The Use of Continuous Silicone Oil Infusion as a Peroperative Tool to Facilitate Break Localisation, Vitreous Base Dissection and Drainage of Subretinal Fluid

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Key Words

Silicone oil infusion • Retinal break • Vitreous base shaving • Subretinal fluid drainage

Abstract

Introduction: We introduce the use of low-molecular-weight silicone oil as an infusion and as a peroperative tool to facilitate three specific surgical steps, namely internal search for retinal breaks, vitreous base shaving and drainage of subretinal fluid. **Method and Patients:** Ethics committee approval was obtained to test this novel agent in a small number of cases as a pilot study. Following vitrectomy the posterior retina was reattached and stabilised using perfluorocarbon liquid (PFCL). The infusion of balanced salt solution was then stopped and replaced with 5 mPas silicone oil. Subsequent surgery was assessed as to whether the infusion was helpful in the three surgical steps. Five cases were selected for this pilot study. Three presented with long-standing rhegmatogenous retinal detachment (RRD) of 2 or more months: 1 had dense vitreous haemorrhage and no fundal view at presentation; 2 had proliferative vitreoretinopathy. Of the remaining 2 cases, 1 had a giant retinal break and the other case had a combined diabetic tractional retinal detachment and RRD. **Results:** Additional retinal breaks were

found in 2 patients. The silicone oil joined with the PFCL to form a single bubble. The vitreous base along with the operculum of any retinal break was reflected anteriorly. The infusion of oil stabilised the anterior retina, making it possible to shave the vitreous closely in all 5 patients. Visualisation of the vitreous gel was also improved. There was a clear interface between vitreous and oil because of the large difference between the refractive indices of vitreous and oil. Four of the 5 patients had a total reattachment with one procedure. In the 2 cases in which 5,000 mPas silicone oil was used for long-term postoperative tamponade, no emulsification was observed. Follow-up of patients ranged from 6 to 13 months. There were no additional serious adverse reactions recorded. **Conclusion:** We found that the experience of using silicone oil was very highly positive.

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Introduction

Successful repair of rhegmatogenous retinal detachment (RRD) crucially depends on the identification and closure of all causative retinal breaks. It has been shown that with meticulous internal search and peroperative sealing of retinal breaks, a high rate of success could be

achieved with vitrectomy surgery even without using postoperative tamponade [1]. Equally, a common cause of failure to repair retinal detachment is proliferative vitreoretinopathy (PVR) [2, 3]. Long-term tamponade is required and silicone oil is the choice for many. In the past, we and others have argued that effective tamponade with silicone oil depends on achieving a near total fill [4, 5]. This in turn relies on complete drainage of subretinal fluid (SRF) and close shaving of the vitreous base. An intraoperative tool that could facilitate these three important procedures – namely exhaustive internal search for retinal breaks, close vitreous base shaving and complete drainage of SRF – would be highly relevant.

Silicone oil is a polymer of dimethylsiloxane. The higher the molecular weight, the greater the shear viscosity of the liquid. Conversely, when the molecular weight is sufficiently low, it is possible to produce a fluid that is water-like. We have chosen to use a silicone with a shear viscosity of 5 mPas. This was designed as a peroperative tool to be used as an infusion in place of balanced salt solution. The oil was supplied in bottles of 500 ml in volume (Fluoron GmbH, Ulm, Germany). Chemically, it is the same as conventional silicone oil 1,000 mPas or 5,000 mPas. The novelty is its low viscosity and the way it is used. The other physical properties remain unchanged: the specific gravity is 0.97 g/ml and the refractive index is 1.40.

Patients and Method

We obtained ethical approval to test silicone oil infusion on a small number of patients. In obtaining consent, the patient understood that the use of silicone infusion as an operative adjunct was novel, that we would only decide peroperatively to proceed to use the infusion if we were convinced it could be useful, that extra tests and clinic visits might be necessary and that we would be monitoring all serious adverse effects. The eligibility criteria were deliberately inclusive for this pilot study. All patients with RRD were considered eligible, provided they were able to give informed consent. We excluded patients with breaks in fixed retinæ because there was a chance of subretinal migration of silicone.

A single surgeon (D.W.) performed all the surgeries. Posterior vitrectomy was carried out and triamcinolone was used to identify and remove any residual vitreous cortex. The posterior retina was then stabilised with the use of perfluorocarbon liquid (PFCL). Vitreous base shaving was performed. The infusion of balanced salt solution was stopped and the infusion of low-molecular-weight silicone oil commenced. Vitreous base shaving, internal search and drainage of SRF through existing peripheral retinal breaks were carried out. Endolaser was used for retinopexy, after which the PFCL was evacuated by passive suction. An air/silicone oil exchange was then carried out. Care was taken to remove the last drop of the low-molecular-weight silicone oil. Finally, either

C₃F₈ gas or conventional 5,000 mPas silicone oil was injected into the air-filled eye as a postoperative endotamponade. The surgeon rated the usefulness of the silicone oil infusion in each of the three surgical steps.

Results

Seven patients were included and consented to the study. At the time of surgery, we did not proceed in 2 cases because we were highly confident that we had found all retinal breaks, that there was no significant PVR and that all surgical steps could be easily achieved without the use of silicone oil infusion.

We used the silicone oil infusion in 5 patients. Three presented with long-standing retinal detachments. One of the 3 had a dense vitreous haemorrhage with no fundal view, another case had posterior PVR, and the last case had both anterior and posterior PVR combined with limited posterior vitreous detachment. Of the remaining 2 cases, 1 had a combined diabetic tractional retinal detachment and RRD, and the other had a giant retinal break. The surgery and clinical details as well as the PVR grades are summarised in table 1. The usefulness of the infusion as rated by the surgeon is summarised in table 2.

Shaving of Vitreous Base

Silicone and PFCL are both hydrophobic. Once in contact with one another, the two liquids joined to form a single bubble. This combined bubble was a heavier-than-water bubble (as expected). Any aqueous or residual vitreous gel was displaced both anteriorly and laterally.

In all instances, vitreous base shaving was carried out using just PFCL, before the silicone oil infusion. After the infusion, in all 5 cases, it was possible to shave the vitreous closer. In all cases, the anterior retina was stabilised, even though there might still have been residual SRF underneath the retina. The vitreous cutter could therefore work much closer to the retina without fear of aspirating the retina or causing iatrogenic holes. In all cases, the gel was highlighted. The refractive index of the silicone oil infusion was 1.40. The refractive index of the vitreous gel was around 1.34. The difference was such that the vitreous gel could clearly be seen. The end point for vitreous shaving was therefore definite. We continued until only the thinnest layer of gel remained. In the one patient with combined diabetic tractional retinal detachment and RRD, it was also possible to cut away all the blood in the vitreous base and to remove the anterior hyaloid. The surgeon rated the silicone oil as being helpful in all 5 cases.

Table 1. Clinical information on the 5 cases

Case No.:	1	2	3	4	5
Age, years	52	40	76	64	57
Gender	Female	Female	Female	Female	Male
Duration of symptoms	Blurred vision and reduced nasal field for 1 month	Blurred vision for 2 months, worse in last 2 days	Poor vision for a few months	Inferior field loss and floaters for 6 weeks	Poor vision for several months
Other medical information	Nil relevant	Diabetic with preproliferative diabetic retinopathy in fellow eye	Wheelchair bound, diabetic and stroke in the past; on aspirin	Nil relevant	Nil relevant
Nature of RD	Subtotal RD with horseshoe tear and lattice	Subtotal RD involving macula	No fundal view from dense vitreous haemorrhage; B-mode ultrasound showed dense vitreous haemorrhage, total RD	Macula-off; giant superior break	Total RD
Preoperative VA	20/60	20/400	HM	20/60	CF
Additional finding at operation	Nil	Chronic RD with reduced mobility; PVR CP12 CA4	Vitreous haemorrhage; total RD; superior break	Nil	PVR CA12 CP12; 5 retinal breaks
Surgery	Vitrectomy; endolaser; 12% C ₃ F ₈	Phacovitrectomy; endolaser; silicone oil injection	Phacovitrectomy; endolaser; 12% C ₃ F ₈	Phacovitrectomy; endolaser; 12% C ₃ F ₈	Phacovitrectomy; endolaser; silicone oil injection
Anatomical result	Attached	Attached	Attached	Attached	Redetached
Further operation	Nil	Oil removal	Nil	Nil	Vitrectomy; retinectomy; retina reattached
Postoperative VA	20/30	20/100	CF	20/40	CF
Complication	Nil	Raised IOP as a steroid response, controlled after stopping steroid	Postoperative vitreous haemorrhage	Nil	Nil
Duration of follow-up, months	13	12	10	7	6
RD = Retinal detachment; VA = visual acuity; HM = hand motion; CF = counting fingers; IOP = intraocular pressure. CP/CA: PVR grades.					

Table 2. Surgeon's rating on the usefulness of silicone oil infusion

Case No.:	1	2	3	4	5
Shaving of vitreous base	Helpful	Helpful	Helpful	Helpful	Helpful
Internal search	Not helpful	Not helpful	Not helpful	Helpful because additional breaks found	Helpful because additional breaks found
Drainage of SRF	Not helpful	Not helpful	Not helpful	Helpful: SRF drained completely	Not helpful

Internal Search for Retinal Breaks

This was rated as helpful in 2 of the 5 cases because additional retinal breaks were found. Silicone oil infusion and PFCL together formed a combined bubble that was heavier than water. The vitreous and the operculum of U tears were reflected anteriorly (fig. 1). The posterior border of the vitreous base was clearly seen inside the silicone oil infusion. This was because of the high refractive index of oil (1.40 as opposed to 1.29 for *n*-octane and 1.31 for perfluorodecalin). The internal search was therefore greatly facilitated. Even where no retinal breaks were found, the clear delineation of the posterior border of the vitreous base (fig. 1) helped us to place the encircling endolaser more accurately in the 2 cases with PVR.

Drainage of SRF

In all cases, PFCL was used. Any SRF was displaced anteriorly. When we infused the silicone oil, the peripheral retina appeared to be flattened. We performed drainage through peripheral retinal breaks to evacuate any remaining SRF. In 2 patients, the SRF drainage was seemingly complete. Only when PFCL was removed did it then become obvious that there still was residual SRF. The SRF was displaced backwards towards the posterior pole by the incoming silicone oil bubble. In this respect, the silicone oil infusion was not that different from air infusion. Complete drainage of SRF therefore remained difficult. It was achieved only in 1 case: that of the giant retinal tear. In 4 of the 5 cases, the silicone oil was not particularly helpful. However, it was noted that visualisation through the oil was excellent. There was no problem with condensation, which could hamper the view in pseudophakic eyes. There also was no feathery lens opacity observed in the phakic patient. In this regard, silicone oil performed better than air.

Adverse Effect

In the 2 patients in whom long-term postoperative silicone oil tamponade was used, no emulsification was ob-

Fig. 1. Peroperative photograph showing silicone oil infusion in situ. The posterior border is seen as a sharp line (small arrow). The operculum of a small retinal break is reflected anteriorly (large arrow).

served. There was 1 patient with raised intraocular pressure. That was attributable to steroid response. The intraocular pressure subsided when the topical steroid was stopped. One patient with PVR needed one further surgery. One patient on aspirin who presented with preoperative haemorrhage experienced a postoperative haemorrhage.

It was noted that at 5 mPas, the silicone oil was still several time more viscous than water, which at body temperature had a viscosity of around 0.8 mPas. This was reflected in the flow rate. On occasions when oil was infused at the same time as vitreous fluid was aspirated, the intraocular pressure could drop because the inflow was not keeping up with the outflow. Once this was appreciated, this complication could be avoided.

Discussion

In the UK, John Scott pioneered vitrectomy and silicone oil injection for complex retinal detachment [6]. His early surgeries did not involve using any saline infusion. The silicone oil was injected incrementally whilst he removed the vitreous gel from around the oil bubble and drained SRF to create space. It was impressive how thorough the vitrectomy was using silicone oil. The majority of this kind of surgery was carried out using indirect ophthalmoscopy. We were also impressed how well the vitreous gel could be visualised because of the difference between the refractive indices of vitreous and oil. As there was no saline infusion, intraocular pressure maintenance was challenging. This was achieved using digital pressure on the eye during vitrectomy and in between injections of the oil.

We had the idea of using low-molecular-weight silicone oil. At 5 mPas, the oil could be infused and intraocular pressure could be maintained. The main motivation for introducing this as an adjunct to vitrectomy was to see if we could perform the three important surgical steps better, namely thorough shaving of the vitreous base, exhaustive identification of all retinal breaks and complete drainage of SRF.

The slightly higher refractive index meant that there was a very clear interface between the vitreous gel and oil. The incoming oil infusion joined with the PFCL to form a single bubble such that any aqueous would be displaced laterally and also anteriorly. The anterior displacement of the gel was anticipated because the combined bubble would have a specific gravity higher than water. The use of oil infusion had the excellent effect of lifting the gel base, which greatly assisted the internal search for retinal

breaks. We were impressed that any operculum was always reflected anteriorly (fig. 1).

We were very conscious that leaving low-molecular-silicone oil might admix with conventional silicone oil. Such a low-molecular-weight component could promote emulsification [7]. It was necessary in all instances to go through an air/silicone infusion exchange to make sure that the very last droplet of oil was removed. Infusing silicone oil under the retina was also a concern. We were careful not to select cases with retinal breaks in fixed retinal. Before infusion of oil was used, sufficient peeling had to be done to ensure that the retina was reasonably mobile.

Overall, we were greatly encouraged by the performance of the infusion. We concluded that silicone infusion was very helpful for break detection and vitreous base shaving. The indication for its use could therefore include cases where no peripheral retinal breaks were identified during the internal search. In cases of PVR where vitreous base dissection was indicated, the infusion offered the distinct advantage of keeping the retina stable and offering excellent visualisation. Kirchhof had used the infusion for managing severe trauma and haemophthalmos. The silicone oil infusion maintained a clear medium. A video recording of this can be seen online [8].

Disclosure Statement

Prof. D.W. has filed a preliminary patent for the use of low-molecular-weight silicone oil infusion as an intraoperative tool and surgical adjunct.

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