Vitrectomy with silicone oil infusion in severe diabetic retinopathy

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Aims: To determine the results of pars plana vitrectomy (PPV) and silicone oil infusion (SOI) in severe proliferative diabetic retinopathy (PDR).

Methods: The records of 23 eyes (21 patients: 12 males, nine females) with PDR who had undergone PPV and SOI were reviewed retrospectively.

Results: Average follow up was 5.4 months (range 1–25). Surgical indications were tractional retinal detachment (TRD) (17.4%), traction-rhegmatogenous retinal detachment (TRRD) (8.7%), TRD with vitreous haemorrhage (VH) (48%), TRD with neovascular glaucoma (NVG) (8.6%), TRD with fibrinoid syndrome (FS) (17.3%). With one operation, the retinal reattachment rate was 17/23 (74%). Among these 23 eyes, 11 (48%) had previously failed vitrectomy, and the retina was attached in 8/11 (73%) with a single procedure. With additional surgery employing PPV and SOI, the final reattachment rate was 20/23 (87%). The only cases with intraocular pressure <5 mm Hg had retinal detachment. Post-operative visual acuity (VA) improved in 10 eyes (44%), was unchanged in three (12%), and decreased in 10 eyes (44%).

Conclusion: SO tamponade is useful in severely diseased eyes with PDR, even in the presence of rubeosis iridis (RI) and NVG, FS, or in cases with previously failed vitrectomy, especially in the presence of RI.

Despite the success of pars plana vitrectomy in managing the severe complications of diabetic retinopathy, significant operative and postoperative complications still occur leading to anatomical failure and blindness. Recurrence of retinal detachment secondary to fibrovascular proliferation, progression of neovascularisation with neovascular glaucoma, hypotony with subsequent phthisis bulbi, and fibrinoid syndrome are some of the many reported postoperative complications of diabetic vitrectomy.

Silicone oil facilitates retinal reattachment by providing extended intraocular tamponade. Silicone oil may compartmentalise the eye¹ and may have a role in inhibiting progressive neovascularisation in the anterior segment by preventing the diffusion of angiogenic substances. In addition, silicone oil can prevent hypotony and subsequent phthisis bulbi.²

We reviewed results of pars plana vitrectomy (PPV) in eyes with severe proliferative diabetic retinopathy (PDR) that underwent silicone oil infusion (SOI). The results indicate that PPV with SOI can salvage useful vision in eyes with an otherwise poor prognosis.

MATERIALS AND METHODS

We retrospectively reviewed the data for 21 patients who underwent standard three port pars plana vitrectomy and SOI for PDR at University Hospital, Newark, NJ, USA, between 1997 and 2002. All patients underwent complete preoperative and postoperative examinations including visual acuity testing, slit lamp biomicroscopy, gonioscopy, intraocular pressure (IOP) measurement, indirect ophthalmoscopy, and ultrasonography when the fundus could not be visualised. To compare cases of similar complexity, a "complexity score" (CS) was defined. The complexity score was graded by quantifying: (1) the number of quadrants of fibrovascular proliferation (FVP; 1–4 quadrants, each quadrant involved corresponds to 1 point increase in the CS); (2) the location of FVP: anterior to the equator (0 points), posterior to the equator (0 points), both anterior and posterior (1 point); (3) tractional retinal detachment (TRD, 1 point); (4) traction-rhegmatogenous retinal

detachment (TRRD, 2 points); (5) the presence or absence of a posterior vitreous detachment (no PVD, 1 point). Anatomical success was defined as complete attachment of the retina or attachment posterior to the scleral buckle, if present.

RESULTS (TABLE 1)

The study comprised 23 eyes (21 patients): 12 males (57%) and nine females (43%); seven Hispanics (33%); 14 (67%) African-Americans. The average age was 53.6 years (range 21–82 years). Surgical indications were: tractional retinal detachment (TRD) (four eyes, 17.4%), traction-rhegmatogenous retinal detachment (TRRD) (two eyes, 8.7%), TRD with vitreous haemorrhage (VH) (11 eyes, 48%), TRD with VH and neovascular glaucoma (NVG) (one eye, 4.3%), TRD with NVG (one eye, 4.3%), TRD with fibrinoid syndrome (FS) (two eyes, 8.7%), TRD with FS and NVG (one eye, 4.3%) and TRD with VH and FS (one eye, 4.3%). The average complexity score was 4.5 (Fig 1). The length of follow up ranged from 1–25 months (mean 5.4 months).

In 12 eyes (52%), SOI was part of the initial operation during primary vitrectomy. In 11 eyes (48%), SOI was done after previous failed vitrectomy. Preoperatively, 14 patients were phakic, six were pseudophakic, and three were aphakic. Eight of 14 (57%) phakic eyes underwent lensectomy (five were left aphakic). Four of the pseudophakic eyes underwent intraocular lens removal and were left aphakic. Different intraocular procedures were performed at the time of surgery. Scleral buckles were placed in two (8.7%) eyes. Epiciliary dissection was done in two (8.7%) eyes, one of which had preoperative hypotony. Cyclocryotherapy was done intraoperatively in two (8.7%) eyes. Membrane peeling was done in all eyes. A Baerveldt valve was placed in one (4.3%) eye, and a peripheral relaxing retinectomy was necessary in one (4.3%) eye. SO was removed in two (8.7%) eyes at 5 and 8 months, respectively, without complication. Silicone was removed because of migration into the anterior segment with corneal touch in one

Table 1 Functional and anatomical status after vitrectomy with silicone oil infusion for proliferative diabetic vitrectomy. Patients 7, 16, and 23 had repeat vitrectomy and silicone oil infusion with final retinal reattachment

Case No	Age/sex/race/eye	Diagnosis	Length of follow up (months)	Vision (preop/final)	IOP (preop/postop)	Rubeosis (preop/postop)	NVG (preop/postop)	Anatomical outcome
1	58/F/H/RE	PDR, TRRD, RI, hypotony	1	LP/LP	6 mm/5 mm	RI/no change	None	Retina flat SO present
2	59/F/AA/RE	PDR, TRD, VH	5	HM/CF 1 ft	19 mm/22 mm	None	None	Retina flat SO present
3	70/M/AA/LE	PDR, TRD, recurrent VH	4	CF 2 ft/5/200	22 mm/15 mm	None/RI	None	Retina flat SO present
4	21/F/AA/RE	PDR, RI, NVG, TRD, subluxed lens	12	CF 2 ft/5/160	16 mm/7 mm	RI/regressed	NVG/resolved	Retina flat SO present
5	21/F/AA/LE	PDR, RI NVG, TRD, FS	1	LP/LP	14 mm/20 mm	RI/no change	NVG/IOP is normal	Retina flat SO present
6	60/M/AA/RE	PDR, TRD, RI, FS	4	LP/10/200	12 mm/9 mm	RI/regressed	None	Retina flat SO present
7	52/M/H/RE	PDR, TRD, VH, FS	12	LP/HM	9 mm/2 mm	None	None	Recurrent RD SO present
8	44/M/H/RE	PDR, TRD, VH	2	CF 1 ft/20/80	10 mm/15 mm	None	None	Retina flat SO removed
9	36/M/AA/RE	PDR, TRD, VH	1	CF 2 ft/5/200	17 mm/21 mm	None	None	Retina flat SO present
10	36/M/AA/LE	PDR, TRD, VH	3	HM/LP	15 mm/14 mm	None	None	Retina flat SO present
11	49/F/AA/RE	PDR, TRD, VH, CT	1	CF 1 ft/HM	11 mm/32 mm	None	None	RD
12	82/F/AA/RE	PDR, TRD	3	LP/NLP	14 mm/8 mm	None	None	Retina flat
13	52/M/AA/RE	PDR, TRD, RI	9	HM/LP	12 mm/2 mm	RI/regressed	None	RD SO present
14	75/F/AA/RE	PDR, TRD, VH	18	LP/HM	9 mm/3 mm	None	None	RD (peripheral) SO present
15	52/F/H/LE	PDR, TRD, CT, RI HYP	1	HM/CF 1 ft	12 mm/12 mm	RI/no change	None	Retina flat SO present
16	68/M/AA/LE	PDR, TRRD	3	CF 2 ft/HM	19 mm/15 mm	None	None	TRD
17	58/M/AA/RE	PDR, TRD, VH	1	CF 1 ft/LP	16 mm/15 mm	None	None	Retina flat SO present
18	29/F/H/LE	PDR, TRD, VH	6	HM/LP	13 mm/12 mm	None	None	RD SO present
19	59/F/AA/RE	PDR, TRD, ERM, VH	25	5/200/CF 2 ft	12 mm/27 mm	None	None	Retina flat SO present
20	58/M/AA/RE	PDR, TRD, FS	8	LP/CF 2 ft	13 mm/16 mm	None	None	Retina flat SO removed
21	74/M/AA/RE	PDR, TRD, CSME	2	HM/HM	10 mm/25 mm	None	None	Retina flat SO removed
22	56/M/H/LE	PDR, TRD, VH, RI, NVG	1	LP/NLP	32 mm/5 mm	RI/no change	NVG/IOP is normal	Retina flat SO present
23	58/M/H/LE	PDR, TRD, VH	2	HM/LP	14 mm/22 mm	None/RI	None	RD SO present

PDR = proliferative diabetic retinopathy; TRRD = tractional rhegmatogenous retinal detachment; RI = rubeosis iridis; SO = silicone oil; TRD = tractional retinal detachment; VH = vitreous haemorrhage; NVG = neovascular glaucoma; FS = fibrinoid syndrome; RD = retinal detachment; CT = cataract; HYP = hyphaema; ERM = epiretinal membrane.

eye and cataract progression in the second eye. In one eye, the oil was removed because it was present in the anterior chamber.

After a single operation employing PPV and SOI, anatomical attachment was achieved in 17 (74%) of 23 eyes. In the 12 eyes that were operated for the first time with primary SOI, the retina was attached in nine (75%). In the 11 eyes that underwent SOI after previously failed vitrectomy, the retina was attached in eight (73%). The difference in the reattachment rate between these two groups was not statistically significant (χ^2 test, $p = 0.9$). Three of the six eyes with recurrent detachment underwent repeat vitrectomy, membrane peeling, and silicone insertion with successful reattachment. (The remaining three patients declined additional surgery.) Therefore, with multiple operations employing silicone oil insertion, the final anatomical success rate at last follow up was 20/23

(87%). The length of follow up after the last procedure for the three reoperated eyes ranged from 3 to 4 months (mean 3.3 months).

Case complexity did not correlate with anatomical success (Table 2).

Postoperative visual acuity (VA) improved in 10 eyes (44%), was unchanged in three (12%) and decreased in 10 eyes (44%). Two eyes (8.7%) had no light perception at last follow up (neither underwent scleral buckling). Both eyes had preoperative vision of light perception. Loss of light perception was due to retinal and optic nerve ischaemia in each case. Preoperatively, the visual acuity of all patients ranged from light perception to less than counting fingers at 1 foot except

Figure 1 Distribution of cases by complexity score.

Table 2 Case complexity v surgical outcome

Complexity score	Anatomical outcome	
	Flat	Retinal detachment
1	1	0
2	1	1
3	2	0
4	4	1
5	3	3
6	6	0
7	0	1

for one patient whose vision was 5/200. After surgery, five of 23 eyes (22%), had vision $\geq$ 5/200.

Rubeosis iridis (RI) was present preoperatively in seven eyes (30.4%), three of which had NVG. Postoperatively, three of seven eyes had regressed rubeosis. Of the three eyes with NVG, one underwent Baerveldt valve placement with normalisation of the postoperative intraocular pressure. In another, the NVG regressed after surgery. The last eye had regression of neovascular glaucoma but no light perception postoperatively because of ischaemia. Only one eye developed de novo RI postoperatively. Postoperatively, at last follow up, the intraocular pressure was > 29 mm Hg in only one patient, who did not have neovascular glaucoma. This patient was using antiglaucoma medications preoperatively. At the last follow up visit after surgery, five eyes (23%) had intraocular pressure ≤ 5 mm Hg. Three of these eyes had persistent retinal detachment, which we presume to be the cause of the hypotony (Table 1). The remaining 17 eyes had intraocular pressure ranging from 6–29 mm Hg, with two patients taking antiglaucoma medications.

Intraoperative complications included iatrogenic retinal breaks during membrane peeling in four of 23 eyes (17.3%). Postoperative complications included keratopathy (two eyes), SO in the anterior chamber (one eye), cataract (one eye), fibrinoid reaction with pupillary membrane formation (one eye), and new onset of RI (one eye). One eye with preoperative fibrinoid syndrome had persistent fibrinoid reaction postoperatively and underwent intraocular tissue plasminogen activator injection at the slit lamp with clinical improvement.

DISCUSSION

Silicone oil promotes retinal reattachment by providing extended intraocular tamponade. Intraocular gas has greater surface tension and spontaneously reabsorbs, but its effect is shorter and does not always create an anatomically stable situation. Silicone oil has been advocated for the treatment of complex retinal detachment^{3–8} and treatment of severe PDR.^{9–13}

Previously, other authors have reported clinical series in which silicone oil infusion was used in the management of severe PDR. Lean *et al*¹² reported a series of 13 eyes that underwent surgery for severe diabetic traction detachment. Four eyes (31%) remained attached with visual improvement in one (7.7%).

Rinkoff and de Juan¹⁰ reported on 10 patients with rhegmatogenous retinal detachment complicated by advanced proliferative vitreoretinopathy following failed vitrectomy for PDR. In this series, three eyes (30%) achieved retinal reattachment. Yeo *et al*¹⁴ reported a series of 23 eyes with PDR in which retinal reattachment was achieved in 16 (70%), and final vision of 5/200 or better was obtained in five eyes (22%). Lucke *et al*⁹ reported a series of 106 patients with PDR, and the reattachment rate was 73%. Brouman *et al*¹³ reported a series of 34 patients (37 eyes) with refractory severe neovascular glaucoma and/or recurrent retinal detachment from PDR. Reattachment was maintained in 26 eyes (70%). Regression of iris neovascularisation occurred in eight (36%) of 22 eyes.

In a more recent prospective study, Azen *et al*¹⁵ reported a series of 340 patients (359 eyes) with PDR that underwent vitrectomy and silicone oil infusion. They found the frequency of complete retinal reattachment at the last follow up was 57% whereas the rate of macular reattachment was 74%. In their series, vision $\geq 4/200$ was retained in 24% of eyes.

In a prospective multicentre study, Scott *et al*¹⁶ reviewed the results of patients who underwent vitrectomy with silicone oil infusion for retinal detachment associated with cytomegalovirus retinitis or non-cytomegalovirus necrotising retinitis, including proliferative diabetic retinopathy, giant retinal tear, proliferative vitreoretinopathy, and ocular trauma. In their

series, 127 patients (132 eyes) underwent vitrectomy and silicone oil infusion for PDR. The reattachment rate of eyes undergoing the first operation or after previously failed vitrectomy was 56/116 (48%) and 8/16 (50%), respectively.

In our study, we found no difference in the reattachment rate among eyes undergoing first time vitrectomy (75%) versus those that had previously failed vitrectomy (73%) (χ^2 test, $p = 0.9$). All three eyes that underwent PPV and SOI twice were reattached after the second procedure. Therefore, with multiple operations employing PPV and SOI, the final anatomical success rate was 20/23 (87%).

Among the 17 eyes with a flat retina, nine (53%) had some degree of visual improvement after surgery. Only five eyes (29% of anatomically successful cases and 22% of all cases) recovered ambulatory vision (that is, $\geq 5/200$) at last follow up. This result probably reflects, in part, the fact that preoperative visual acuity was poor in most eyes. At last follow up, two eyes (8.7%) had no light perception. One of the two developed the fibrinoid syndrome after surgery and had a flat retina. The other patient had preoperative neovascular glaucoma with a flat retina at last follow up.

In the series reported by Rinkoff and de Juan¹⁰ two (20%) of 10 patients regained ambulatory vision. Yeo *et al*¹⁴ reported final vision of 5/200 or better in five (22%) of 23 eyes. Lucke *et al*⁹ reported visual acuity of 5/200 or better in 65% of patients. Brouman *et al*¹³ reported final visual acuity of at least 5/200 in nine (24%) of 37 eyes and nine (35%) of 26 anatomically successful cases. Azen *et al*¹⁵ reported vision $\geq 4/200$ in 24% of eyes. Scott *et al*¹⁶ reported a final ambulatory vision in 45% of the reported eyes. In their series, a higher rate of ambulatory vision was also achieved for primary anatomical success cases compared to reoperated cases (48% v 25%) although differences were not statistically significant ($p = 0.1$).

Rubeosis iridis was present preoperatively in seven eyes, three of which had neovascular glaucoma. Rubeosis regressed in three (43%) of the seven eyes, and none of the patients had active neovascular glaucoma at last follow up. Regression of neovascularisation after silicone oil infusion has been reported in other series. Bourman *et al* reported regression in 36% of eyes with rubeosis iridis.¹³

The rationale for using silicone oil in the management of anterior segment neovascularisation is that silicone compartmentalises the eye and confines angiogenic substances to the posterior segment.^{1,17} In addition, silicone oil acts as a diffusion/convection barrier to oxygen, as it prevents the decrease in anterior chamber oxygen tension that occurs after lensectomy and vitrectomy in cats.¹⁸ Silicone oil does not always prevent the development of neovascularisation.^{10,14} In our series, one eye developed de novo rubeosis iridis, and another eye developed increased posterior segment neovascularisation. Peri-silicone proliferation may be due to entrapment of retina derived angiogenic substances between the retina surface and the silicone oil bubble.¹⁹

Hypotony in this setting can result from cyclitic membrane formation with ciliary body detachment and/or sequestration or from ciliary body atrophy.^{20,21} The high percentage of eyes with hypotony (IOP = 5 mm Hg) at last follow up (5/23 (22%)) has been noted by others. Azen *et al*¹⁵ reported an incidence of 21% among 359 eyes. Brouman *et al*¹³ reported an incidence of 22% in 37 eyes. In contrast, Yeo *et al*¹⁴ reported no cases of hypotony in a series of 23 eyes. All the eyes with postoperative hypotony in our series had undergone multiple vitrectomies before silicone oil infusion.

Four eyes in this series had the fibrinoid syndrome preoperatively, most likely secondary to excessive postoperative inflammation following previous failed vitrectomy and laser photocoagulation. Schepens described the fibrinoid syndrome.²² It is characterised by fibrin strand formation in the vitreous cavity, condensation of fibrinoid material on the surface of the retina, eventual development of turbid vitreous gel (or fluid, in eyes that have undergone vitrectomy) and,

often, in progressive traction retinal detachment. Other features include neovascular glaucoma, pupillary block glaucoma, recurrent haemorrhage, cataract, and ciliary body detachment with hypotony. The incidence of fibrinoid syndrome in patients undergoing vitrectomy for the complications of PDR is approximately 8%.²³ In one series, postvitrectomy fibrin formation occurred in 49 of 222 eyes (22%) within 72 hours of surgery.²⁴ The prognosis is generally poor. In the present series, of the four eyes with preoperative fibrinoid syndrome, vision improved in three eyes (one from light perception to counting fingers, another from light perception to hand movements, and the last from light perception to 10/200). In the remaining eye, the vision was unchanged at light perception. One of the patients had persistent fibrinoid syndrome and therefore underwent intravitreal tissue plasminogen activator injection (50 µg/0.1 ml) at the slit lamp with resolution of the fibrin strands. We believe that aggressive management including excision of the posterior hyaloid face and vitreous base dissection, extensive panretinal photocoagulation (to induce regression of or prevent anterior hyaloidal fibrovascular proliferation), and silicone oil infusion can create a stable anatomical situation even in eyes with the fibrinoid syndrome.

One patient developed de novo postoperative fibrinoid syndrome after PPV with SOI. Other authors reported fibrin formation following vitrectomy and silicone oil infusion.²⁵ Low molecular weight components and other impurities in the silicone oil may cause a postoperative inflammatory reaction. The eye that developed de novo fibrinoid syndrome postoperatively had a flat retina at last follow up with no light perception vision.

There was no correlation between case complexity and anatomical success. In a retrospective study comparing the use of viscodelamination versus en bloc dissection, we reported 150 eyes with PDR that underwent pars plana vitrectomy with membrane peeling.²⁶ To compare cases of similar anatomical complexity, the same "complexity score" (CS) was employed. The reattachment rate in that series among eyes with 6 months of follow up was 36/43 (84%) among cases undergoing viscodissection v 55/58 (95%) without viscodissection. In that series, the average complexity score was 3.7, statistically significantly lower than the average complexity score of this series ($p=0.03$). We were not able to compare the results with eyes of a given complexity score in that study with those of similarly complex eyes in the present study because the sample of eyes with silicone infusion is too small.

The outcome of this study further supports the role of silicone oil infusion as a useful option in severely diseased eyes with PDR, even in the presence of rubeosis iridis, neovascular glaucoma, or the fibrinoid syndrome. In the group of eyes that underwent pars plana vitrectomy and silicone infusion at the time of the first vitrectomy, the retinal reattachment rate was 75%, and no eye developed hypotony after surgery.

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