ORIGINAL ARTICLES

Fluorosilicone oil in the treatment of retinal detachment

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Abstract

We evaluated the use of a heavier-than-water fluorinated silicone oil in the treatment of 30 selected cases of complicated retinal detachment from January 1988 to July 1989. Proliferative vitreoretinopathy grade C-2 or greater accounted for 19 cases, proliferative diabetic retinopathy with traction detachment for two cases, giant retinal tears five, ruptured globe with retinal detachment two, massive choroidal effusion with retinal detachment one, and acute retinal necrosis with retinal detachment one. Initial retinal reattachment was achieved in all cases. Complications included redetachment seven (23%), cataract six (75% of phakic patients), raised intraocular pressure four (13%), hypotony four (13%), keratopathy three (10%), uveitis-synechia formation three (10%), phthisis two (3%), choroidal haemorrhage one (3%), and vitreous haemorrhage one (3%). Postoperative visual acuities with at least six months' follow-up range from no light perception to 20/50, with seven patients (23%) 20/400 or better.

Since its introduction by Cibis *et al* in 1962[1] silicone oil has proved useful in the repair of complicated retinal detachment. It is relatively transparent and provides retinal tamponade for longer periods than intraocular gases. Conventional silicone, with a specific gravity of 0·9 g, floats on the surface of intraocular fluids, producing its most effective retinal support in the superior quadrants.[2] We evaluated a fluorinated, heavier-than-water (specific gravity of 1·35 g) silicone oil[3] in 30 patients with retinal detachment. This property could eliminate the need for posterior retinotomy by allowing subretinal fluid to be drained through peripheral retinal breaks and could simplify repair of giant retinal tears.[4-7] We also evaluated its usefulness in retinal support in the inferior quadrants, an area of the retina exposed to intraocular fluid following gas or conventional silicone placement and the commonest site for the development of proliferative vitreoretinopathy (PVR).

Materials and methods

From January 1988 to July 1989 we used high specific gravity fluorosilicone oil (FSO) in the repair of complicated retinal detachment in 30 selected cases (Tables 1 and 2). Ages ranged from 11–79 years with 20 males and 10 females. Rhegmatogenous retinal detachment with significant PVR accounted for 19 cases, proliferative diabetic retinopathy with traction detachment for two, giant retinal tears five, ruptured globe with retinal detachment two, massive choroidal

Table 1 Fluorosilicone cases

Case	Age/ sex	Nature of RD	Preop visual acuity	Time to FSO removal (weeks)	Follow-up (months)	Postop visual acuity
1	11 M	PVR-D_2 aphakic	HM	8	12	HM
2	47 M	PVR-D_1	HM	8	12	HM
3	33 M	Giant tear	HM	IO	12	HM
4	36 M	PVR-D_1, ectopia lentis	CF	6	11	20/400
5	51 M	PDR	CF	7	7	HM
6	52 M	PVR-D_1	HM	6	10	CF
7	35 M	PVR-D_1, aphakic	CF	8	7	CF
8	26 F	Giant tear	CF	IO	7	20/200
9	21 M	PVR-D_2	HM	8	5	LP
10	55 F	PVR-D_2, aphakic	HM	8	4	CF
11	43 M	PDR	CF	8	3	LP
12	59 F	PVR-D_1	HM	8	4	HM
13	26 F	Blunt trauma, ruptured globe, VH, RD	LP	3	3	HM
14	14 F	PVR-D_2	HM	3	3	HM
15	73 M	PVR-D_3	LP	6	10	HM
16	64 M	PVR-C_3	HM	4	9	CF
17	79 M	PVR-D_2	HM	5	6	LP
18	27 M	PVR-D_2	HM	3	6	CF
19	49 M	Ruptured globe, choroidals, VH, RD	LP	3	6	NLP
20	36 M	PVR-C_1	20/200	4	10	HM
21	49 M	PVR-D_2	HM	5	8	HM
22	53 M	PVR-D_1	CF	6	6	LP
23	39 M*	Giant tear	CF	7	7	CF
24	31 F*	Giant tear, macular hole	20/200	4	11	20/100
25	16 F	Dialysis PVR-B_1	20/400	2	6	20/100
26	30 M	PVR-C_1	CF	6	9	20/70
27	53 M	PVR-C_3	HM	4	10	HM
28	11 F	Giant tear	LP	3	10	CF
29	72 F	Massive choroidal effusion	HM	3	6	20/50
30	26 F	Acute retinal necrosis	CF	3	6	20/200

*1000 cSt (=mm²/s) fluorosilicone.
CF=counting fingers. VH=vitreous haemorrhage. HM=hand motion. RD=retinal detachment.
LP=light perception. IO=intraoperatively. PVR=proliferative vitreoretinopathy.
PDR=proliferative diabetic retinopathy.

Table 2 Preoperative profile, fluorosilicone cases

Rhegmatogenous		19
PVR C_1	3	
C_2	1	
C_3	2	
D_1	6	
D_2	6	
D_3	1	
Proliferative diabetic retinopathy		2
Giant tear		5
Ruptured globe with retinal detachment		2
Massive choroidal effusion		1
Acute retinal necrosis with retinal detachment		1
Total		30

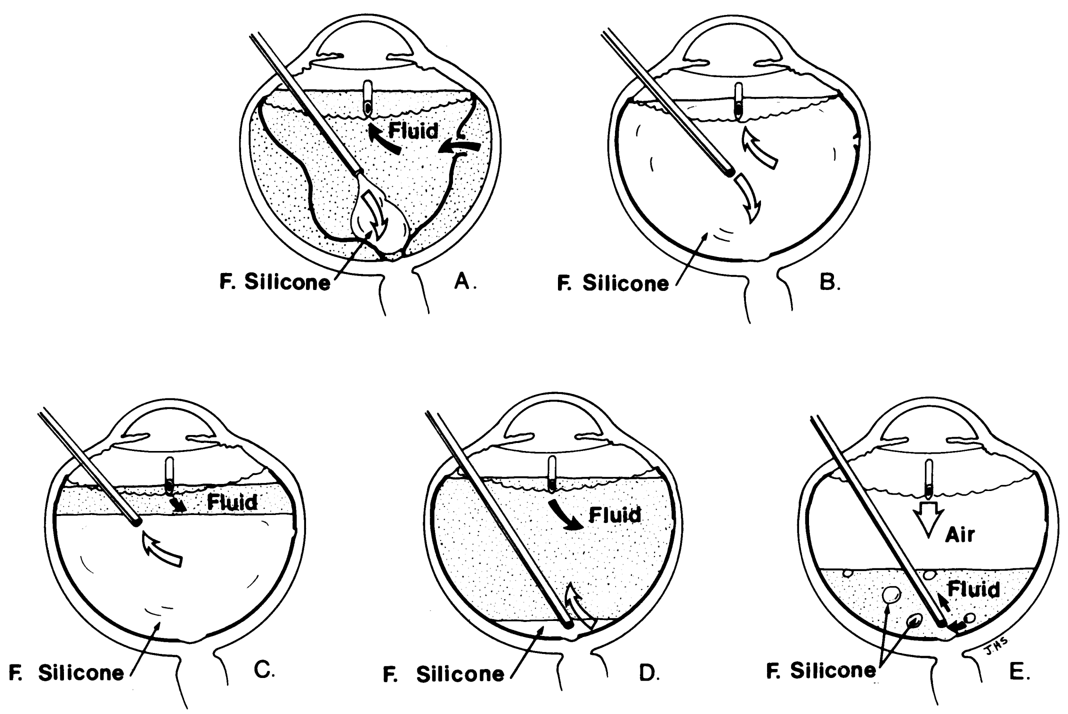

Figure 1 Fluorosilicone oil injection. (A) The oil is injected near the optic disc. Consequently, subretinal fluid is drained through the peripheral retinal break. (B) As more oil is injected, the retina is completely flattened and all subretinal fluid is drained. Fluorosilicone oil removal: (C and D) The extrusion needle is kept below the ingoing fluid level. (E) Repeated air/fluid exchange is performed to obtain complete fluorosilicone oil removal.

effusion ('kissing choroidals') with retinal detachment one, and acute retinal necrosis with retinal detachment 1. The decision to use FSO was based on the size and location of retinal break (peripheral to the equator), degree of PVR (15 cases C_2 or worse),[8] or the need for posterior/inferior tamponade. Nineteen patients had had previous surgical attempts at repair of retinal detachment (Table 2).

PROCEDURE

Rectus muscles were isolated and tagged in standard fashion and an infusion cannula was placed through a sclerotomy 4·0 mm from the limbus (phakic) or 3·5 mm (aphakic). Pars plana vitrectomies or revision of prior vitrectomies were performed on all patients through sclerotomies in the superonasal and superotemporal quadrants. Epiretinal membrane dissection and relaxing retinotomies were performed when necessary. After mobilisation of the retina was complete, FSO was injected through a 20-gauge cannula via a 12 ml syringe (Fig 1A, B). The cannula tip was held posteriorly over the optic nerve and the FSO (3·5 to 4·0 ml) slowly injected, forcing the subretinal fluid peripherally and eventually out the peripheral breaks. Endophotocoagulation and peripheral retinal cryopexy were applied where indicated. Scleral buckling or revision of existing buckles was performed in 29 of 30 cases (all except case 29). Fluorosilicone oil was aspirated or injected via the infusion cannula to establish intraocular pressure between 15 and 20 mmHg. Copious irrigation of the surgical field was performed to remove FSO from the ocular surface, and the conjunctiva was closed in standard fashion. In two cases 1000 cSt (1000 mm^2/s) FSO was used, and 300 cSt (300 mm^2/s) FSO was used in the remaining 28 (Table 1).

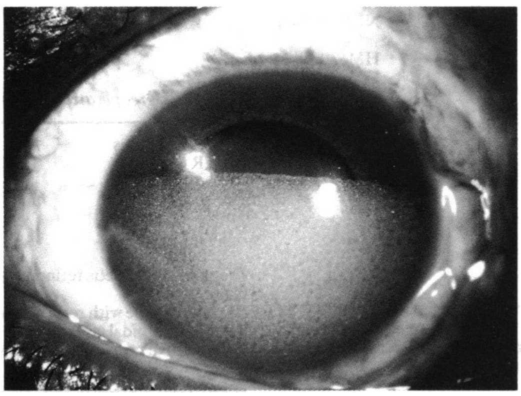

Figure 2 Emulsified FSO occupying two-thirds of the anterior chamber.

TIMING AND TECHNIQUE OF FLUOROSILICONE OIL REMOVAL

Fluorosilicone oil was removed from all eyes two to eight weeks after its insertion. The determination to remove FSO was based primarily on emulsification. Although strict grading of the degree of emulsification was not recorded, fluorosilicone oil was removed in early cases (1 and 2) when retinal details became obscured by emulsification and in later cases when the first signs of emulsification were observed (Fig 2).

Removal was performed under general anaesthesia in 29 cases (all except case 30). An infusion cannula was placed and sclerotomies performed as for standard pars plana vitrectomy. Balanced salt solution (BSS plus) was used as an infusion fluid.

In cases 23 and 24, where high viscosity FSO was used (1000 cSt=mm^2/s) a powerful aspiration source was necessary to evacuate the substance adequately. An 18 gauge blunt cannula was attached to flexible tubing affixed to a 50 ml syringe. The cannula was directed by the surgeon using endoillumination and microscopic visualisation. The aspiration was performed by an assistant with retraction of the syringe plunger. The process was carried out until all visible FSO was removed.

In the remaining 28 cases, in which 300 cSt (=mm²/s) FSO was used, aspiration was possible by means of standard vitrectomy aspirating equipment (microvit, vitrophage) connected to a blunt 20 gauge cannula (Fig 1C, D). The fluorosilicone oil was aspirated until all visible FSO was removed. In cases where FSO was present in the anterior chamber of phakic and pseudophakic patients a limbal incision was performed, and the FSO was aspirated via the above system.

After removal of all visible FSO repeated air-fluid exchange was performed (Fig 1E). This manoeuvre resulted in additional accumulation of FSO posteriorly, which was removed by the above aspiration technique. Air-fluid exchange was performed two to three times in each patient. The eye was filled with the infusion fluid after all FSO appeared to be removed. The infusion cannula was removed, and sclerotomies and conjunctiva were closed in standard fashion.

Results

Intraoperative retinal reattachment was achieved in all cases. Relaxing retinotomy was required in nine of 30 cases. Retinal detachment recurred in seven cases (23%), three of which occurred at the time of FSO removal (cases 16, 21, 30). These were limited and appeared to occur from undetected breaks on the posterior slope of the scleral buckle. They were repaired during the same operation by standard air-fluid exchange and injection of conventional silicone oil. In three cases the retina beame detached after FSO removal as a result of PVR. Two of these cases required reattachment procedures with injection of conventional silicone oil. One case was deemed inoperable, and the remaining case had a limited detachment not involving the macula and has remained unchanged for four months.

In cases of giant tears, injection of FSO over the optic disc produced immediate flattening of the posterior retina, with extrusion of subretinal fluid out of the peripheral break. With additional FSO injection the entire retina was reattached from posterior to anterior.

Postoperative visual acuities ranged from no light perception (NLP) to 20/50 (Table 1, Fig 3). Fourteen patients (47%) showed improvement of one line or more while seven (23%) lost one line or more. Nine patients remained unchanged.

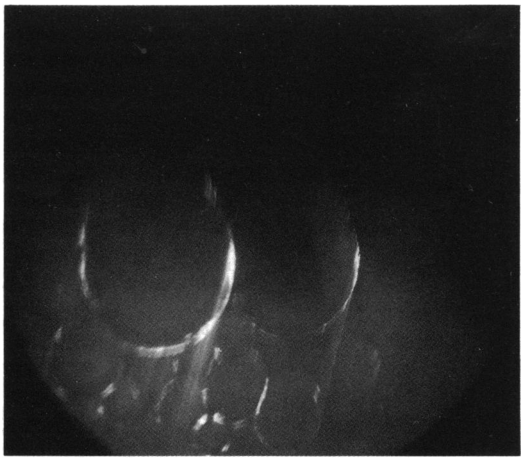

Figure 4 Emulsified FSO in the vitreous cavity.

Emulsification of FSO occurred as early as one week after injection (case 25) and was present in all cases at the time of FSO removal (Figs 4, 5, Table 3). Significant emulsification (obscuring retinal details) occurred in eight patients. The two cases in which FSO was removed during the initial procedure were excluded when calculating the rate of occurrence of this complication (Table 3).

Cataract formation occurred in six of eight phakic patients. These were posterior subcapsular in nature. A raised intraocular pressure was detected in four patients and was treated with topical and oral antiglaucoma medications. Hypotony (intraocular pressure less than 6 mmHg) occurred in four patients. Marked intraocular inflammation and synechia formation between iris and lens capsule or intraocular lens was present in three eyes (all were also hypotonus and included above).

Keratopathy, defined as corneal thickening or oedema detected by slit-lamp examination in the absence of raised or reduced intraocular pressure, was present in three eyes and resolved after removal of FSO (Fig 5). One eye (case 19) developed postoperative choroidal haemorrhage and became phthisical.

Discussion

Heavier-than-water vitreous replacement substances have been used with variable results.[9-12]

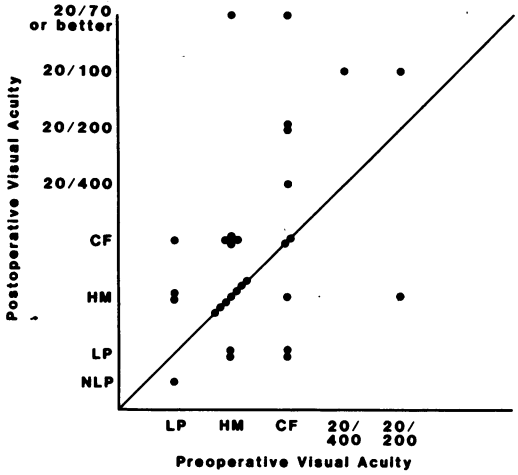

Figure 3 Preoperative, postoperative visual acuities. CF – counting fingers. HM – hand motion. LP – light perception. NLP – no light perception.

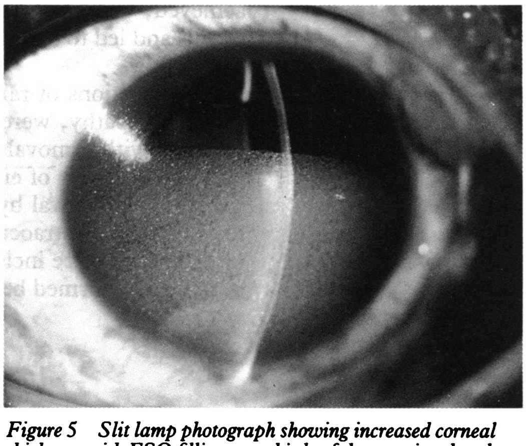

Figure 5 Slit lamp photograph showing increased corneal thickness with FSO filling two-thirds of the anterior chamber.

Table 3 Postoperative complications (n=30)

Emulsification*	28	(93%)
PVR	8	(26%)
Redetachment	7	(23%)
Cataract†	6	(75%)
Retinal breaks	5	(18%)
Raised IOP	4	(13%)
Hypotony	4	(13%)
Uveitis/synechiae	3	(10%)
Keratopathy	3	(10%)
Phthisis	2	(3%)
Choroidal haemorrhage	1	(3%)
Vitreous haemorrhage	1	(3%)

*n=28
†n=8

The theoretical advantages of the higher specific gravity materials are (1) draining subretinal fluid via a peripheral break and eliminating the need for posterior retinotomy; (2) obviating the need for inverting the patient or a complicated technique in repair of giant tears; (3) maintenance of postoperative retinal tamponade in the inferior quadrants; (4) post-operative supine positioning; and (5) long-term retinal tamponade. Our study suggests that four of these objectives can be achieved with FSO.

In patients with peripheral retinal breaks (including giant tears) subretinal fluid was easily removed by injecting FSO posteriorly over the optic disc and allowing the fluid to exit via the break and through the infusion cannula or sclerotomy site.

Inferior retinal tamponade can be maintained postoperatively for three to four weeks. In our hands considerable emulsification occurred after this period, rendering the FSO less efficient and complicating the removal. This emulsification was variable and appeared to relate to the patients' level of activity; however, this could not be statistically correlated. A higher viscosity FSO may reduce emulsification, but its removal is very difficult.[13]

As described above the 1000 cSt (=mm^2/s) FSO was removed by creating suction with a 50 ml syringe connected via tubing to an extrusion cannula. Intense and continuous retraction on the plunger was required to remove the oil at a very slow rate. Approximately one hour of actual aspiration time was required. Removal of 300 cSt (=mm^2/s) FSO was quite easily done with a standard extrusion needle.

Postoperative supine positioning was used in all patients, often with the head slightly elevated. Long-term tamponade was not satisfactorily achieved, as emulsification obscured retinal details and led to other complications previously discussed.

Complications of raised intraocular pressure, and keratopathy, were managed medically and resolved with removal of FSO. Cataract formation was high (six of eight phakic eyes), and the subsequent removal by extracapsular technique led to marked intraocular inflammation. Three of these eyes were included in 'uveitis/synechia' as synechiae formed between the iris-intraocular lens or iris-lens capsule. Two of these eyes became hypotonus (IOP ≤ 6). It is our impression that FSO may alter the blood-ocular barrier, which gives rise to a marked inflammatory response if subsequent surgery is performed on the anterior segment. Surprisingly, this inflammatory response was not observed in patients requiring an additional posterior segment operation.

Though retinal reattachment was achieved in all cases, redetachment occurred in seven (23%). Three of these were rhegmatogenous and appeared to result from previously undetected breaks on or near the posterior slope of the buckle. Reattachment was achieved in five of these cases with repeat surgery and injection of conventional silicone oil.

Our series demonstrates that FSO can be used as an intraoperative tool to facilitate repair of complicated retinal detachment and to provide retinal support in the inferior quadrants. Complications are similar to those reported with conventional silicone oil.[14-16] However, our observation of marked inflammation following anterior segment surgery in three patients is of concern and warrants further evaluation. FSO may prove useful as an intraoperative tool or intermediate vitreous replacement as the evaluation and search for a more permanent heavier-than-water substitute continues.

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1 Cibis PA, Becker B, Okun E, Canaan S. The use of liquid silicone in retinal detachment surgery. *Arch Ophthalmol* 1962; **68:** 590–9.
2 McCuen BW, de Juan E Jr, Landers MB, Machemer R. Silicone oil in vitreoretinal surgery. Part 2: Results and complications. *Retina* 1985; 5: 198–205.
3 Miyamoto K, Refojo MF, Tolentino F, Fournier GA, Albert DM. Fluorinated oils as experimental vitreous substitutes. *Arch Ophthalmol* 1986; **104:** 1053–6.
4 Liu KR, Peyman GA, Miceli MV. Experimental evaluation of low viscosity fluorosilicone oil as a temporary vitreous substitute. *Ophthalmic Surg* 1989; **20:** 720–5.
5 Peyman GA, Smith T, Charles H. Injection of fluorosilicone oil and pars plana vitrectomy for complex retinal detachment. *Can J Ophthalmol* 1987; **22:** 276–8.
6 Peyman GA, Smith RT. Use of fluorosilicone to unfold a giant tear. *Int Ophthalmol* 1987; **10:** 149–51.
7 Paylor R, Peyman GA, Badri S. Effects of intravitreal injection of fluorosilicone oil after vitrectomy in the rabbit eye. *Can J Ophthalmol* 1987; **22:** 251–3.
8 Retina Society Terminology Committee. The classification of retinal detachment with proliferative vitreoretinopathy. *Ophthalmology* 1983; **90:** 121–5.
9 Chang S. Low viscosity liquid fluorochemicals in vitreous surgery. *Am J Ophthalmol* 1987; **103:** 38–43.
10 Chang S, Zimmerman NJ, Iwamoto T, Ortiz R, Faris D. Experimental vitreous replacement with perfluorotributylamine. *Am J Ophthalmol* 1987; **103:** 29–37.
11 Miyamoto K, Refojo MF, Tolentino FI, Fournier GA, Albert DM. Perfluoroether liquid as a long term vitreous substitute. *Retina* 1984; **4:** 264–8.
12 Biro GP, Blais P. Perfluorocarbon blood substitutes. *CRC Crit Rev Oncol Hematol* 1987; **6:** 311–74.
13 Crisp A, de Juan E Jr, Tiedeman J. Effect of silicone oil viscosity on emulsification. *Arch Ophthalmol* 1987; **105:** 546–50.
14 Labelle P, Okun E. Ocular tolerance to liquid silicone: an experimental study. *Can J Ophthalmol* 1972; **7:** 199–204.
15 Nabih M, Peyman GA, Clark LC Jr, *et al.* Experimental evaluation of perfluorophenanthrene as a high specific gravity vitreous substitute: a preliminary report. *Ophthalmic Surg* 1989; **20:** 286–93.
16 Leaver PK, Grey HB, Garner A. Silicone oil injection in treatment of massive preretinal retraction. II. Late complications in 93 eyes. *Br J Ophthalmol* 1979; **63:** 361–7.