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Cataracts associated with posterior segment surgery

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Cataract formation is the most frequent complication of pars plana vitrectomy, even without the use of air, gas, or silicone oil. The formation of lens opacities may occur intraoperatively, precluding adequate visualization during the last phases of a long procedure, or early postoperatively, making it difficult or impossible to complete fundus examination. Alternatively, a slow but progressive lens opacification following vitrectomy can be a major cause of underestimation of visual potential.

Although cataract is widely described among the complications of vitrectomy, the precise relationship between vitrectomy and the development of lens opacity is not completely understood. The following text presents an extensive literature review and the authors' personal experience with this complication.

Pathophysiology

The cause of nuclear sclerotic cataracts after vitrectomy is unknown. Anterior segment surgical procedures such as penetrating keratoplasty or trabeculectomy are associated cataract formation [1,2], and many investigators suggest that the natural aging of the crystalline lens is accelerated by surgical manipulation of the eye.

The crystalline lens responds to the cataractogenic stimulus of vitrectomy in the acute and chronic phases. The typical intraoperative or early postoperative feathered subcapsular opacities usually disappear completely. The formation of permanent posterior subcapsular cataracts after vitrectomy is infrequently observed [3–5]. More commonly, permanent changes occur slowly weeks to months following the procedure and involve the nuclear layer. The reasons for these lenticular changes are unclear. It is possible that contact of the posterior capsule with the vitreous substitute (BSS [balanced saline solution] at high flow during the procedure, air/gas, silicone oil) produces acute damage in the permeability of the posterior capsule, with accumulation of fluid in the posterior subcapsular fibers (a phase called "lens edema"). This accumulation is then reabsorbed with relative restoration of "lens balance" following the formation of a stable and increasing meniscus of fluid behind the lens (the absence of this meniscus after the use of silicone oil is probably the reason for the frequent formation of posterior subcapsular cataracts). A similar hypothesis has been suggested by Hsuan et al [5]. The permeability of the posterior capsule is altered, and, slowly, an accumulation/denaturation of proteins in the nucleus causes the formation of nuclear sclerotic cataracts. Other factors that have been advocated to contribute to lens damage after vitrectomy are described in the following sections.

Intense light exposure

Lens exposure to the ultraviolet light of the microscope or to the reflected light from the fiberoptic probe may be partially responsible for cataract formation. The mechanism may involve light inactivation of the antioxidant enzyme catalase and subsequent oxidation of lens proteins [6].

Fluid infusion into the vitreous cavity

High levels of glucose cause nonenzymatic glycation of lens proteins and eventual cataract formation [7]. This experimental finding led to the

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theory that lens opacities after vitrectomy could be caused by an excessive glucose concentration in the vitreous cavity from the infusion bottle. Nevertheless, this hypothesis is not confirmed by the clinical reports of de Bustros et al [4] and Cherfan et al [8] who found no differences in cataract formation in two groups of patients with varying glucose concentrations in the infusion solution. Moreover, in a well-conducted study, Haimann and Abrams [9] demonstrated that, although a low glucose concentration (BSS Plus, glucose = 100 mg/dL) in the infusion bottle was related to intraoperative lens opacification, a more elevated glucose concentration (glucose-fortified BSS Plus, glucose = 400 mg/dL) prevented intraoperative lens changes.

In a similar fashion, high concentrations of oxygen in the irrigating solution could contribute to oxidation of lens proteins, leading to an increase in fluorescent derivates and the development of nuclear cataracts [4].

Vitreous gel removal

Removal of the vitreous gel is probably the most important factor influencing cataract formation. This hypothesis is strongly supported by the fact that vitreoretinal procedures without vitreous gel removal seem to avoid the development of cataracts. Saito and associates [10] reported no cataract formation in 21 eyes followed up for 6 to 24 months (mean, 9.7 months) after nonvitrectomizing vitrectomy (two-port access to the vitreous cavity and membrane peeling without infusion and without vitreous gel removal) for idiopathic epiretinal membranes. These results were confirmed by the same investigators [11] in a larger series of eyes (41) with a longer follow-up (mean, 22 months) and using Scheimpflug photographs to measure the progression of nuclear sclerosis. The pneumatic retinopexy procedure also seems to have a low risk of cataract formation. Mougharbel et al [12] observed for 2 years a group of 33 patients treated in one eye with pneumoretinopexy (SF_6 20%) for superior retinal detachment. They compared using Scheimpflug photographs the lens transparency of both eyes in each patient, finding no statistical differences and no nuclear sclerotic cataract formation in the operated eye.

Why vitreous gel removal is related to nuclear sclerosis is unclear. Is is possible that the presence of the vitreous gel is essential to maintain the lens transparency, and that contact with a fluid media alters the permeability of the posterior capsule, modifying the lens metabolic exchange and leading to the accumulation of insoluble proteins and pigments responsible for the eventual color changes in the nucleus. This hypothesis is supported by the observation that vitreous gel liquefaction is often followed by cataract formation in many physiologic or pathologic conditions such as aging, degenerative myopia, chronic posterior uveitis, and Wagner-Stickler syndrome, among others.

Age

The development or progression of nuclear sclerotic cataracts after vitrectomy is greatly influenced by age. In 1991, Cherfan et al [8] were the first to report a much higher incidence of cataracts in patients older than 50 years following vitrectomy for macular pucker. Of 100 eyes observed for an average of 29 months, 9% of patients aged less than 50 years experienced a significant nuclear sclerosis compared with 68% of patients aged more than 50 years ($P < .0003$). The lower incidence of cataract formation in young patients was confirmed by Melberg and Thomas [13], even in cases of gas tamponade. In their study, three independent masked observers compared the progression of lens opacities (Lens Opacities Classification System [LOCS] III) after vitrectomy and fluid-gas exchange in two sets of 28 patients followed for a mean of 25.4 months. Only 7% of patients younger than 50 years experienced significant lens opacity in the surgical eye when compared with the nonsurgical eye versus 79% of patients older than 50 years ($P < .001$). The same results were reported by Ogura et al [14] who prospectively evaluated lens changes after vitrectomy on 55 patients with vitreoretinal interface syndrome by fluorophotometric measurement of lens autofluorescence.

Thompson [3] used linear regression analysis to evaluate (LOCS II grading scale) the development of lens opacity as a function of patient age in 301 eyes observed for a mean of 2.1 years after vitrectomy. His study not only demonstrated that the risk for nuclear sclerotic cataracts was sixfold greater after the age of 50 years but also that, after this age, the progression rate of cataracts was similar in patients 60, 70, or 80 years of age independent of the grade of preoperative lens opacity.

Incidence

Vitrectomy without tamponade

Although the development of nuclear sclerotic cataracts is the most frequent complication of

Table 1
Percentage of nuclear sclerotic cataract after simple vitrectomy without use of vitreous tamponade

Study	Eyes	Follow-up	Percentage of cataract
Margherio [18]	184	12–92 Months	12.5
McDonald [19]	33	—	39.0
De Bustros [4]	75	14 Months	47.0
Cherfan [8]	100	29 Months	80.0
Helbig [15]	306	5 Years	75.0
Berger [20]	63	6 Months	30.0
Hsuan [5]	10	—	30.0
Panozzo, Parolini[a]	305	3 Years	42.3

[a] Unpublished data.

vitrectomy, the reported incidence is extremely variable in the literature, ranging from 20% to 80%. This variability reflects many factors—the method used to define and grade the lens opacity, the length of follow-up, the mean age of patients, and the use of vitreous tamponade (Tables 1 and 2) [15–27].

De Bustros and associates studied the relationship between vitrectomy without the use of tamponade and the development of cataracts. They reported the development of nuclear sclerotic cataracts in 47% of 75 eyes (35 eyes) observed for an average of 14 months [4]. In a second report on more eyes (100) with a longer follow-up (mean, 29 months), this percentage increased to 80% [8]. When this value is compared with the 23% of nonoperated eyes that experienced similar cataracts, vitrectomy increased about four times the risk for significant lens opacities after 2 years. The development of posterior subcapsular opacity was not relevant in these two studies.

A similar high incidence was reported by Helbig et al [15] who studied the time course of cataract formation following vitrectomy for diabetic retinopathy. The course of 306 consecutive eyes in which the lens was retained during vitrectomy was analyzed for subsequent cataract surgery. The proportion of eyes that underwent cataract surgery after vitrectomy increased nearly linearly with time, approaching 75% after 5 years.

Following gas tamponade

Gas tamponade seems to have a significant effect on cataract formation, increasing from three to six times the incidence of lens opacities after vitrectomy. Thompson [3] evaluated the rate of nuclear sclerosis in eyes as a function of patient age and the use of intravitreal gas at the time of vitrectomy. The study population consisted of 301 consecutive eyes. Lens opacities were graded on a scale from 0 to 4.0 (LOCS II) before and after vitrectomy and compared with the findings in a similar group of nonoperated eyes. Follow-up ranged from 0.5 to 9.2 years (mean, 15 months). Using linear regression analysis, Thompson did not report an absolute value of incidence of cataract but found a progression rate of lens opacity that was sixfold to sevenfold greater in the operated eyes when compared with the nonoperated eyes. Intravitreal gas bubbles were associated with a nuclear sclerosis increase of approximately 60% in a comparison with eyes without use of a gas bubble. Hsuan and coworkers [5] conducted a prospective study to evaluate morphologic changes of the crystalline lens by digital Scheimpflug image analysis in 33 consecutive phakic patients after vitrectomy. A transient posterior subcapsular cataract developed in 89% (17 of 19) of eyes with gas tamponade within 24 hours of surgery compared with 9% (1 of 11) of the nontamponated eyes. Nuclear opacity developed in 67% (12 of 18) of the tamponated cases versus 30% (3 of 10) of the nontamponade cases. Eighteen percent (2 of 11) of the nontamponade cases and 67% (14 of 21) of the tamponade cases had cataract surgery after 10.7 months and 12.4 months of follow-up, respectively.

A longer tamponade is correlated to a higher incidence of cataract. Mulhern et al [28] compared the use of SF_6 and C_3F_8 for macular hole surgery, focusing on the development of lens opacities in a short-term study with 3 months of follow-up. They found an incidence of cataract 1.5 times greater in the group of eyes with long-standing tamponade. Progression of lens opacities occurred in 55% of cases with C_3F_8 compared with 37% of cases with SF_6.

Table 2
Incidence of cataract after vitrectomy and use of gas tamponade

Study	Eyes	Follow–up (months)	Percentage of cataract
Pournaras [21]	12	3.0	42.0
Ezra [22]	46	10.3	65.0
Blumenkranz [23]	99	11.0	33.0
Tabandech [24]	62	12.0	45.0
Scott [17]	74	13.9	83.4
Ezra [25]	124	24.0	58.1
Thompson [26]	21	24.0	76.0
Haritoglu [16]	86	32.0	84.0
Kalvodova [27]	84	36.0	67.9
Panozzo, Parolini[a]	22	36.0	95.0

[a] Unpublished data.

The incidence of cataracts after vitrectomy with gas tamponade increases with time and eventually approaches 100% (Table 2) [16,17,21–27]. Haritoglou et al [16] studying the long-term results of vitrectomy for macular holes in 86 eyes reported cataract extraction in 72 eyes (84%) 32 months after surgery. Of a cohort of 99 eyes that underwent a combined phaco/vitrectomy procedure, 91 were pseudophakic after 3 years of follow-up.

Contrary to most of the literature, Helbig et al [15] found no significant cataractous effect of intravitreal gas when compared with balanced salt solution in a group of 306 eyes with diabetic retinopathy followed up for 5 years.

Following silicone oil injection

Intravitreal silicone oil increases the incidence of cataracts following vitrectomy, but the percentage varies greatly in the literature, ranging from 60% [29] to 100% [30]. Histopathologic evaluation has not demonstrated silicone oil in the crystalline lens, and the cataract may be caused by the inhibition of normal metabolic exchange by the silicone bubble [31].

The cataract formation seems to be independent from the viscosity of silicone used, from partial or complete filling, from the postoperative positioning, and even from the time of removal.

Perfluorocarbon

Liquid perfluorocarbon is a heavy fluid used in vitreoretinal surgery as an intraoperative tool and as early postoperative vitreoretinal tamponade for complicated retinal detachments. Because this agent is used in complex cases and is removed at the end of surgery or soon after, its role in the formation of postoperative cataracts is difficult to establish and ranges from a rate of 18% to 92% at 1 year [17,32–35].

Personal experience

To determine the incidence of cataract extraction after vitrectomy in surgical practice, the authors retrospectively reviewed the data from surgical procedures performed over 3 years (2000 to 2002). Excluding combined phaco/vitrectomies and procedures for complex cases such as retinal detachments and diabetic or other proliferative retinopathies, a total of 327 eyes that underwent vitrectomy for macular pathologies were identified. Of these, 305 procedures were performed without the use of gas tamponade and 22 with the use of gas (the low percentage of gas tamponade was due to the authors' preference of combining phaco/pars plana vitrectomy in these cases). Ninety-three of the patients were over 50 years of age. Among the 305 eyes undergoing simple vitrectomy, after 3 years, 42.3% (129 eyes) had cataract extraction compared with 95% of eyes undergoing vitrectomy with gas tamponade (21 of 22 eyes).

Cataracts and other vitreoretinal procedures

Episcleral surgery

Although there is no direct relationship between episcleral surgery and the crystalline lens, an encircling buckle may cause anterior segment ischemia [36], possibly leading to cataract formation. The incidence of cataracts after episcleral surgery is unknown. Tornambe et al [37], comparing pneumatic retinopexy with episcleral surgery, reported nuclear sclerotic cataract requiring surgery after 2 years of follow-up in 18% of eyes treated with scleral buckling (4% incidence in the pneumatic retinopexy group).

Pneumatic retinopexy

The insertion of a small gas bubble into the vitreous cavity probably does not significantly interfere with the lens metabolism and leads to cataract formation much more infrequently than does a full gas fill procedure. Mugharbel et al [12] monitored for 2 years with a Scheimpflug camera the lens transparency of both eyes of 33 patients who underwent pneumatic retinopexy in one eye for a localized superior retinal detachment. They found no differences in lens opacity in treated versus fellow eyes. The 4% of cataracts reported by Tornambe et al [37] in the multicenter study on pneumatic retinopexy may have been related to the normal incidence of cataract in that group of patients. Inadvertent injection of a gas bubble into the lens may lead to cataract formation; however, this complication is uncommon.

Management of cataracts after vitreoretinal procedures

A few special modifications must be made to contemporary cataract extraction procedures in eyes with previous vitreoretinal surgery. Current phacoemulsification techniques with a small corneal incision, maintenance of a regular anterior chamber during the procedure, and insertion of the intraocular lens in the bag increase the safety of the extraction in eyes with a history of previous posterior segment work. The cataract surgeon should be prepared for potentially challenging factors relative to the procedure itself or to the correct intraocular lens selection and power calculation.

Cataract extraction after previous episcleral surgery

No significant modifications in the cataract surgical technique are necessary in eyes with previous retinal reattachment surgery with scleral buckling. The cataract can usually be extracted by an extracapsular technique or phacoemulsification [38].

The overall complication rate is low. Because cryotherapy or marked intraoperative scleral indentation can cause focal zonular dialysis, excessive traumatic maneuvers on the lens during phacoemulsification or intraocular insertion should be avoided.

A high encircling scleral buckle can cause an increase in corneal curvature and anterior displacement of the lens with shallowing of the anterior chamber [39]. Intraocular pressure is not altered, but intraoperative anterior chamber loss can be prevented using a small corneal incision. The use of viscoelastics helps protect corneal endothelium.

Although some postoperative complications occur, they do not seem to be related to previous retinal surgery and usually do not prevent good vision. Immediate postoperative complications include corneal edema, anterior chamber hyphema, vitreous hemorrhage, and fibrinous pupillary membrane. Late complications include isolated cases of posterior capsular opacity, herpetic corneal ulcer, and iris posterior synechia [40].

Cataracts after vitrectomy

Timing

The ideal timing of cataract removal after vitrectomy is unclear. The cataract should be removed when visual improvement is expected to be good, or when visualization of the retinal surface is precluded. There is no evidence that cataract extraction is a risk factor for recurrence of the retinal pathology in eyes with a history of vitrectomy surgery.

Numerous reports have suggested that cataract extraction leads to visual improvement in the vast majority of eyes with a history of previous vitreous surgery for macular hole formation, and no relationship with hole reopening has been reported [16,25,27]. Similar results are reported in cases of epiretinal membrane removal [4]. Although there is no supportive evidence in the literature, in the authors' experience, cataract extraction performed early after vitrectomy may have an increased inflammatory response, with subsequent cystoid macular edema (Irvine-Gass syndrome); therefore, cataract extraction is not recommended in the first 3 months following vitrectomy unless absolutely necessary.

Procedure

The best way to manage cataract extraction in the vitrectomized eye was controversial in previous decades, and many different techniques were proposed [41–43]. Phacoemulsification and in-the-bag intraocular lens implantation is now considered the safest technique [44–47]. Nevertheless, this procedure can be challenging, and the surgeon must be prepared for some unusual surgical findings.

Absence of the central vitreous gel following vitrectomy eliminates some of the natural support for the crystalline lens. This deficiency can lead to the formation of an abnormally deep anterior chamber and is a frequent, if not constant, finding during the forced fluid infusion of phacoemulsification. In these cases, the position of the surgical instruments is unusually tilted posteriorly and can generate intraoperative complications. The self-sealing corneal tunnel may remain open and leak, increasing the risk of capsular rupture. A small corneal incision, attention to avoid pressure on the corneal side of the tunnel, a lower infusion bottle height, and complete lens hydrolysis may guard against these risks.

Other surgical challenges include loose zonular fibers, a small pupil size, sudden changes in anterior chamber depth, unusual mobility and flaccidity of the posterior capsule [48,49], and posterior capsule fibrosis or plaque [44,46,47]. These complications are rare in eyes with previous limited core vitrectomy [50].

Control of intraocular fluid flow is crucial to avoid intraoperative hypotony. Some authorities suggest performing cataract extraction (both extracapsular and phaco) under posterior irrigation with an infusion cannula [43]. In the authors' experience, this is not necessary, and infusion from the vitreous chamber may increase the risk of anterior chamber loss during surgical maneuvers.

When feasible, phacoemulsification should immediately be followed by implant of the intraocular lens in the capsular bag. The use of different techniques of intraocular lens implantation depending on the post-vitrectomy anterior segment anatomy is not discussed in this review.

Table 3
Visual results in eyes undergoing cataract surgery following vitreous surgery

Study	Percentage of eyes with final vision ≥ 20/40
Chang (2002)	77.4
Grusha (1998)	72.7
Pinter (1999)	46.0
McDermott (1997)	50.0

Results

The anatomic and visual results of cataract extraction after vitrectomy depend in large part on previous retinal pathology but are generally satisfying, with most patients experiencing improvement. The percentage of patients with prior vitrectomy who improve to 20/40 or better after phacoemulsification ranges from 46% to 70% (Table 3) [41,42,48,51].

In one study by Ahfat et al [50], Snellen visual acuity improved in 84.6% of eyes previously treated for a macular hole, in 85.7% of eyes treated for "macula-on" retinal detachment, in 66.7% of eyes treated for "macula-off" retinal detachment, and in 57.1% of eyes treated for diabetic retinopathy.

Complications

The occurrence and rate of early and late complications are not significantly different when compared with the outcome of cataract extraction in nonvitrectomized eyes [42,43]. Postoperative posterior capsule opacification is more common in postvitrectomy than in control eyes (51% versus 21%; $P = .002$), especially if expandable gas or silicone oil is used at the time of vitrectomy. Rubeosis iridis and secondary glaucoma are rare postoperative complications when vitrectomy is performed in diabetic eyes.

Combined procedure of cataract extraction and vitrectomy

Since the advent of vitreous surgery, the crystalline lens has been removed during vitrectomy to allow a better view of the surgical field or to facilitate more complete access to the vitreous, which may be required in complicated proliferative vitreoretinopathy cases [52–54], in infants [55–57], or in trauma cases [58–61]. Nevertheless, the term *combined surgery* mainly refers to the surgical choice of combining, in a single surgical procedure, a conventional cataract extraction with artificial lens implantation and vitrectomy in cases when lens extraction is not strictly necessary for the retinal procedure. This approach has been proposed since the early 1990s and is now widely used when initial lens opacity is already present, or its evolution is expected after vitrectomy. Combined surgery has the advantage of single surgical intervention, cost reduction, and is less troublesome, especially for elderly patients [62,63].

The authors have reviewed more than 40 articles concerning combined surgery of cataract extraction and vitrectomy published since 1991 [59,62–98] and herein report a summary of our personal experience of more than 200 cases.

Technique

Phacoemulsification and posterior chamber intraocular lens implantation followed by three-port vitrectomy (phacovitrectomy) is the preferred technique for cataract surgery. Chen and Zhang [73] have investigated the combined operation of pars plana lensectomy-vitrectomy, preserving the lens anterior capsule and implanting the intraocular lens into the ciliary sulcus. They believe that this technique is a valuable option when cataract extraction becomes necessary in the course of a vitrectomy. When the necessity of lens extraction is obvious preoperatively, the combination of phacoemulsification and in-the-bag intraocular lens insertion is preferable. The addition of phacoemulsification does not prolong vitreoretinal operative time notably nor increase the risk of intraoperative and postoperative complications significantly [86]. A small limbal incision in phacoemulsification allows better control during the vitrectomy procedure and ensures a watertight wound. In addition, with the limbal approach, the posterior lens capsule is maintained, with all the attendant advantages [64].

Most surgeons simply perform the two procedures as independent steps, beginning with cataract extraction. Possible variants are limited and depend on the surgeon's preference. These variants include positioning of the posterior infusion cannula before cataract extraction to improve anterior chamber stability, filling of the anterior chamber with viscoelastic fluid until the end of vitrectomy, and intraocular lens implantation in the bag as the last step (but before the use of any vitreal tamponade). Reported techniques that may also simplify surgery and reduce complications include careful curvilinear capsulorrhexis, the use of intraocular lenses with larger optics, suturing of cataract wounds before vitrectomy, the use of miotics, and the avoidance of long-acting dilating drops in patients with intravitreal gas [95].

When the scleral approach is compared with a clear corneal incision, either technique seems safe. Eyes with smaller clear corneal incisions and foldable intraocular lenses have less postoperative inflammation and posterior capsule opacification, but may experience corneal endothelial dysfunction more frequently [97].

The authors' technique is a normal two-step procedure, with a superior (not temporal) corneal self-sealing incision. A corneal suture is not used unless necessary. The intraocular lens is positioned before vitrectomy, and, in the authors' experience, even a heavy peripheral indentation to remove vitreous base does not create anterior chamber loss nor dislocate the intraocular lens if the capsulorrhexis overlaps with the intraocular lens optic and a scleral tunnel incision is used.

Complications

Intraoperative

Because phacovitrectomy can be considered as two separate procedures, the intraoperative complications and their management do not differ from those reported for either step separately and are not reported herein. Accidental rupture of the posterior capsule does not preclude proceeding with vitrectomy if safe implantation of an intraocular lens in the bag can still be performed. Major ruptures with lens fragments in the vitreous chamber are usually managed by the vitreoretinal surgeon with conventional techniques. In this event, the authors recommend completion of the vitrectomy and consideration of postponing implantation of the artificial lens, with performance of one of the multiple options available (anterior chamber, sulcus, scleral fixation) in a second step, because the use of vitreous tamponade, already programmed or unexpected, can be followed by lens dislocation and significant anterior segment complications.

Postoperative

The incidence of postoperative complications is higher and the need for additional operations greater in eyes that require tamponade, corresponding with the severity of each case and the complexity of the surgical procedures [76]. Complications that may be increased with combination surgery include the following:

Neovascular glaucoma [64,67,89,91]. This complication is reported to be more frequent in diabetic patients undergoing combined surgery. Unless it is strictly necessary, in cases of advanced retinopathy, the authors recommend postponing cataract surgery for at least for 3 months following vitrectomy.

Pupillary capture [79,94]. The incidence of pupillary capture after phacovitrectomy and the injection of long-acting gas is high. This complication can be minimized by creating a smaller capsulorrhexis, avoiding long-acting dilating drops after surgery, face-down positioning, securing wound closure, and injecting an air bubble into the anterior chamber to push the iris-lens diaphragm posteriorly.

Intraocular lens dislocation [79].

Cystoid macular edema. Cystoid macular edema is a recognized complication of cataract surgery that does not seem to be enhanced by the combination with vitrectomy. Ando and coworkers [69], measuring with laser flare and cellometry the anterior chamber level of proteins, demonstrated that pars plana vitrectomy alone created little trauma to the blood-aqueous barrier, and that the postoperative flare in pars plana vitrectomy alone was close to preoperative levels. The association of pars plana vitrectomy and lens surgery should not be more traumatizing to the eye than lens surgery alone. A slightly higher occurrence of postoperative macular edema following phacovitrectomy when compared with vitrectomy alone has been reported by el Aouni [75] and Sheidow [78] and their colleagues, but this is probably related to cataract extraction and not to the combination of the two procedures.

Posterior capsular fibrosis. This complication seems to be more frequent when tamponade is used [77,89,90,94,95]. The capsular fibrosis is presumably caused by an accumulation of fibrin and the proliferation of stimulating factors in the narrow space between the intraocular lens and air/SF_6 gas bubble.

Myopic shift. Use of a gas tamponade may increase the myopic change owing to slight anterior displacement of the intraocular lens [67].

Cataracts and silicone oil

Cataract extraction in silicone oil–filled eyes

Cataract formation is the most common complication of intraocular silicone oil. Preventing cataract formation by removing the silicone oil in the first postoperative weeks is hampered by an increased risk of recurrence of vitreoretinal pathology. If cataract surgery becomes necessary, it should be performed maintaining the silicone oil tamponade [99,100].

Although extracapsular cataract extraction has been performed [101], the most suitable technique is phacoemulsification with in-the-bag intraocular lens implantation, avoiding damage to the posterior capsule and zonules [100]. An uncomplicated phacoemulsification using an anterior chamber maintaining system and a self-sealed corneal tunnel incision followed by in-the-bag intraocular lens implantation is usually not followed by anterior chamber migration of silicone oil [101]. Silicone intraocular lenses should be avoided.

The main postoperative complication is increased intraocular pressure [102]. Posterior capsule opacification occurs in all eyes within a few months and may be resolved with a neodymium: yttrium-aluminum-garnet laser capsulotomy [100,101].

Combined cataract and silicone oil extraction

Combining cataract surgery with silicone oil removal offers the advantages of a single surgery and faster visual rehabilitation [98]. The most common technique requires cataract extraction with phacoemulsification and silicone oil removal via pars plana sclerotomies, but different techniques have been proposed [98,99,103–109].

Investigators have compared the pars plana technique with transpupillary removal of the silicone oil [98,108,109]. In view of a decreased frequency of postoperative vitreous hemorrhage, a reduced rate of secondary cataract, and a shorter duration of surgery and visual rehabilitation, transpupillary drainage of silicone oil through a planned posterior capsulotomy compares favorably with removal of silicone oil through pars plana sclerotomies. The frequency of retinal redetachment did not differ significantly between the two groups and usually occurred within the first 3 postoperative months.

Combined cataract extraction and silicone oil removal poses a problem when trying to determine the power of intraocular lens to be used. Silicone oil leads to the following artifacts in ultrasonography [110–112]:

Longer eye due to slower sound speed. The sound velocity in normal vitreous is 1532 m/s, whereas in silicone oil–filled eyes, the velocity is 987 m/s. The sound velocity also depends on the degree of filling of vitreous cavity by silicone oil and whether the eye is phakic (1139 m/s) or aphakic (1052 m/s), on the length of the eye, and on the viscosity of silicone oil used.

Multiple fluid interfaces.

“**Lighthouse artifact.**” This artifact resembles a slightly divergent cone of light from a lighthouse and is caused by the accumulation of foreign body substances within silicone oil.

Different methods have been proposed to calculate biometry in combined procedures:

Conversion factors multiplied to the axial length measured in the presence of silicone oil. The conversion factor is different based on the viscosity of silicone oil. Some investigators report 0.71 for 1300 centistokes, 0.62 for 1000 centistokes, and 0.30 for 5000 centistokes [113].

Changing the velocity of the beam in a silicone oil–filled vitreous cavity to 987 m/s. This method is not accurate in highly myopic eyes.

Intraoperative biometry right after silicone oil removal. This is surely the most valuable intraocular lens measurement and is the method that the authors use in clinical practice, but it requires a wide availability of all powers of intraocular lens implants.

Fellow eye calculation.

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