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RETINAL DISORDERS

1000 cSt silicone oil vs heavy silicone oil as intraocular tamponade in retinal detachment associated to myopic macular hole

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Abstract
Background Several surgical techniques have been described for the treatment of retinal detachment (RD) associated to myopic macular hole (MMH). In this retrospective study, the anatomical and functional outcomes of pars plana vitrectomy (PPV) with long-term tamponade, using either 1000 cSt silicone oil (SO) or heavy silicone oil (HSO), are compared.
Methods Forty-two eyes affected by RD associated with MMH were included. The surgical technique involved standard 3-port 20-gauge PPV with long-term tamponade. The patients were divided into two groups, according to the intraocular tamponade: SO in group 1 (n=17), and HSO in group 2 (n=25). Internal limiting membrane (ILM) removal was performed in 15 cases of group 1 and 20 cases of group 2. Tamponade removal was performed 2 to 5 months after primary surgery. The patients were assessed 1 week and 1 month after primary surgery, and then 1 week and 1 month after tamponade removal or after further surgery if macular redetachment had occurred. The patients were also visited every 2 months for at least 1 year after final tamponade removal. Follow-up was considered closed at 1 year after final tamponade removal.
Results Preoperative best-corrected visual acuity (BCVA), expressed as LogMar, was 2.8±0.77 for group 1 and 2.1±0.94 for group 2. At the last visit, the BCVA was 1.41±0.96 and 1.48±0.77 for groups 1 and 2 respectively. Retinal reattachment was achieved with one operation in 13 eyes of group 1 (76.5%) and 18 of group 2 (81.8%) (P=0.69). The average number of surgery needed to achieve retinal attachment by patients of group 1 and 2 was respectively 1.36±0.63 and 1.46±0.59 (P=0.77). Five patients of group 1 and four of group 2 developed a chronic glaucoma (P=0.238).
Conclusions PPV with ILM peeling and long-term tamponade was demonstrated to be a good surgical option to treat RD due to MMH; SO and HSO seemed to be equally effective, although the success rates remained far from an ideal 100%.

Keywords Heavy silicone oil · Macular hole · Myopia · Retinal detachment · Silicone oil · Vitrectomy

Introduction

Retinal detachment (RD) secondary to myopic macular hole (MMH) with a posterior staphyloma still represents a surgical challenge. The pathophysiological mechanism is uncertain, but it is thought to involve several features of pathological myopia including antero-posterior and tangential traction, posterior staphyloma, and retinal pigment epithelium atrophy [1–3]. Several therapeutical strategies have been reported, including pars plana vitrectomy (PPV) with gas tamponade [4], additional laser photocoagulation of the hole margin [5, 6], episcleral buckling of the macular area [7], and infolding of the sclera [8]. Most of these procedures are time-consuming, have marked risks of intraoperative complications, or include destruction of

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perifoveal tissue. Moreover, redetachment may still develop, and often multiple surgeries are required to achieve reattachment [1, 4, 9]. Silicone oil tamponade was introduced in macular hole surgery as an option for patients unable to maintain postoperative positioning, as required for gas-filled eyes [10–12]; it has also been suggested in the treatment of persistent idiopathic macular hole [13–15]. The use of silicone oil in RD associated to MMH has been proposed as a primary approach, with promising anatomical and functional results [16]. Recently, some authors have demonstrated that heavy silicone oil (HSO) conforms better than silicone oil (SO) to the foveal depression, mainly in the upright position, suggesting a role as a vitreous substitute in this kind of surgery [17].

The aim of our study was to compare the anatomical and functional outcomes of vitrectomy, internal limiting membrane (ILM) peeling and SO versus HSO as tamponades in the surgical treatment of RD associated to myopic MH.

Materials and methods

This retrospective review includes 42 eyes from 41 patients (10 males. 31 females) with RD and MMH, who underwent vitreoretinal surgery in our institution between 2004 and 2009. The mean age of the patients was 63± 10.9 years.

Informed consent for the procedure was obtained from all patients.

Preoperative investigations included evaluation of best-corrected Snellen visual acuity (BCVA), intraocular pressure (IOP), slit-lamp examination and optical coherence tomography (Stratus OCT, Zeiss Meditec, Dublin, CA, USA and, since April 2008, Spectralis HRA + OCT, Heidelberg Engineering Inc., Germany). The degree of refractive error of the operated eyes, measured as spherical equivalent (SE) prior to any surgery, and collected from the history of the patients, ranged between −6 and −35 diopters. Data on axial length were not available for every eye. In fact, biometry measurements were not taken where the eye was already pseudophakic or when the shape of the retinal detachment prevented a reliable measurement. In four eyes of group 1 and in ten of group 2, the axial length (AL) was measured before the detachment, ranging between 28.13 and 34.66 mm (IOL-Master, Zeiss Meditec, Dublin, CA, USA).

The surgical technique involved a standard three-port 20-gauge PPV, removal of the posterior hyaloid verified with triamcinolone staining and, unless it became too difficult, peeling of the internal limiting membrane (ILM). ILM was stained with infracyanine green (ICG), trypan blue (Membrane Blue 0.15%, Dutch Ophthalmic, Exeter, NH, USA) or Brilliant Peel (Fluoron, GmbH, Germany) and peeled with ILM forceps. The choice of the staining product was based on availability of the staining at time of surgery. The vitreous base was dissected, and any visible epiretinal membrane (ERM) or remnants of the vitreous cortex were removed with intraocular forceps. The subretinal fluid was drained during the fluid–air exchange either through the macular hole, in case of macular detachment limited into the area of the staphyloma, or through a peripheral small retinotomy, in the case that the detachment was expanded beyond the staphyloma. Finally, an air–silicone oil exchange was performed.

No postoperative posturing advice was suggested to the patients. All surgeries were performed by two expert surgeons (GP, BP).

We divided the patients into two groups, according to the tamponade randomly choosen at the end of the primary surgery. Group 1 included 17 eyes. SO 1000 cSt (Sil-1000, Dorc — Dutch Ophthalmic Research Center, Zuidland, The Netherlands) was used in group 1. Group 2 consisted of 25 eyes. HSO (Densiron, Fluoron GmbH, Ulm, Germany) was used in group 2.

Silicone oil removal was performed 2 to 4 months after primary surgery if the retina appeared attached, or earlier if a macular retinal detachment occurred.

Follow-up

Every patient was assessed at 1 week and 1 month after primary surgery, and 1 week and 1 month after tamponade removal or after further surgery if macular redetachment occurred.

Furthermore, every patient was visited every 2 months for at least 1 year after final tamponade removal.

The follow-up was considered closed 1 year after the final tamponade removal.

During each follow-up visit, BCVA was measured and a complete ophthalmologic evalutation was performed. OCT scans were obtained at the end of follow-up.

The main outcomes included changes in BCVA, the number of surgeries needed to reach permanent macular reattachment after tamponade removal, and the appearance of the macular hole at the end of the follow-up.

The macular hole presented two possible outcomes: (1) flat and closed, when the margin was flat on the retinal pigment epithelium, and retinal tissue separation was not visible at OCT, or (2) flat and open, when the margin was flat on the retinal pigment epithelium, while retinal tissue separation was still possible (Fig. 1).

Surgeries were considered to have failed when macular detachment occurred. A localized detachment of the peripheral retina was not considered a failure of the surgery, but was recorded as well.

Both intraoperative and postoperative complications and need of further surgeries was also recorded.

Results

The mean age of the patients did not significantly differ between the two groups, being 60.4±10.1 and 64.6±11.3 years in groups 1 and 2 respectively (P=0.84, two-tailed paired t-test). Mean preoperative SE was −11.3±8.5 D in group 1 and −10.9±9.2 D in group 2, with no significant differences between the two groups (P=0.66, two-tailed paired t-test), as well as AL, when available (32.74±2.3 mm and 30.64±2.1 mm namely in group 1 and 2, P=0.75).

Preoperative BCVA, expressed as LogMar, was 2.8±0.77 for group 1 and 2.1±0.94 for group 2. At the last visit, the BCVA was 1.41±0.96 and 1.48±0.77 for groups 1 and 2 respectively, with no statistically significant differences between the two groups (P=0.74, two-tailed paired t-test).

The primary surgery led to macular reattachment in 13 eyes of group 1 (76.5%) and 18 of group 2 (81.8%). The difference was not statistically significant (P=0.69, Fisher's exact test).

Table 1 summarizes the surgical strategies required to reach permanent retinal attachment for every eye, as well as the status of the macular hole at the end of the follow-up.

During the primary surgery, ILM peeling was considered as not executed in two cases of group 1 and one of group 2, because too difficult or not certain.

In two eyes of group 1 and in four of group 2, retinal redetachment occurred after tamponade extraction (5.3±2.2 months in group 1 and 6.3±3.2 months in group 2), with no significant difference between the two groups (P=0.56, Fisher's exact test).

A second surgery was performed in six eyes in group 1 and eight eyes in group 2 (P=0.56, Fisher's exact test), while a third surgery was necessary in one eye in group 1 and one eye in group 2 (P=0.88, Fisher's exact test). Both types of tamponade were used for treating the primary surgery failures in order to test them also for redetachments.

Redetachments observed during the follow-up were associated with macular hole reopening.

At the end of the follow-up, retinal attachment with macular hole closure was achieved in 11 eyes of group 1 and 13 eyes of group 2 (P=0.36, Fisher's exact test); flat retina with macular hole opened was the anatomical outcome for five eyes of group 1 and ten of group 2 (P=0.23, Fisher's exact test). A localized peripheral detachment occurred in one eye of group 1, after a successful macular buckling. A persistent nasal retinal detachment, but with attached macula, occurred in one eye of group 2. Both patients refused further surgeries and tamponade removal, because of systemic health issues.

On the whole, the average number of surgeries needed by patients of groups 1 and 2 was respectively 1.36±0.63 and 1.46±0.59; the difference between the two groups was not statistically significant (P=0.77, two-tailed paired t-test).

Although AL data were not obtainable for every eye, they did not seem to correlate either with the number of surgeries, or with anatomical and functional results.

During the follow-up, some eyes developed ocular hypertension. In group 1, two cases were observed, and resolved within 2 months after surgery with topical beta-blocker treatment. Five patients developed chronic glaucoma (5/17=29%) that in one case was refractory to medical treatment and required a ciliary body cyclophotocoagulation. Only one eye in group 2 developed a transient IOP increase, while in four cases (4/22=18%) a topical eyedrop regimen was required to achieve a satisfactory IOP control. No statistically significant differences were found with regard to the risk of developing glaucoma between the two groups (P=0.238, Fisher's exact test). One eye of group 1 and one of group 2 developed cataract during the follow-up, and facoemulsification with IOL implantation in the capsular bag was performed without any complication. No statistically significant differences were observed in cataract incidence between the two groups (P=1.00, Fisher's exact test).

Discussion

According to our results, the use of either SO or HSO did not significantly modify the outcome of the surgery for RD associated to MMH. The percentages of reattachment after primary surgery did not significantly differ between the two groups, nor did the number of reoperations or the visual acuity at the end of the follow-up. Reattachment rate after primary surgery was 76.5% in group 1 and 81.8% in group 2. These percentages are similar to those reported by other authors, achieved with other surgical techniques.

In 1982, Bonnet proposed a lamellar scleral pocket and patch pocket on the posterior pole on 17 eyes, with a success rate of 17% [18]. Those first attempts with epicleral surgery were tested on a relatively small number of patients. Therefore, the rates of success are not reliable. Furthermore the technical difficulties of these surgical strategies made them poorly reproducible. Moreover, in the same years, endobulbar surgery was proving useful in difficult cases of RD associated with MMH: in 1986, Vallat presented a series of five patients, in which PPV, air–fluid exchange and prone postoperative positioning was adopted, with an initial 100% success rate and only a late recurrence of RD, not caused by MH [19]. With the advent of new instruments for endobulbar surgery, Oshima confirmed PPV and gas with the use of the Tano scraper for epiretinal membrane removal: in his series of six eyes, the author

Table 1 Number of surgeries and anatomical outcomes for patients of Group 1 (A) and 2 (B)

Patient (initials)	1st surgery		2nd surgery	3rd surgery	Anatomical outcomes (end of follow-up)
	(PPV + SO)	ILM peeling			
A					
1	Successful	+			1
2	Successful	-			1
3	Successful	+			1
4	Successful	+			1
5	Successful	+			1
6	Failed	+	PPV + HSO	Macular buckling	2
7	Successful	+			1
8	Successful	+	PPV + SO		1
9	Successful	+	PPV + HSO		2
10	Failed	+	PPV + SO		1
11	Successful	+			2
12	Successful	+			2
13	Successful	-			2
14	Failed	+	Macular buckling		2[a]
15	Failed	+	PPV + SO		1
16	Successful	+			1
17	Successful	+			1
B					
1	Successful	+	PPV + SO		2
2	Succesful	+	PPV + HSO		2
3	Failed	-	PPV + SO		1
4	Successful	+			1
5	Failed	+			2[a]
6	Successful	+			1
7	Successful	+			1
8	Successful	+			2
9	Failed	+	Macular buckling		2
10	Successful	+			1
11	Successful	+			1
12	Successful	+			2
13	Successful	+			1
14	Successful	+			1
15	Failed	+	PPV + HSO	PPV + SO	2
16	Successful	+			2
17	Successful	+			1
18	Failed	+	PPV + SO		2
19	Successful	+			1
20	Failed	+	PPV + SO		1
21	Successful	+			2
22	Successful	+			1
23	Successful	+			1
24	Failed	+	Macular buckling		2
25	Successful	+			1

PPV pars plana vitrectomy; *SO* standard silicone oil; *HSO* heavy silicone oil; *cS* centi-Stokes. Anatomical outcomes: 1: flat and closed macular hole; 2: flat and open macular hole; [a]: localized peripheral detachment with flat macula.

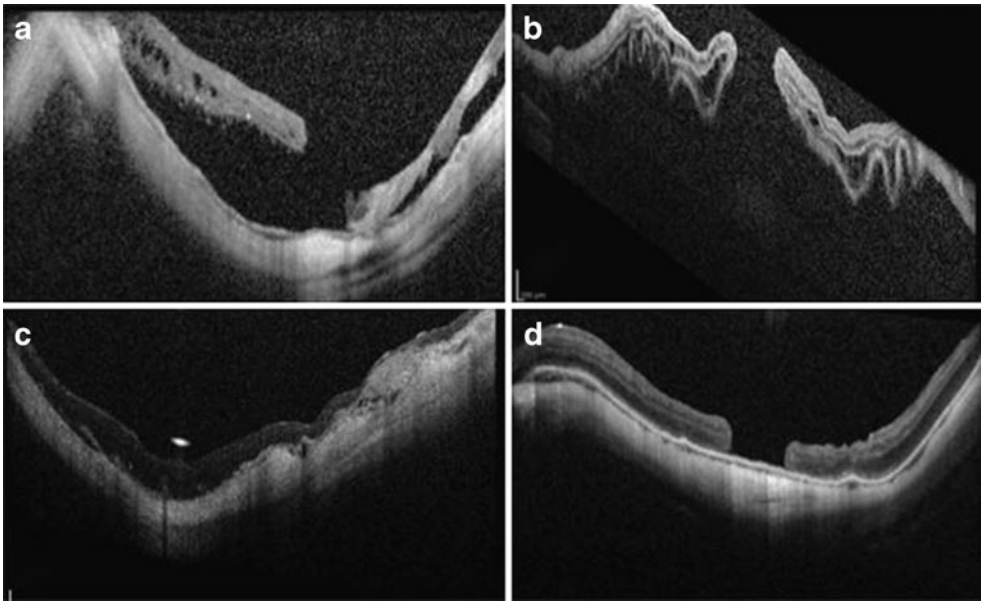

Fig. 1 **a**,**b** Preoperative spectral domain OCT of two patients affected by RD associated with MMH. **c**,**d** Postoperative images of the same patients, showing retinal reattachment with flat and closed MH (**c**) and flat and open MH (**d**)

achieved a 100% success rate at the first surgery, while in the remaining 11 subjects, in which epiretinal membrane removal had been less accurate, a 45.5% success rate was reported [2]. Wolfensberger et al. introduced the silicone tamponade plus laser around the hole, with a 92% attachment rate. Although only 11 patients had been included, that study had a long follow-up (69 ± 17 months). Their visual acuity, expressed in logMar, increased from 1.39 ± 0.12 before surgery to 1.18 ± 0.13 after surgery. The poor functional results (defined "acceptable" by the authors) were probably conditioned by the effect of the laser on the perifoveal retina [20]. Thereafter, Lu et al. compared PPV plus gas and laser, vs gas and no laser vs silicone and no laser, favoring the first with a success rate of 93% vs 58% and 57% respectively for the others, suggesting a key role for laser in the determination of the anatomical results [21]. However, Sholda et al. presented a series of 11 eyes in which no photocoagulation of perifoveal retina was executed, with a 100% reattachment rate and good functional results [16]. The introduction of silicone oil seemed to improve the average success rate of surgery, although remaining substantially far from ideal in larger series. The widespread adoption of ILM peeling into the surgical technique further improved the success rate of endobulbar surgery, as showed by Kadonoso et al. [22]. Ripandelli et al. reported that the retinal reattachment rates of PPV with gas tamponade or macular buckle were respectively 73% and 93% [5]. In another study, Chen reported reattachment rates around 50–60% after PPV and gas tamponade [23]. Sasoh et al. reported a 94% reattachment rate in 33 patients who underwent macular buckling for RD associated with posterior staphyloma [7]. Therefore, the anatomical outcomes of macular buckling appeared to be better. However, the absence of standardization and the technical difficulties of the surgery prevented the technique from becoming widespread.

Recently, Cheung et al. first reported on the use of HSO, with an 83% success rate, considered as hole closure and retinal reattachment. That study included 12 patients. After tamponade removal, two eyes experienced failure: one eye had retinal reattachment after reoperation, and the other patient refused further surgery [24]. Kokame and Yamamoto showed that in the upright position a silicone oil bubble does not conform well to the foveal depression, and that an interface anterior to the fovea can be observed by OCT [17]. Rizzo et al. presented promising results using HSO in the treatment of two eyes with persistent idiopathic macular hole after PPV and gas tamponade [25].

The available peer-reviewed studies offer a discordant success rate. It is difficult to determine the best surgical technique. Furthermore, the features of the highly myopic eyes that could interfere with the success rate are the morphology and the diameter of the staphyloma, chorioretinal atrophy at the posterior pole, and the quality of the retinal pigment epithelium [1, 2]: all these parameters are difficult to assess, although they could be crucially correlated with the surgical outcomes.

In the literature, no data about a comparison between either standard SO and gas, or standard SO and HSO were available.

Since the recurrence rate of retinal detachment is high with any tamponade, as reported in literature and as we observed in our clinical experience, we decided to use long-term tamponade in order to maintain attachment as long as

possible, at least in the macular area , to avoid need for frequent reoperation. In fact, a recurrence under gas requires quick reoperation, while a recurrence under silicone usually involves only part of the retina, allowing, if the macula is still attached, a longer interval between surgeries.

Our results support the conclusion that the use of either 1000 cSt SO or HSO did not significantly influence the anatomical and functional outcomes of the surgery for RD associated to MMH. Based on the reports available in the literature [26–29], the authors considered ILM peeling an extremely significant step in the surgical procedures, in order to relieve the tangential traction around the macular hole due to the rigid structure of the membrane.

With regard to complications, only temporary rises in IOP and, in some cases, chronic glaucoma had been observed, with no differences between the tamponades.

The major limits of our study are its retrospective nature , the small number of eyes in each group, and the lack of direct comparison with gas tamponade.

The results of our study showed that PPV with ILM peeling and long-term tamponade is a good surgical option for treating RD due to MMH. We conclude that SO and HSO are equally effective. Nevertheless, the success rates were far from an ideal 100%. More modifications seem necessary to improve the outcomes of surgery. Perhaps macular buckling in combination with vitrectomy could achieve better results. Further studies and a higher number of patients are needed to identify the most efficient and safest surgical technique.

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