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Intravitreal silicone oil injection: complications and treatment of 415 consecutive patients

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Abstract. Silicone oil injection in conjunction with pars plana vitrectomy was carried out by five surgeons in 415 consecutive patients using the same surgical equipment, the same surgical techniques and the same highly purified silicone oil (viscosity, 5000 mPa·s). Indications for silicone oil injection after vitrectomy included advanced stages of proliferative vitreoretinopathy following rhegmatogenous retinal detachment (49%), severe proliferative diabetic retinopathy (38%), and proliferative vitreoretinopathy following retinal detachment due to ocular trauma (13%). Postoperative complications were noted in a 6- to 30-month follow-up period. Cataractous changes of varying degree were seen in all phakic eyes. Silicone oil entered the anterior chamber in 6% of all phakic and pseudophakic eyes. Subretinal silicone oil was noted in 4%. Other complications associated with the use of intravitreal silicone oil included biomicroscopically visible silicone oil emulsification (0.7%), keratopathy (5.5%), glaucoma (6%), closure of the inferior iridectomy (6%), and reproliferation of epiretinal and subretinal fibrous membranes (40%). We anticipate that the physicochemical characteristics of the highly purified silicone oil (viscosity, 5000 mPa·s) and the routine performance of an inferior iridectomy in all aphakic eyes had a positive impact on the low incidence of silicone-oil-related complications such as emulsification, keratopathy and secondary glaucoma.

Introduction

Intravitreal injection of silicone oil for the treatment of complicated retinal detachments has been used with increasing frequency [15, 18, 24, 26, 30, 37, 38] since it was introduced by Cibis et al. [7] in 1962. Despite a high success rate in otherwise desperate cases, it is well known that the use of either intraocular gas or silicone oil in combination with intravitreal surgery produces side effects and complications, limiting their efficacy and therapeutic value.

Gas has the advantage of sufficiently high surface tension to facilitate the occlusion of retinal breaks; it also has the advantage of spontaneous absorption. However, its potential disadvantages include postoperative intraocular pressure rise, cataract formation, and a high rate of recurrent retinal detachments [4, 23].

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Intraocular silicone oil is advantageous in that it may provide extended or permanent retinal tamponade. Its application creates no major technical problems, and its optical qualities enable a clear view of the fundus. However, the instillation of intravitreal silicone oil has been found to cause a significant number of related complications including glaucoma, cataract formation in phakic eyes, oil emulsification, and keratopathy [5, 6, 9, 11, 15, 16, 18, 20, 21, 25, 27, 31, 35, 38]. Moreover, several authors have claimed that intraocular silicone oil is toxic to the retina and optic nerve and induces reproliferation of preretinal membranes in proliferative vitreoretinopathy and proliferative diabetic retinopathy [3, 10, 19, 22, 28, 35]. In view of the various complications of silicone oil injections recorded in the literature, the present study was undertaken to review our considerable recent experience at the University Eye Hospital, Munich.

Materials and methods

A total of 415 consecutive patients underwent intravitreal surgery with silicone oil injection in 1986 and 1987. An additional 29 patients who were surgically treated had to be excluded from this study due to inadequate follow-up. Indications for silicone oil injection included: (1) advanced stages of proliferative vitreoretinopathy following rhegmatogenous retinal detachment (206 eyes, 49%), (2) proliferative vitreoretinopathy following ocular trauma (52 eyes, 13%), and (3) severe proliferative diabetic retinopathy (157 eyes, 38%). The follow-up period ranged from 6 to 30 months, with a mean follow-up of 14 months. All eyes were subjected to complete pre- and postoperative examinations including visual acuity testing, intraocular pressure measurement, slit-lamp microscopy, fundus biomicroscopy and indirect ophthalmoscopy. Sonography was carried out when the media were opaque.

The degree and extent of the proliferative vitreoretinopathy (PVR) in eyes with retinal detachment (RD) due to rhegmatogeneous detachment and ocular trauma were graded according to the classification of The Retina Society Terminology Committee [33]. Grade C1 PVR was present in 2%; grade C2 PVR, in 18%; grade C3 PVR, in 19%; grade D1 PVR, in 22%; grade D2 PVR, in 29%; and grade D3 PVR, in 10% of our patients. In all eyes with proliferative diabetic vitreoretinopathy (PDR), vascularized vitreous membranes leading to retinal detachment and recurrent vitreous hemorrhage were present.

All surgery was carried out by five surgeons following the same surgical principles and using the same instruments for vitrectomy and membrane peeling [37]. Highly purified silicone oil with a viscosity of 5000 mPa·s was manually injected either following a fluid-air exchange or using a direct fluid-oil exchange. Chorioretinal adhesion around preexisting or iatrogenic retinal breaks was induced by endophotocoagulation or endocryocoagulation.

In all, 33% of all patients in our series were aphakic or pseudophakic at the time of vitrectomy, and 26% required a lensectomy during the surgical procedure; 41% remained phakic. All aphakic or pseudophakic eyes underwent an inferior peripheral iridectomy. Postoperatively, all patients received topical steroids and antibiotics. Phakic and pseudophakic eyes were treated with dilating agents, whereas the pupil in aphakic eyes was kept narrow with miotic agents to prevent the silicone oil from entering the anterior chamber. Rarely, in patients with severe postoperative inflammatory response, oral steroids had to be added to the treatment schedule.

Results

For analysis, complications occurring during vitrectomy with silicone oil injection and during follow-up in 415 consecutively treated eyes were divided into two groups: (1) complications not directly related to the physicochemical properties of silicone oil, such as entry of the oil into the anterior chamber in phakic or pseudophakic eyes and the development of large retinal tears, leading to subretinal silicone oil injection; and (2) complications possibly related to silicone oil as a chemical substance, such as keratopathy, silicone oil emulsification, glaucoma, cataract formation in phakic eyes, and reproliferation of fibrovascular membranes with retinal detachment.

Silicone oil in the anterior chamber, which had migrated around the crystalline or implanted lens, was seen in 26 of 209 phakic or pseudophakic eyes (6%; Fig. 1). The highest incidence of this complication was seen in eyes with PVR due to ocular trauma (21%), followed by eyes with PDR (13%) and those with PVR due to rhegmatogenous retinal detachment (10%). Silicone oil entering the subretinal space through large preexisting or iatrogenic tears was found in 4% of all eyes treated (17 of 415). Again, eyes with PVR due to ocular trauma (8%) showed the highest incidence, followed by eyes with PVR due to rhegmatogenous detachment (5%) and those with PDR (2%).

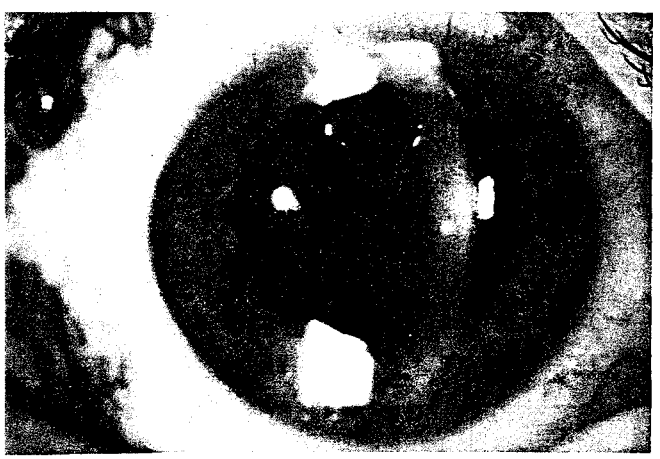

Fig. 1. Slit-lamp photograph, showing a silicone oil bubble in a phakic eye after vitreoretinal surgery with silicone oil injection

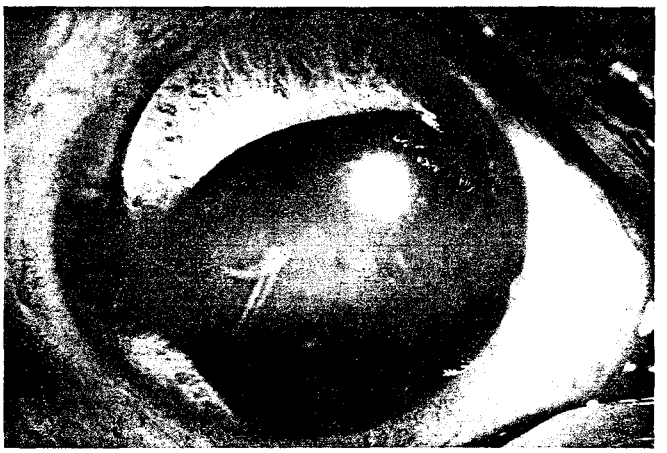

Fig. 2. Band-shaped keratopathy in an aphakic eye, demonstrating corneal silicone oil contact. Vitreoretinal surgery was carried out for PVR following severe ocular trauma due to a foreign body

Keratopathy following vitrectomy with silicone oil injection appeared in 5.5% of all eyes treated (23 of 415). Included were eyes with chronic or chronically recurrent corneal edema, with and without bullous keratopathy, and those with band-shaped keratopathy (Fig. 2). In eyes with PVR due to ocular trauma, the incidence was 12%; in those with PVR due to rhegmatogenous retinal detachment it was 6%, and in eyes with PDR, 3%. Postoperatively, 77% of those eyes developing keratopathy were aphakic, 15% were pseudophakic, and 8% contained a crystalline lens.

Clinically significant silicone oil emulsification that was visible by biomicroscopy occurred in 3 of 415 eyes, representing 0.7% of all eyes treated. However, when silicone oil was surgically removed from the anterior chamber of phakic or pseudophakic eyes, some small oil bubbles usually remained within the anterior chamber and could be visualized by gonioscopy; these oil bubbles were not included with the emulsification cases.

Increases in intraocular pressure (IOP) up to 30 mmHg within 10 days following surgery occurred in 21% of the eyes (89 of 415), whereas a rise to levels above 30 mmHg was observed in 13% (53 of 415) during this period. This complication was most frequently seen in patients with PVR due to ocular trauma where IOP did not exceed 30 mmHg in 25% and was above 30 mmHg in 15% of cases. During the long-term follow-up, 6% of all eyes treated (26 of 415) developed secondary glaucoma, 59% of these being aphakic. The highest incidence of this complication occurred in eyes with PVR following ocular trauma (10%), followed by those with PDR (8%) and those with PVR due to rhegmatogenous retinal detachment (4%). In the majority of all eyes with elevated IOP, either no treatment (IOP up to 30 mmHg) or short-term antiglaucoma treatment (IOP, >30 mmHg) using miotics, beta blocker and/or carbonic anhydrase inhibitors was required in addition to the steroid application. Surgical procedures for secondary glaucoma were carried out in 26 eyes. A total of 14 eyes received cyclocryocoagulation. In 12 eyes with elevated IOP, the silicone oil had to be partially removed. Additionally, in 26 aphakic or pseudophakic eyes, the inferior peripheral iridectomy had to be reopened either surgically

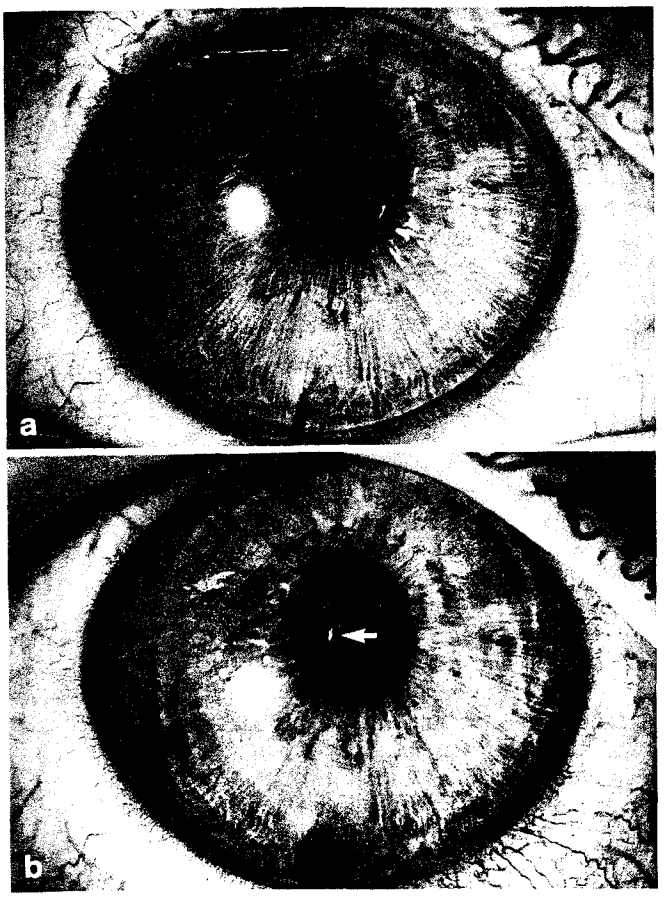

Fig. 3. **a** Silicone oil filling the anterior chamber of an aphakic eye due to secondary obstruction of the inferior iridectomy. **b** At 1 h following reopening of the inferior iridectomy by YAG laser, the silicone oil was entirely within the vitreous cavity, indicated by the light reflex (*arrow*) on the anterior oil surface within the pupil

(13 eyes) or by Nd:YAG laser treatment (13 eyes) to prevent these eyes from developing closed-angle glaucoma. These procedures became necessary because the iridectomy was secondarily closed by fibrin due either to an inflammatory reaction within the anterior segment or to fibrous reproliferation behind the iris (Fig. 3).

Cataract formation following intraocular silicone oil injection was a constant finding in all phakic eyes, usually becoming evident within 6–12 months following surgery. However, the amount and the progression of opacities within the crystalline lens varied, as some eyes exclusively presented minor vesicular posterior subcapsular opacities and others developed a dense cataract that prevented visualization of the fundus. During the follow-up period, in 18% of all eyes operated on subsequent cataract extraction was performed.

During the follow-up period, significant reproliferation of fibrovascular tissue, leading to partial retinal redetachment and thus requiring a second surgical procedure, was found in 63 of 415 eyes treated (15%). A total of 102 additional eyes (25%) with massive reproliferation were considered inoperable, and no further surgical procedure was performed. Combining both groups, reproliferation occurred in a total of 165 eyes, that is, in 40% of all eyes treated. Reproliferation occurred in 60% of all eyes with PVR due to ocular trauma, in 39% of those with PVR following rhegmatogeneous retinal detachment surgery and in 31% of those with PDR.

Discussion

In the past few years, the use of intravitreal injections of silicone oil has been successful in certain complicated retinal detachments with PVR and PDR that were previously considered to be unsalvageable [5, 14, 16, 18, 20, 24, 29, 32, 37]. In the United States, however, the use of intraocular silicone oil is still restricted by regulations of the Food and Drug Administration [13] to the surgical centers that make up The Silicone Study Group [34].

Our cohort of patients was substantially homogeneous insofar as (1) 415 patients received intravitreal silicone oil within the 2-year period of this study, (2) surgery was carried out during this period by five surgeons using the same surgical principles and equipment, and (3) the oil injected was in all cases highly purified silicone oil with a viscosity of 5000 mPa·s. In other studies published heretofore, the data were based on smaller numbers of treated eyes or were collected from patients undergoing surgery up to 1984 [9, 15, 16, 18, 22, 24, 31, 32, 38]. Since that time, several improvements in both the surgical equipment and the surgical techniques have taken place. Furthermore, some authors have drawn their conclusions from patients with aphakia or pseudophakia who underwent inferior peripheral iridectomy as described by Ando [1], whereas in other studies, patients had intravitreal silicone oil injection before the advent of this technique [9, 21, 24, 25, 31, 32]. In other series, silicone oil with different physicochemical properties (e.g., viscosity of 1000, 5000 or 12500 mPa·s) was used, leading to an inhomogeneous group of cases [8, 24, 25].

As previously reported by other authors [11, 25, 36], the entry of silicone oil into the anterior chamber in phakic or pseudophakic eyes is a rare complication. In our series, it occurred in 6% of all phakic or pseudophakic eyes and in 21% of eyes developing PVR due to ocular trauma. We anticipate that partial zonulysis following either ocular trauma or extracapsular cataract extraction enabled the oil to migrate around the crystalline or implanted lens, thus reaching the anterior chamber. In other cases, partial zonulysis may be caused by high infusion pressure during silicone oil injection and endodrainage. Silicone oil was seen less frequently in the anterior chamber of phakic or pseudophakic eyes when a complete fluid-air exchange was done prior to the silicone oil injection. Although small oil bubbles may remain in the anterior chamber without causing serious problems, larger amounts of silicone oil can easily be removed by injecting sodium hyaluronate through a limbal paracentesis and evacuating the oil through a second paracentesis at the opposite site. Postoperatively, some patients required topical miotics to prevent the oil from reentering the anterior chamber. Silicone oil was seen in the subretinal space in 4% of our patients. This complication was most frequently seen in eyes that had experienced severe ocular trauma (8%). Because treatment of this complication causes serious technical problems, it is often wise to avoid further surgery [32].

Keratopathy, including chronic corneal edema and band-shaped keratopathy, was found in 5.5% of our patients. The incidence of keratopathy, presumably due to endothelial cell damage, was 12% in eyes with PVR following ocular trauma and as low as 3% in those with PDR.

In addition to the presumed toxic effect of silicone oil, in aphakic eyes endothelial cell damage caused during vitrectomy by surgical procedures such as fluid irrigation, the use of epinephrine, air or gas insufflation and IOP rise must be considered in the pathogenesis of keratopathy. According to the results published by other authors, keratopathy was found in 12%–63% of patients with a follow-up period comparable to ours, and turned out to be one of the most frequent causes for loss of vision following silicone oil injection during the early period of surgery [9, 11, 15, 21, 25, 31, 38]. In most patients with corneal decompensation, there was a corneal silicone contact that was believed to cause this severe complication [9, 11, 21, 25, 31]. These authors expected that the incidence of corneal decompensation would be lower if an inferior peripheral iridectomy were routinely carried out in all aphakic and pseudophakic eyes [1, 2]. In our series, all aphakic and pseudophakic patients underwent an iridectomy at the 6 o'clock position. As recommended by Ando [1], the regular performance of an inferior iridectomy reduces the possibility of a pupillary block by the silicone oil bubble. However, we believe that not only did the regular performance of an inferior iridectomy lead to a substantially lower incidence of keratopathy in our series, but the use of high-purity and high-viscosity (5000 mPa·s) silicone oil had an additional, important impact on our results [11, 12, 16]. The chemical purity of the silicone oil used by our group since 1980 was determined by gel chromatography; the oil contains fewer low-molecular-weight components ($<0.4\%$) and no appreciable catalytic remnants. Both the high viscosity and the chemical purity presumably resulted in low incidences of silicone oil emulsification (0.7%) and secondary glaucoma (6%) as compared with other studies [8, 9, 11, 21, 25].

In all, 34% of the patients who underwent intravitreal silicone oil injection at our institution showed a usually transient postoperative IOP rise. Our data are consistent with the results of other authors reporting that following cataract formation, a postoperative IOP rise occurs in 2%–40% of all patients and is therefore the second most common complication of vitrectomy with intravitreal silicone oil injection [8, 11, 36]. Despite the mechanical effects of excessive silicone oil, which were seen in 12 patients in our series (2.9%) and required partial oil removal, factors such as inflammation, hemolysis, rubeosis iridis, and pupillary block may be responsible for the IOP rise. In 26 aphakic or pseudophakic eyes with relative pupillary blocks reopening of the inferior peripheral iridectomy was sufficient to solve this complication. In 14 of 26 patients with long-lasting secondary glaucoma, the IOP increase could not be managed by topical or oral antiglaucoma agents, and these patients had to undergo cyclocryocoagulation. With respect to the otherwise desperate situation of all eyes treated, secondary glaucoma and keratopathy were severe complications; however, the latter did not cause treatment failure in a substantial number of our patients.

Lens opacification is a common finding in phakic eyes, generally occurring within 6–12 months following vitrectomy with silicone oil injection [5, 9, 11, 15, 25, 29, 35, 38]. In a series of 32 patients with phakic eyes described by Casswell and Gregor [5], all patients developed lens opacities if the oil was present for longer than 10 weeks. Only in some eyes with early oil removal were lens opacities found to decrease [17]. Our findings agree with previously published data indicating that cataract formation is the most frequent complication in eyes containing intravitreal silicone oil [5, 11, 14].

As reported by other authors, a prominent cause of late visual failure following vitrectomy and silicone oil injection is reproliferation of pre- and subretinal membranes, leading to recurrent retinal detachment [6, 9, 11, 22, 24, 35]. At present, there is a controversy as to whether reproliferation of preretinal membranes occurs independently of the presence of intraocular silicone oil or is caused or triggered by intravitreal silicone oil [3, 10, 19, 22, 28, 35]. Similar to the variation in the incidence of complications such as keratopathy and corneal edema due to the use of silicone oil of different degrees of viscosity and purity, the reproliferation rate in the presence of intravitreal silicone oil may be dependent on the physicochemical characteristics of the silicone oil injected. At present, however, our understanding of the pathogenesis of preretinal membrane proliferation is still inconclusive.

Increased knowledge regarding membrane proliferation and further improvements in the chemical and physical characteristics of silicone oil will result in an optimization of the efficacy of intraocular silicone oil application. We therefore agree with other authors [9, 11, 22, 27, 31] that intravitreal silicone oil should currently be exclusively reserved for (1) eyes with advanced stages of PDR and (2) eyes with otherwise intractable PVR following conventional surgical techniques, such as scleral buckling, vitrectomy, membrane peeling, endolasercoagulation, fluid-gas exchange, and postoperative laser photocoagulation.

References

1. Ando F (1985) Intraocular hypertension resulting from pupillary block by silicone oil. Am J Ophthalmol 99:87–88
2. Beekhuis W-H, Ando F, Zivojnovic R, Mertens OAE, Peperkamp E (1987) Basal iridectomy at 6 o'clock in the aphakic eye treated with silicone oil: prevention of keratopathy and secondary glaucoma. Br J Ophthalmol 71:197–200
3. Bornfeld N, El-Hifnawi E, Laqua H (1987) Ultrastructural characteristics of preretinal membranes from human eyes filled with silicone oil. Am J Ophthalmol 103:770–775
4. Bourgeois JE, Machemer R (1983) The results of sulfur hexafluoride gas in vitreous surgery. Am J Ophthalmol 96:405–406
5. Casswell AG, Gregor ZJ (1987) Silicone oil removal: I. The effect on the complications of silicone oil. Br J Ophthalmol 71:893–897
6. Chan C, Okun E (1986) The question of ocular tolerance to intravitreal liquid silicone. Ophthalmology 93:651–660
7. Cibis PA, Becker B, Okun E (1962) The use of liquid silicone in retinal detachment surgery. Arch Ophthalmol 68:590–599
8. De Corral LR, Cohen SB, Peyman GA (1987) Effect of intravitreal silicone oil on intraocular pressure. Ophthalmic Surg 18:446–449
9. Dimopoulos S, Heimann K (1986) Spätkomplikationen nach Silikonölinjektion. Langzeitbeobachtungen an 100 Fällen. Klin Monatsbl Augenheilkd 189:223–227
10. Failer J, Faulborn J, Erb P (1984) Die Phagozytose von Silikon-Ölen unterschiedlicher Viskosität durch Peritoneal-Makrophagen der Maus. Klin Monatsbl Augenheilkd 184:450–452
11. Federman JL, Schubert HD (1988) Complications associated with the use of silicone oil in 150 eyes after retina-vitreous surgery. Ophthalmology 95:871–876
12. Gabel V-P, Kampik A, Burkhardt J (1987) Analysis of intraocular applied silicone oils of various origins. Graefe's Arch Clin Exp Ophthalmol 225:160–162
13. Glaser B (1988) Silicone oil for proliferative vitreoretinopathy. Does it help or hinder? Arch Ophthalmol 106:323–324

14. Gonvers M (1985) Temporary silicone oil tamponade in the management of retinal detachment with proliferative vitreoretinopathy. Am J Ophthalmol 100:239–245
15. Heimann K, Dimopoulos S (1984) Intra- und postoperative Komplikationen bei Silikonölinjektion zur Behandlung komplizierter Netzhautablösungen. Klin Monatsbl Augenheilkd 185:371–372
16. Kampik A, Gabel V-P, Spiegel D (1984) Intraokulare Tamponade mit hochviskösem Silikonöl bei massiver proliferativer Vitreo-Retinopathie. Klin Monatsbl Augenheilk 185:368–370
17. Kroll P, Hennekes R, Berg P (1985) Linsentrübungen nach intravitrealer Silikoninjektion. Fortschr Ophthalmol 82:235–236
18. Kroll P, Berg P, Biermeyer H (1988) Langzeitergebnisse nach vitreoretinaler Silikonölchirurgie. Fortschr Ophthalmol 85:259–262
19. Lambrou FH, Burke JM, Aaberg TM (1987) Effect of silicone oil on experimental traction retinal detachment. Arch Ophthalmol 105:1269–1272
20. Leaver PK, Grey RH, Garner A (1979) Silicone oil injection in the treatment of massive preretinal retraction: II. Late complications in 93 eyes. Br J Ophthalmol 63:361–367
21. Lemmen K-D, Dimopoulos S, Kirchhof B, Heimann K (1987) Keratopathy following pars plana vitrectomy with silicone oil filling. Dev Ophthalmol 13:88–98
22. Lewis H, Burke JM, Abrams GW, Aaberg TM (1988) Perisilicone proliferation after vitrectomy for proliferative vitreoretinopathy. Ophthalmology 95:583–591
23. Lincoff H, Coleman J, Kreissig I, Richard G, Chang S, Wilcox LM (1983) The perfluorocarbon gases in the treatment of retinal detachment. Ophthalmology 90:546–551
24. Lucke KH, Foerster MH, Laqua H (1987) Long-term results of vitrectomy and silicone oil in 500 cases of complicated retinal detachments. Am J Ophthalmol 104:624–633
25. Lucke K, Foerster M, Laqua H (1987) Langzeiterfahrungen mit intraokularer Silikonöl-Füllung. Fortschr Ophthalmol 84:96–98
26. Lund OE (1967) Silikon als Glaskörperersatz. Ber Dtsch Ophthalmol Ges 68:166–169
27. McCuen BW, Juan E de, Landers MB (1985) Silicone oil in vitreoretinal surgery: 2. Results and complications. Ophthalmology 93:646–650
28. Refojo M, Leong F-L, Chung H, Ueno N, Nemiroff B, Tolentino F (1988) Extraction of retinol and cholesterin by intraocular silicone oils. Ophthalmology 95:614–618
29. Roussat B, Ruellan YM (1984) Traitement du décollement de rétine par vitrectomie et injection d'huile de silicone. J Fr Ophthalmol 7:11–18
30. Scott JD (1977) A rationale for the use of liquid silicone. Trans Ophthalmol Soc UK 97:235–237
31. Sell Ch, McCuen BW, Landers MB, Machemer R (1987) Long-term results of successful vitrectomy with silicone oil for advanced proliferative vitreoretinopathy. Am J Ophthalmol 103:24–28
32. Stilma JS, Koster R, Zivojnovic R (1986) Radical vitrectomy and silicone oil injection in the treatment of proliferative vitreoretinopathy following retinal detachment. Doc Ophthalmol 64:109–116
33. The Retina Society Terminology Commitee (1983) The classification of retinal detachment with proliferative vitreoretinopathy. Ophthalmology 90:121–125
34. The Silicone Study Group (1985) Proliferative vitreoretinopathy. Am J Ophthalmol 99:593–595
35. Yeo JH, Glaser BM, Michels RG (1987) Silicone oil in the treatment of complicated retinal detachments. Ophthalmology 94:1109–1113
36. Zborowski-Gutman L, Treister G, Naveh N, Chen V, Blumenthal M (1987) Acute glaucoma following vitrectomy and silicone oil injection. Br J Ophthalmol 71:903–906
37. Zivojnovic R (1987) Silicone oil in vitreoretinal surgery. Junk, Dordrecht Boston Lancaster
38. Zivojnovic R, Mertens DAE, Peperkamp E (1982) Das flüssige Silicon in der Amotiochirurgie: II. Bericht über 280 Fälle – weitere Entwicklung der Technik. Klin Monatsbl Augenheilkd 181:444–452

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