Original Article

The Combined Use of Heavy and Light Silicone Oil in the Treatment of Complicated Retinal Detachment with 360º Retinal Breaks: Tamponade Effect or Filling Effect?

Stefano Zenoni, [1]MD, Natalia Comi, [1]MD, Piero Fontana, [1]MD, Mario R Romano, [2]MD PhD

Abstract

Introduction: This study aims to report the safety and efficacy of the combined use of 70% Densiron®-68 and 30% polydimethysiloxane as a temporary vitreous substitute after pars plana vitrectomy (PPV) in selected cases of retinal detachment with superior and inferior retinal breaks. Material and Methods: Fifty consecutive eyes of 50 patients affected by complicated retinal detachment with retinal breaks of the superior and inferior quadrants associated with proliferative vitreoretinopathy (PVR) of grade C2 or more, underwent a pars plana vitrectomy and a combination internal tamponade with 70% Densiron®-68 and 30% silicone oil. The main outcome measures were visual acuity, retinal attachment, intraocular pressure (IOP) and incidence of complications. Results: The mean best-corrected visual acuity rose from 1.4 logMAR to 0.7 logMAR (*P* <0.01). Initial retinal reattachment was achieved in 48 (96%) patients. In 15 patients (30%), IOP increased over 21 mmHg. The main complications were redetachment at the 3 month follow-up in 12/48 cases (25%) and cataract formation in 13/21 phakic eyes (62%). Conclusion: This combination tamponade comprised lighter and heavier oil compounds was well tolerated and effective. It may be a useful tool for the treatment of retinal detachment complicated with breaks and PVR involving the upper and lower quadrants.

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Key words: Double tamponade, Heavy silicone oil, Retinal detachment, Semifluorinated alkane, Shear stress

Introduction

Silicone oil (polydimethysiloxane; PDMS) is used as a postoperative vitreous substitute to provide a tamponade effect and at same time, to stabilise the retina and vitreous cavity, limiting the effects of proliferation.[1]

At present, no single tamponade agent, heavier or lighter than water, has the ability to treat superior and inferior retinal breaks simultaneously.[2] Silicone oil always leaves a free space in the superior or inferior retinal hemifields, depending on the density of the oil. Previous studies have reported satisfying anatomical and functional results using oils of different densities for complicated retinal detachment.[3]

It is still unclear how exactly an intraocular tamponade acts effectively. Recently, it has been proposed that in the presence of an intraocular tamponade, saccadic eye and head movements generate fluid shear forces on the retinal surfaces that overcome the adhesive forces between the retina and retinal pigment epithelium.[4]

The shear stress produced by fluid movement at the interface between water and tamponade may cause residual vitreous contraction or retinal redetachment from a previous retinal break treated with either cryotherapy or retinal photocoagulation.[4]

High anatomical success with oil tamponades has also been reported after the retinal detachment surgery, even without direct contact between the retina and the tamponade in the postoperative period.[5] Success was probably the result of alleviating the traction that had occurred during the previous surgery rather than a true postoperative tamponade effect.[4,5] A new oil mixture of different densities should potentially reduce compartmentilisation of proliferative serum components in the vitreous cavity, hence limiting the effects of proliferative phenomena and also minimising shear retinal stress.

The aim of this paper was to investigate the use and

[1]Ospedali Riuniti di Bergamo, Bergamo, Italy
[2]Istituto Clinico Humanitas, Rozzano, Milan, Italy
Address for Correspondence: Dr Mario R Romano, Istituto Clinico Humanitas Via Manzoni 56, 20089, Milano, Italy.
Email: romanomario@email.it

efficacy of double filling (DF) with Densiron®-68 (70%) and PDMS (30%) in cases of retinal detachment with superior and inferior retinal breaks. The 2 tamponades were not pre-mixed, since as a single bubble their density would be close to that of water, and thus they would have been ineffective.

Materials and Methods

Study Design

This study was a retrospective, non-comparative interventional study of 50 consecutive eyes of 50 patients affected by retinal detachment and treated with pars plana vitrectomy (PPV) and DF tamponade, recruited from July 2005 to January 2009.

Patients

The patients (28 males and 22 females with a mean age of [67 ± 12] years, range, 47 to 80 years) included in this study presented complete macula-off retinal detachment with inferior and superior retinal breaks. All cases were complicated by proliferative vitreoretinopathy (PVR), which was graded according to the updated classification system of Machemer et al.[6] Twenty-five patients had a PVR grade of C2, 19 patients had a grade of C3, 4 patients of grade C4 and 2 patients of grade D. At the time of enrolment, 28 eyes were phakic, 20 eyes are pseudophakic and 2 eyes were aphakic. The exclusion criteria were severe systemic disease, pregnancy, and any uncontrolled ocular disease other than retinal detachment (Table 1).

Table 1. Characteristics of Study Patients

No. of Patients	50
Age	67 ± 12
Sex (Male / Female)	28 / 22
Phakic / Pseudophakic / Aphakic	28 / 20 / 2
PVR	
A	0
B	0
C 1	0
C 2	25 (50%)
C 3	13 (26%)
C 4	4 (8%)
D	2 (4%)
Retinectomy	10 (20%)

PVR: Proliferative Vitreoretinopathy

Examination

The baseline and postoperative examinations included refracted best-corrected visual acuity (BCVA) using the Early Treatment Diabetic Retinopathy Study (ETDRS) chart, slit lamp biomicroscopy, tonometry for recording of intraocular pressure (IOP) and indirect ophthalmoscopy. The patients with 1 week, 1, 3 and 6 months follow-up after Double Filling (DF) removal were included.

Surgical Procedures

In 7 of 28 phakic eyes (25%), the lens had to be removed during surgery due to the presence of cataract. Combined phacoemulsification was performed through a clear cornea tunnel and was followed by implantation of an intraocular lens.

In all cases, a standard 3-port 20 gauge PPV with a 20-gauge system was carried out using the ACCURUS® vitrectomy machine (Alcon Laboratories, Inc.).

The surgeon aimed in all cases to achieve posterior vitreous detachment, by thoroughly trimming the vitreous base and peeling away the epiretinal traction. In 10 eyes, a peripheral retinectomy was performed to mobilise the retina and relieve retinal traction. Perfluorodecalin (PFD, HPF10-Graf tec-AL.CHI.MI.A. Srl) was injected over the posterior pole to obtain the retinal flattening and stabilisation necessary for the surgical maneuver.

In all cases, 360º endolaser photocoagulation was performed, including all retinal breaks and the edge of the retinectomy, with a 20-gauge illuminated probe. Fluid–air exchange was then performed with humidified air and a mixed tamponade comprised 70% Densiron®-68 (Fluoron GmbH, Neu-Ulm, Germany) followed by 30% PDMS (OIL 1000 centistokes-Graf tec-AL.CHI.MI.A. S.r.l.) was injected. The surgeon always aimed to achieve a complete fill of the vitreous cavity.

DF was removed after an average period of (55 ± 9) days and exchanged with balanced saline solution (BSS) through the pars plana.

Outcome Measures

The primary endpoint was anatomical reattachment of the retina in the absence of any tamponade agent. Our secondary endpoints were assessment of functional outcome and the incidence of complications arisen from the use of the DF tamponade.

Given the small sample size and assuming that the population was normally distributed, we analysed the data using the student's t-test.

Table 2. Anatomical and Functional Outcomes Through the Follow-up

Variable	Baseline	1 Week DF-in	1 Month DF-in	1 Week DF-out	1Month DF-out	3 Month DF-out	6 Month DF-out
Retina attached		50 (100%)	50 (100%)	48 (96%)	48 (96%)	38 (76%)	38 (76%)
BCVA logMar	1.4 ± 0.7	1.2 ± 0.23	1.2 ± 0.3	1.1 ± 0.5	0.8 ± 0.4	0.7 ± 0.9	0.70 ± 0.7
IOP > 21 mmHg	1 (2%)	12 (24%)	10 (20%)	4 (8%)	7 (14%)	12 (24%)	15 (30%)

DF: Double filling, Densiron-68 + 1000 cSt silicone oil; BCVA: Best-corrected visual acuity; IOP: Intraocular pressure

Table 3. Complications Occurred During the Follow-up

Complications	Frequency	Percentage
Retinal break reopened	0	0
Recurrent retinal detachment (out of 48 eyes of primary re-attachment)	12	25
Oil in AC	1	2
Emulsification in AC	0	0
Inflammation 30 days DF-in	0	0
Cataract formation (21 phakic eyes)	13	62
Sticky oil formation	0	0
Posterior synaechie	1	2
Elevated edge of retinectomy	0	0

AC: Anterior chamber

Results

Anatomical Results

No signs of clinically significant emulsification or inflammation were recorded in the presence of the DF tamponade. At the time of its removal, 48 of 50 eyes (96%) had retinal reattachment with a clearly visible laser photocoagulation pigmented scar. The 2 cases of retina redetachment were due to new retinal breaks in the superior retina. Those cases were than treated with a standard tamponade of 1000 cSt silicone oil. Three months after tamponade removal, 12 of 48 (25%) eyes developed recurrent retinal detachment (4 in the superior retina and 8 in the inferior retina) due to secondary epiretinal traction. These patients were also then treated with a conventional endotamponade of silicone oil.

Functional Results

At the baseline examination, the mean BCVA was 1.40 ± 0.4 logMar. This rose significantly to 0.70 ± 0.7 logMAR at the last follow-up visit (P <0.01, 2-tailed student's t-test) (Table 2).

Complications

Thirteen of 21 phakic eyes (62%) developed subcapsular cataracts during the follow-up period. At the last follow-up visit, the IOP was higher than 21 mmHg in 15 of 50 patients (30%), all of whom were successfully managed with pharmacological therapy. Dispersion or emulsification of the DF tamponade into small bubbles was not observed (Table 3).

Discussion

The theoretical benefit of an intraocular tamponade is the instantaneous interruption of an open communication between the subretinal and the pre-retinal space: the well-known "tamponade effect" produced by silicone oil.[7] Nevertheless, the hydrophobic nature and low buoyancy (density 0.97 g/cm^3) of silicone oil make it an inefficient tamponade. The arc of contact between the retina and silicone oil is virtually absent until the vitreous cavity is about half filled.[8] Assuming that the vitreous cavity volume is filled by 90%, the arc of contact would be less than 180º.[8] However, the use of silicone oil is widespread, especially for giant retinal tears and retinal detachment complicated by PVR. It does appear to be effective in reducing proliferation and inflammatory cell infiltration in the vitreous cavity. However, the regions most frequently affected by proliferation in PVR are those not in contact with silicone oil. Over time, this high-density oil causes redetachment due to the accumulation of growth factors on the opposite side of the tamponade since the oil floats or sinks, displacing pre-retinal and subretinal fluid from the upper or lower part of the fundus.[7]

The aim of our combination treatment was to obtain a simultaneous tamponade effect on the superior and inferior retina for the first few days using "light" and "heavy" silicone oil. In the first weeks, the 2 oils are not yet completely mixed, and thus produce a tamponade effect on both sides. Both silicone oils, Densiron-68 and PDMS, are hydrophobic and even though initially the 2 compounds did not mix, we believe that they were in contact, excluding water from the interfaces and producing an oval-shaped silicone oil bubble that becomes more rounded as the 2 compounds were completely mixed. For this reason, the density of the single compounds changes, reaching a density close to 1 after the first few weeks. We also believed that the contact arc of the DF tamponade is less in the superior and inferior retina than the singly used PDMS and Densirom-68, respectively.

We performed a laboratory test to characterise the

properties of the mixture and the interface between the 2 endotamponades. For better visualisation, a coloured PDMS was used and a clearly delineated interface between the 2 oils was visible at day 6. After the first week, the silicone oil phase nearly completely diffused into the Densiron-68 phase. The new mixed bubble endotamponade had new physical properties: a density of 1028 g/cm^3, viscosity of 1253 mPas and a surface tension of 19.84 mN/m. After a second week, the bubble had a density similar to water, not floating or sinking, in the vitreous cavity. At this time, the compound acted more as a "filling effect" than a "tamponade effect".

The advantage of using a DF tamponade lies in having a vitreous substitute that limits the spreading of the "PVR soup" into the vitreous cavity. Moreover, as compartmentalisation is an important cause of PVR, in the presence of a compound with a density of 1028 g/cm^3, growth factors are not concentrated only on one side of the vitreous.

We also speculate that the "filling effect" induced by the presence of a viscous compound could reduce the shear stress on the retina, minimising the risk of elevating the retinal tear and allowing the running of fluid beneath the retina with normal saccadic eye movements.[4] Several reports have demonstrated that silicone oil should be preferred to a gas tamponade for the treatment of myopic macular hole with posterior staphyloma.[9,10] The good outcome observed in these studies was probably due to a filling effect, with shear retinal stress reduction, rather than a tamponade effect, in which case, a gas tamponade would have been better.

In a retrospective case series of 41 retinal detachments complicated with inferior PVR, Ozdek et al[11] showed that a heavy tamponade agent had a high success rate (87%), but was associated with corneal edema (7.3%), band keratopathy (7.3%) and intraretinal and subretinal fibrosis (29.2%).

Recently, a multicentered, randomised, retrospective clinical trial reported that there was no significant difference between tamponades (light vs heavy) with regard to anatomical success for the treatment of proliferative vitreoretinopathy of the lower retina.[3]

The greatest challenge for the vitreoretinal surgeon is the treatment of retinal detachment complicated by PVR with multiple breaks in the superior and inferior retina. Wong et al[12] proposed the sequential use of conventional silicone oil and heavy oil as a strategy for the management of PVR. However, this approach requires a second surgical treatment in order to exchange the light silicone oil for heavy oil. Kolomeyer et al[13] reported a retrospective case series of 41 eyes treated with 360-degree retinectomy for complex retinal detachment. The primary success rate of these series was 63% at 6 postoperative months followed by severe complications as corneal decompensation in 7 eyes (17%), hyphema in 6 eyes (15%), phthisis in 6 eyes (15%).[13] In this study, enucleation of 3 eyes was performed for management of a blind painful eye or for cosmesis with a blind eye.[13]

In the present series, the success rate at the last follow-up visit was 76% (38 cases) and retinectomies were performed in only 10 cases. The primary complication of this DF with Densiron-PDMS was the high rate of early subcapsular posterior cataract formation, probably due to the endotamponade. However, functional and anatomical outcomes were quite encouraging, showing a lack of retinal toxicity and major complications. In conclusion, a DF tamponade with Densiron-68 (70%) and PDMS (30%) behaves as a new entity, evolving during the postoperative time and providing both a filling and tamponade effect. This combination may be a useful tool in complicated retinal detachment with superior and inferior retinal breaks.

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