling and gas injection in three pseudophakic patients. SF6 and C3F8 were used in seven (53.8%) and six (46.2%) eyes, respectively. The mean logMAR BSCVA was not statistically different at baseline and after primary (failed) surgery (1.21 ± 0.24 and 1.35 ± 0.32, respectively; $P = 0.126$). Mean interval between the primary and redo surgeries was 3.7 ± 2.0 months (range, 1 to 8 months).

Table 2 presents the characteristics and outcome of redo surgery by patient. During redo surgeries, 11 (84.6%) subjects underwent additional ILM peeling. Viscosities of the injected SO were 5700 cSt in ten (76.9%) and 1300 cSt in three (23.1%) eyes. All redo surgeries were performed with the sutureless 23-gauge setting, with the exception of patient number 13 who underwent conventional 20-gauge PPV. SO removal was performed in all patients. The mean interval between the redo surgery and SO removal was 5.9 ± 2.1 months (range, 3 to 10 months).

After SO removal, patients were followed for 21.8 ± 14.2 months (range, 3 to 51 months). At the last follow-up exam, the mean logMAR BSCVA increased to 0.78 ± 0.37, which was a significant improvement from baseline ($P < 0.001$) and after primary (failed) surgery ($P < 0.001$). Figure 1 depicts alterations in logMAR BSCVA at baseline, before redo surgery, and at the last follow-up exam. Mean Snellen equivalent BSCVA was 20/323, 20/452, and 20/121 at baseline, after primary surgery, and at the last follow-up, respectively. At baseline or after primary surgery, three (23.1%) patients had BSCVA ≥20/200, while at the last exam, ten (76.9%) subjects had BSCVA ≥20/200.

Overall, anatomical success was achieved in 11 (84.6%) patients [nine (69.2%) MHs were closed and two (15.4%) were flat-open]. In three patients, an injection of 0.4 mL undiluted C3F8 was tried about 1 month after failed primary surgery [Table 2], which was unsuccessful in all three eyes, and one patient developed inferior retinal detachment. At the last follow-up (after additional surgeries), one of these MHs remained elevated-open (failed), and two developed into flat-open configuration. One patient (number 10) developed cystoid macular edema after SO removal that responded well to a single intravitreal injection of 1.25 mg bevacizumab. Redo surgery and SO removal were not associated with major complications (such as retinal detachment, vitreous or suprachoroidal hemorrhage, endophthalmitis, or ocular hypertension requiring long-term medication or therapy) in any patients.

DISCUSSION

Findings of the present study indicate that redo PPV with light SO injection is associated with a significant improvement in mean BSCVA (20/452 to 20/121) and high closure rate of MH (84.6%). In addition, we found no major intra- or postoperative complications. Taken together, light SO injection seems effective and safe in the context of persistent MH.

Different protocols have been developed to classify failed MH surgery. In this study, we used the clinical classification, which was originally introduced by Tornambe et al.[6] Based on optical coherence tomography (OCT) findings, another article classified MH closures into type 1 closure (closed without foveal neurosensory retinal defect) and type 2 closure (closed with foveal neurosensory retinal defect), which intimately correspond to flat-closed and flat-open configurations, respectively.[7]

Currently, the standard approach for MH surgery includes PPV, epiretinal membrane removal (if present),

Table 2: Redo operation with light silicone oil injection and its outcome in patients with failed macular hole surgery

Patient	ILM peel	SO, cSt	Interval, m[a]	Anatomical result	Final VA	FUC, m	Notes
1	Yes	5700	5.5	Flat-closed	20/200	25	
2	Yes	5700	7.0	Flat-closed	20/200	24	
3	Yes	5700	9.0	Flat-closed	20/50	33	
4	Yes	5700	10.0	Flat-open	20/100	27	C3F8 was injected
5	Yes	5700	6.0	Elevated-open	20/400	6	Did not maintain face down position
6	Yes	5700	5.0	Flat-closed	20/400	9	
7	Yes	5700	3.0	Elevated-open	20/300	25	C3F8 was injected;[b] Maintained face down position
8	No	5700	7.5	Flat-open	20/200	36	C3F8 was injected;[b] Developed inferior retinal detachment after C3F8 injection
9	Yes	5700	6.0	Flat-closed	20/100	27	
10	No	5700	5.5	Flat-closed	20/30	12	Developed macular edema after SO removal, which responded to 1 intravitreal injection of bevacizumab
11	Yes	1300	4.0	Flat-closed	20/50	51	
12	Yes	1300	5.0	Flat-closed	20/70	5	
13	Yes	1300	3.0	Flat-closed	20/70	3	

[a]The time between redo surgery and silicone oil removal. [b]0.4 mL undiluted C3F8 was injected into the vitreous cavity about 1 month after the failed primary operation. In these patients, the macular hole remained open after C3F8 injection. [c]Follow up after silicone oil removal. ILM, internal limiting membrane; cSt, centistoke; FU, follow-up; m, month; SO, silicone oil; VA, visual acuity

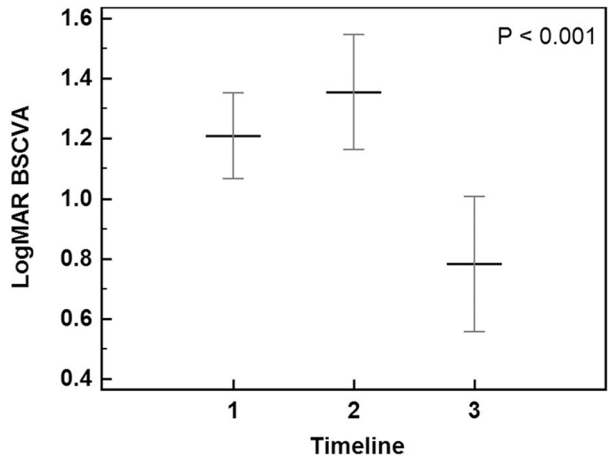

Figure 1. Mean logMAR visual acuity (central line) with 95% confidence intervals of the mean (error bars) for baseline (1), before redo operation (2), and final (3) measurements. BSCVA, best spectacle corrected visual acuity; LogMAR, logarithm of the minimum angle of resolution.

vital dye-assisted ILM peeling, and fluid-gas exchange using a long-acting gas such as C3F8 or SF6.[8] This approach is successful in >90% of cases.[9] However, some cases still fail after primary intervention. Several factors have been linked to the failure of primary MH surgery, including residual traction from epiretinal membrane or ILM, ineffective tamponade, poor patient compliance with proper positioning, and MH size of >400 μm.[10,11] However, in some cases, no obvious cause can be found.[12] Two main factors are considered to contribute to MH closure: removing all types of tractional forces on the hole, and limiting the passage of fluid through the hole to promote gliosis at the hole edges. The former goal is accomplished by intraoperative induction of posterior vitreous detachment (removal of vertical traction), epiretinal membrane removal, and ILM peeling (removal of tangential traction). The latter goal is achieved using long-lasting tamponade, and/or intraoperative adjuvants. During redo surgery, adequacy of epiretinal membrane or ILM removal is usually evaluated using vital dyes, and additional peeling is performed if deemed necessary. Currently, there is no consensus about the effect of the extent of ILM peeling on the closure rate of large MHs. In principle, more peeling may provide a more relaxed retina to be closed. A recent study reported less tension on the macula with extended ILM peel.[13] In general, redo surgery is concluded with fluid-air exchange and injection of long-lasting tamponade agents such as gases or SO.

Previous studies used various approaches to manage persistent MH such as in-office fluid-gas exchange, redo surgery with gas or SO tamponade, or the use of intraoperative adjuvants. Table 3 summarizes the visual and anatomical outcomes of persistent MH management in different studies.[14-27] According to the data presented in this table, a second procedure for management of persistent MH using various techniques led to anatomical success in 60-100% of eyes. In addition, significant visual improvement was reported in almost all mentioned studies, paralleling anatomical success. Therefore, regardless of the surgeon preferences for the technique, type of tamponade, or adjuvant, a second procedure is likely to improve the final outcome of MH surgery in most patients. Using some type of

Table 3. Characteristics of procedure, and anatomical and visual outcomes in various studies that evaluate interventions for persistent macular holes

Study	No. Eye (case)	Age, y	Procedure	ILM Peel	Dye	Adjuvant	Tamponade	FU, m	Success, %	Mean Visual Acuity			Notes
										Before	After	*P*	
Ie et al., 1993	12 (11)	63	20-g PPV	No	No	TGF-β2	C3F8	11	100	20/265	20/108	0.005	The VA was calculated from available data
Smiddy et al., 1996	48 (46)	62	20-g PPV	No	No	TGF-β2	C3F8	7.4	83 (40/48)	20/140	20/60		7 were not closed and 1 was re-opened
Kozy and Maberley, 1996	17					TGF-β2	Gas		94 (16/17)		1.76 lines improvement		
Ezra et al., 1997	46	66	20-g PPV	No	No	Autologous Serum	C3F8	10.3	80.0 (37/46)		Median: 20/60		Membranectomy was done in 29/46 eyes. VA was reported for closed holes.
Johnson et al., 1997	23	69±6[b]	Outpatient fluid-gas exchange (C3F8)	No	No	None	C3F8	13.2±8	74 (17/23)	20/247	20/86	<0.001	The VA was calculated from available data
Ikuno et al., 1998	13 (12)	64±8	Outpatient fluid-gas exchange (SF6)	No	No	Laser (to the hole bed)	SF6	10.2±4.2	92.3 (12/13)	20/200	20/98	0.005	The VA was calculated from available data
Kumar et al., 2002	8	69	Standard PPV	No	No	Autologous Serum	LSO	7.5	87.5 (7/8)		0.03 logMAR improvement		6 were closed and 2 were flat-open. One of the closed holes was re-opened after silicone oil removal.
Iwase and Sugiyama, 2007	7	66±8	Outpatient fluid-gas exchange (SF6)	No	No	None	SF6		100	20/138	20/46		
Hillenkamp et al., 2007	28	71	Standard PPV	No	ICG	Platelet: 22 Blood: 1 None: 1	SF6: 15 LSO: 12 None: 1	15.3±8.6	68 (19/28)		0.6±3.3 lines improvement		
Saeed et al., 2009	5			Yes	TB	None	HSO	3	60.0 (3/5)	20/142[b]	20/81[b]	0.109[b]	
Rizzo et al., 2009	23	69	20-g PPV	No	ICG	None	HSO	12	87.0 (20/23)	20/276	20/81	*P*<0.001	One of the failed eyes was reported to have flat edges.

Contd...

Table 3. Contd...

Study	No. Eye (case)	Age, y	Procedure	ILM Peel	Dye	Adjuvant	Tamponade	FU, m	Success, %	Mean Visual Acuity		P	Notes
										Before	After		
Lappas et al., 2009	12	68±7	Standard PPV	No	ICG	None	HSO	4.8±1.4	83.3 (10/12)	20/250	20/160		One patient failed after redo surgery and one macular hole reopened after HSO removal.
Moisseiev, et al., 2013	29	69±6	3-port PPV	Yes (89.6%)	ICG	None	SF6/C3F8	12.9±10	68.9% (20/29)	20/250	20/135	<0.001	
Che et al., 2014	13	65±6	23-g PPV	Yes (up to arcades)	ICG	None	C3F8		61.5 (8/13)	20/214	20/166	0.021	Two of the failed eyes were reported to have flat edges.
Present	13	66±7	23-g PPV	Yes	BBG	None	LSO	21.8±14.2	84.6	20/452	20/121	<0.001	

BBG, brilliant blue G; FU, follow-up; HSO, heavy silicone oil; ICG, indocyanine green; ILM, internal limiting membrane; LSO, light silicone oil; NO., PPV, pars plana vitrectomy; No., number; TB, trypan blue; TGF, transforming growth factor; VA, visual acuity; y, year.

intraocular tamponade in redo surgeries was the only consistent finding in all presented studies, implying its fundamental role in closure of persistent MHs. In fact, several studies demonstrated that intraocular tamponade for an extra period of time without any other intervention was associated with successful closure of MH in the majority of treated eyes.[11,18] Table 3 also reveals that older studies (before 2007) tended to use intra- or peri-operative adjuvants such as laser, autologous blood, or transforming growth factor-β to increase the overall success of MH surgery, while in recent studies adjuvants were substituted by chromovitrectomy and advancement of ILM removal.

For unsuccessful primary MH surgery, light SO has been advocated as a tamponade.[20,22] Kumar et al[20] reported that of the eight previously failed MH surgeries, six were closed and two were flat-open after light SO (1300 cSt) tamponade. One of the closed holes re-opened after SO removal. Based on the criteria used in the present study for MH closure, the final success rate reached 87.5% (7/8). Among other methods, Hillenkamp et al[22] reported 12 cases of persistent MH treated with light SO tamponade, of which eight (66.7%) were successfully closed. In comparison, our data indicates an 84.6% success rate of anatomical closure, corroborating previous evidence about the value of light SO in the context of failed MH surgery.

Long-acting gasses as intraocular tamponades in persistent MH have advantages over SO. Gases could be injected in an office-based setting (and are hence more cost-effective),[28] claimed to be less toxic to the retina,[29] and need no additional procedure for removal. In contrast, SO is less position dependent (especially when the vitreous cavity is properly filled), do not limit air travel, and is associated with faster visual rehabilitation.[30] Therefore, SO may be preferred over gases in monocular patients, socially active individuals, or those who are unable or unwilling to restrict their position. In fact, adequate light SO-MH apposition could be achieved in any position except the supine position [Figure 2],[5] while patients with gas-filled eyes should usually be instructed to maintain the prone position for several hours a day for about one week.[31] In addition, unlike gases, SO do not lose volume over time, and can offer longer-term tamponade for complicated cases such as very large MHs that theoretically need longer periods of tamponade to accomplish gliosis around their lengthy edges.

Heavy SO has shown promise in the treatment of persistent MHs. It has the advantage of maximum tamponade effect in the supine position (a more comfortable position for most patients) and offers even less position limitation compared to light SO. Heavy SO may be especially useful in patients who have to maintain strict supine positioning for other medical reasons.[23] However, removal of heavy SO is more

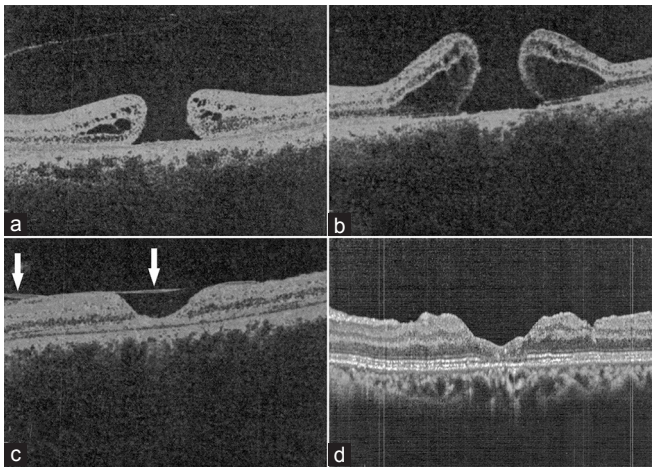

Figure 2. Optical coherence images of the patient number 11. (a) at baseline; (b) after primary surgery; (c) after redo surgery (arrows delineate the silicone oil interface); (d) after silicone oil removal.

challenging than light SO, and often needs active aspiration during the removal procedure. In addition, emulsification, and cataract formation are more frequent with heavy SO.[32]

Previous studies have defined different criteria for MH closure. Although all studies considered flat-closed MH as anatomical success and elevated-open MH as failure, they were not consistent in categorizing flat-open MHs as either anatomical success or failure. According to our experience, in the setting of very large MHs, apposition of edges is unlikely even after extensive ILM peel. However, flattening of MH edges and elimination of the surrounding cuff of fluid was associated with visual improvement. Therefore, we considered the flat-open configuration as a successful outcome.

One of the successful techniques to minimize the risk of persistent holes in the primary surgery of MHs is the inverted ILM flap technique. This technique is particularly useful in very large or myopic MHs.[33,34] The inverted ILM flap technique could be considered for primary MH surgeries with a low chance for primary closure. However, the technique could not be considered for redo surgeries where the ILM has been peeled in the previous surgery.

This study is limited by its retrospective nature and relatively small sample size. In addition, lack of a comparison group that is treated with gas tamponade prevents any conclusion regarding the best choice of tamponade for persistent MHs. Since only two patients did not undergo extended ILM peel, we could not draw any conclusions regarding the beneficial role of extended ILM peel. Because of the uncommon occurrence of MH, and high success rate of the primary operation, we do not expect emergence of a well-designed prospective controlled trial on this topic soon. Hence, at the moment, a report of retrospective case series on the subject and comparison with similar studies in the literature seems clinically useful.

In summary, redo surgery with light SO tamponade is an effective and safe procedure for management of persistent MHs. Light SO tamponade may be optimal for very large holes that are supposed to benefit from long-term tamponade, or for individuals who plan to travel, cannot maintain prone positioning, or are monocular. Considering the current scarcity of well-designed studies, multicenter, randomized clinical trials comparing different materials for intraocular tamponade in redo surgery for persistent MHs are warranted.

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Conflicts of Interest

There are no conflicts of interest.

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