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Cataract surgery and YAG-laser capsulotomy following vitrectomy for diabetic retinopathy

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Abstract The present study was initiated to assess time-course and risk factors for the development of cataract and posterior-capsule opacification as well as complications of cataract surgery and YAG-laser capsulotomy following vitrectomy for diabetic retinopathy. The charts of all patients undergoing vitrectomy for diabetic retinopathy during a 5-year period in a university eye hospital were retrospectively reviewed. The course of 306 consecutive eyes in which the lens was retained during vitrectomy was analyzed for subsequent cataract surgery and YAG-laser capsulotomy. The first 6 months after cataract or YAG-laser surgery were examined for the occurrence of complications. Data were analyzed with regard to the time course using Kaplan-Meier life-table analysis. The proportion of eyes that underwent cataract surgery after vitrectomy increased nearly linearly with time, approaching 75% after 5 years. Silicone tamponade (relative risk 1.9; $P=0.0005$) and transscleral retinal cryotherapy (relative risk 1.4; $P=0.003$) were risk factors for subsequent cataract surgery. No significant cataractogenous effect of intravitreal gas as compared with balanced salt solution was found. YAG-laser capsulotomy was performed in 60% of vitrectomized diabetic eyes within 2 years but in only 10% of nondiabetic controls ($P<0.0001$). Within 6 months of extracapsular cataract surgery with implantation of an intraocular lens (IOL) in 54 eyes, no serious complication was observed. After YAG-laser capsulotomy, vitreous hemorrhage occurred within 6 months in 6 of 21 eyes. In conclusion, cataract surgery was performed in 75% of the phakic eyes within 5 years of vitrectomy for diabetic retinopathy. Posterior capsular opacification is particularly common in this subset of eyes. No serious complication was observed after extracapsular cataract surgery with IOL implantation, but YAG-laser capsulotomy was associated with an increased risk for vitreous hemorrhage.

Key words Cataract surgery · Diabetic retinopathy · Vitrectomy · Posterior capsular opacification · YAG-laser capsulotomy

Zusammenfassung Die vorliegende Arbeit untersucht Zeitverlauf und Risikofaktoren für die Entwicklung von Katarakt und Nachstar nach Vitrektomie bei diabetischer Retinopathie sowie Komplikationen nach Kataraktchirurgie und YAG-Laserkapsulotomie. Die Krankenakten aller in einem Zeitraum von 5 Jahren in einer Universitätsaugenklinik vitrektomierten Diabetiker wurden retrospektiv analysiert. 306 konsekutive Augen, bei denen die Linse bei der Vitrektomie im Auge belassen wurde, wurden auf nachfolgende Kataraktoperationen und YAG-Laserkapsulotomien untersucht. Die ersten 6 Monate nach Kataraktoperation und YAG-Laserkapsulotomie wurden auf Komplikationen untersucht. Die Analyse der Daten erfolgte unter Berücksichtigung des Zeitverlaufes mit der Kaplan-Meier-Life-Table-Methode. Der Anteil der Augen, die nach Vitrektomie an einer Katarakt operiert wurden, stieg über die ersten Jahre annähernd linear an und erreichte nach 5 Jahren 75 %. Silikontamponade (relatives Risiko 1,9; $p=0{,}0005$) und transsklerale Netzhautkryobehandlung (relatives Risiko 1,4; $p=0{,}003$) waren signifikante Risikofaktoren für eine nachfolgende Kataraktoperation. Die intravitreale Gastamponade hatte im Vergleich zu BSS keinen signifikanten kataraktogenen Effekt. Eine YAG-Laserkapsulotomie wurde bei 60 % der vitrektomierten diabetischen Augen innerhalb von 2 Jahren durchgeführt, aber nur bei 10 % nichtdiabetischer Kontrollaugen ($p<0{,}0001$). Nach extrakapsulärer Kataraktoperation mit Implantation einer intraokularen Linse (IOL) traten an 54 Augen keine ernsthaften Komplikationen auf. Nach YAG-Laserkapsulotomie wurde bei 6 von 21 Augen innerhalb von 6 Monaten eine Blutung in den Glaskörperraum beobachtet. Innerhalb von 5 Jahren nach Vitrektomie bei diabetischer Retinopathie wurde bei 75 % der phaken Augen eine Kataraktoperation durchgeführt. Bei diesen Augen ist ein Nachstar besonders häufig. Nach extrakapsulärer Kataraktoperation mit IOL-Implantation wurden keine ernsthaften Komplikationen beobachtet, aber nach YAG-Laserkapsulotomie fanden sich gehäuft Blutungen in den Glaskörperraum.

Schlüsselwörter Kataraktoperation · Diabetische Retinopathie · Vitrektomie · Nachstar · YAG-Laserkapsulotomie

Introduction

The guidelines for the management of the lens during vitrectomy for complications of diabetic retinopathy have changed considerably during recent decades. In early years the lens was routinely removed during vitrectomy because rapid progression of cataract after vitrectomy was commonly observed [19]. Later it was found that intracapsular cataract surgery during and after diabetic vitrectomy dramatically increased the risk for development of neovascular glaucoma [5], and the lens was retained whenever possible.

If the lens is preserved during vitrectomy for complications of diabetic retinopathy, cataract formation is the most common postoperative complication. Several reports describe the development of cataracts without focusing on the time course of cataract formation [23, 25]. In the first part of the present report we describe cataract formation following pars plana vitrectomy with regard to the time course using Kaplan-Meier analysis and we systematically analyze risk factors for the development of cataracts using multivariate analysis.

Extracapsular cataract surgery with implantation of intraocular lenses (IOL) is mostly well tolerated during and after vitrectomy in diabetic eyes [4, 7, 9, 24]. Opacification of the posterior lens capsule is a common problem following extracapsular cataract surgery [2]. Data do not exist for the incidence of posterior capsular opacification in vitrectomized diabetic eyes. In the second part of the present report we describe the time course of the formation of posterior capsule opacification as compared with an age-matched control. In the third part we analyze the occurrence of complications following extracapsular cataract surgery and YAG-laser capsulotomy in vitrectomized diabetic eyes.

Patients and methods

We reviewed the charts of 337 consecutive patients (420 operated eyes) undergoing vitreous surgery for complications of diabetic retinopathy between 1990 and 1994, performed by the authors. If the charts did not provide sufficient data, follow-up information was obtained from the referring ophthalmologist. In all, 5 patients (7 eyes) had moved abroad earlier than 6 months after surgery and were excluded. Data on 413 eyes (332 patients) were analyzed. A total of 47 patients (56 eyes) had died; they were included with the last available follow-up data. The median follow-up period was 24 months. There were 153 men and 179 women aged a median of 58 years (range 24–91 years). In 114 patients the onset of diabetes had occurred before the age of 30 years and in 218 patients, after the age of 30 years. Indications for surgery were vitreous hemorrhage with attached retina in 166 eyes, tractional detachment of the macula in 52 eyes, combined traction-rhegmatogenous detachment in 48 eyes, and severe progressive proliferative retinopathy in 147 eyes. For intravitreal tamponade we used liquid silicone in 65 eyes, SF_6 gas (20–40 % in air) in 213 eyes, and balanced salt solution (BSS) in 135 eyes. Transscleral cryotherapy was performed in 157 eyes, especially in eyes with rubeosis of the iris, if endolaser coagulation was not possible.

The parameter analyzed in the present study was the time of cataract surgery and YAG-laser capsulotomy, respectively. This approach has the disadvantage that the indications for surgery may vary and different degrees of opacification may have been treated. Optimal monitoring of lens opacifications would require standardized Scheimpflug photographs or similar extensive techniques, but for a retrospective analysis the time of surgery gives a parameter of reasonable reliability.

Data were analyzed using the Kaplan-Meier life-table method and were tested with the log-rank test for univariate analysis and with the Cox proportional-hazards model for multivariate analysis.

Results

Cataract surgery after vitrectomy

The crystalline lens was present at the time of vitreous surgery in 383 eyes. It was primarily removed in 60 eyes

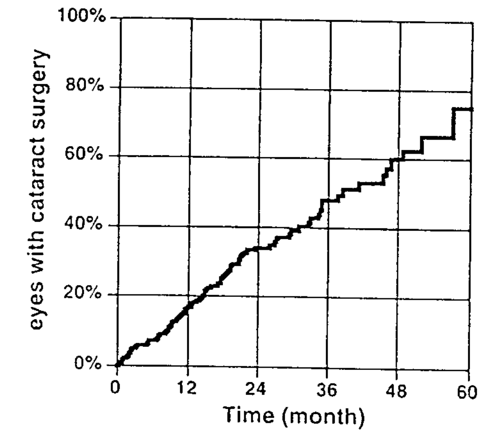

Fig. 1 Cumulative proportion of eyes undergoing cataract surgery following vitrectomy for complications of diabetic retinopathy ($n=306$)

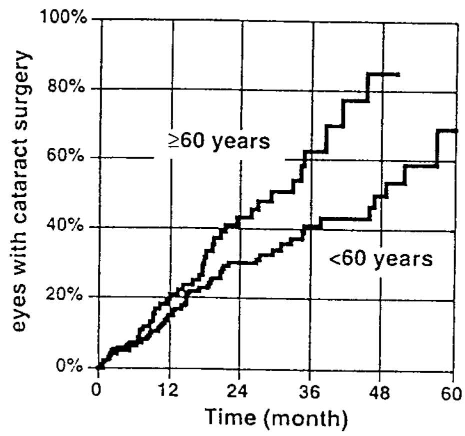

Fig. 3 Cumulative proportion of eyes undergoing cataract surgery following vitrectomy for different age groups (≥60 years, $n=101$; <60 years, $n=205$)

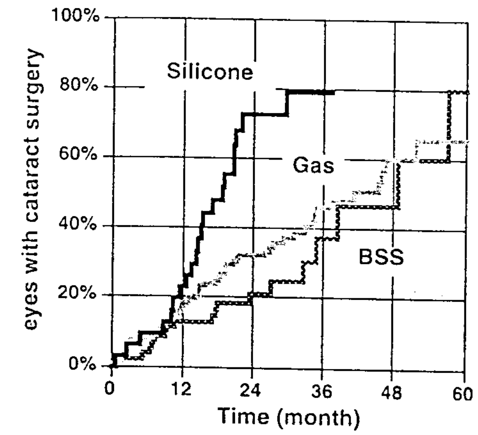

Fig. 2 Cumulative proportion of eyes undergoing cataract surgery following vitrectomy for different vitreous substitutes (silicone $n=34$; gas $n=169$; BSS $n=103$)

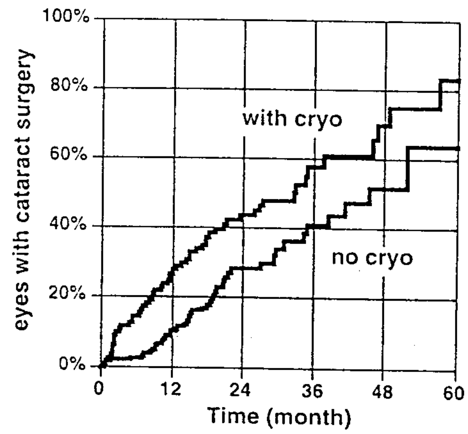

Fig. 4 Cumulative proportion of eyes undergoing cataract surgery following vitrectomy for eyes with ($n=114$) and without cryoablation ($n=192$) of the peripheral retina during vitrectomy

during vitrectomy. Thus, in 84% of the phakic eyes the lens was retained during vitrectomy, and 323 eyes of 255 patients remained phakic after vitreous surgery. In all, 17 eyes that had developed a dense cataract but were not operated on because of poor retinal function were excluded from further analysis. Cataract surgery was performed in 103 of 306 phakic eyes following vitrectomy. Figure 1 shows the time course for the cumulative proportion of eyes undergoing cataract surgery. Cataract surgery was performed without simultaneous procedures in 56 eyes, as cataract removal with simultaneous vitrectomy reoperation in 32 eyes, and in combination with silicone removal in 15 eyes. Phacoemulsification with implantation of a posterior-chamber lens was performed in 66 cases, in 4 eyes a posterior chamber lens was not implanted, and in 33 cases the lens was removed by pars plana lentectomy without implantation of an IOL. The average interval between vitrectomy and cataract surgery was 17±14 months (median 14 months; range 0.5–57 months).

Figure 2 shows the Kaplan-Meier plot generated for the cumulative proportion of eyes undergoing cataract surgery after vitrectomy for different vitreous substitutes. There was no statistically significant difference between eyes receiving gas or BSS as a vitreous substitute ($P=0.13$). In eyes receiving silicone tamponade, cataract surgery was performed earlier as compared with those receiving gas or BSS ($P=0.0001$). Figure 3 shows the life-table plots generated for the cumulative proportion of eyes undergoing cataract surgery for different age groups. Patients over 60 years of age had a higher risk of developing a cataract ($P=0.04$). Eyes that had transsceral cryo-surgery of the peripheral retina during vitreous surgery also had cataract surgery earlier ($P=0.0009$, Fig. 4). Vitreous substitute and cryosurgery of the peripheral retina were independent risk factors for subsequent cataract surgery, whereas the age of

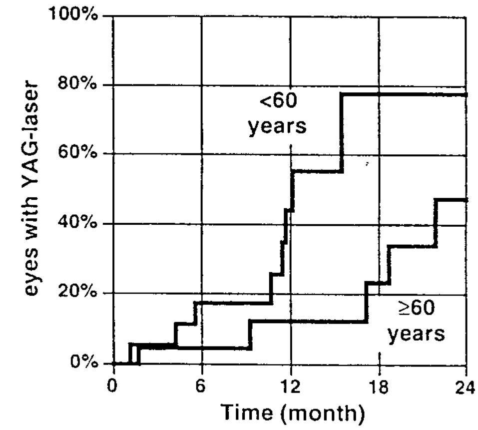

Fig. 5 Cumulative proportion of vitrectomized eyes undergoing YAG-laser capsulotomy following phacoemulsification with implantation of an IOL for different age groups (<60 years $n=26$; ≥60 years $n=28$)

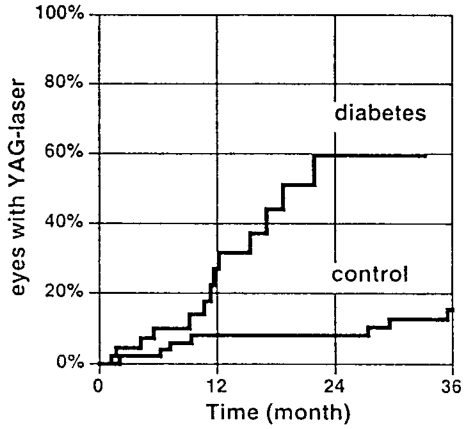

Fig. 6 Cumulative proportion of vitrectomized diabetic eyes (*diabetes*; $n=54$) and of eyes of age-matched nondiabetic patients (*control*; $n=54$) undergoing-YAG-laser capsulotomy following phacoemulsification with implantation of an IOL

Table 1 Multivariate analysis of factors influencing the probability of cataract surgery following vitrectomy[a]

Risk factor	Risk ratio	95% Confidence limits	*P* value
Silicone (yes vs no)	1.6	1.25±2.0	0.0005
Transscleral cryotherapy (yes vs no)	1.4	1.1–1.6	0.003
Age (years)	1.02	1.00–1.03	0.054

[a] Cox proportional-hazards model

the patient was not a significant factor in a multivariate analysis including these three variables (tested with the Cox proportional-hazards model; Table 1).

YAG-laser capsulotomy after cataract surgery

To evaluate the incidence of capsulotomy after extracapsular cataract surgery in vitrectomized diabetic eyes we studied 54 eyes of 43 patients in whom phacoemulsification with implantation of a posterior-chamber lens without simultaneous vitreoretinal surgery was performed. In most cases the IOL was positioned in the capsular bag. In 6 eyes without a smooth capsulorhexis it was placed in the sulcus. YAG-capsulotomy was performed in 13 of these 54 eyes. Figure 5 shows the Kaplan-Meier life-table analysis of the proportion of eyes undergoing YAG-laser capsulotomy for patients younger and older than 60 years. YAG-laser capsulotomies were more commonly performed in younger patients ($P=0.03$).

As a control we compared the incidence of YAG-laser capsulotomy in 54 (non-vitrectomized) age-matched nondiabetic eyes without inflammatory disease in which phacoemulsification with IOL implantation was performed. Patients in the control group were operated on by the same surgeons with the same techniques. Figure 6 shows that YAG-laser capsulotomies were more commonly performed in vitrectomized diabetics as compared with nondiabetic age-matched controls ($P=0.0001$).

Complications of cataract surgery and YAG-laser capsulotomy

The 6-month period after extracapsular cataract surgery and after YAG-laser capsulotomy was examined for postoperative complications. A total of 54 eyes undergoing phacoemulsification with implantation of a posterior-chamber lens without simultaneous vitreoretinal surgery were analyzed. None of the eyes had iris neovascularization at the time of cataract surgery.

Minor complications after extracapsular cataract surgery with IOL implantation were iris capture in 1 eye, posterior synechiae in 3 eyes, and significant inflammatory precipitates on the anterior surface of the IOL in 5 cases. In 2 eyes, minor neovascularization of the iris appeared, which regressed after retinal photocoagulation. No case of neovascular glaucoma developed. One eye was silicon-filled and was excluded from the analysis for vitreous hemorrhage after cataract surgery. Among the remaining 53 eyes, vitreous hemorrhage was found in 4 eyes within 6 months of cataract surgery; 1 of these eyes needed surgery, whereas in the other 3 eyes the hemorrhage cleared spontaneously.

A total of 21 eyes of 18 patients were evaluated for complications following YAG-laser capsulotomy. In 13 eyes, cataract surgery had been performed without simultaneous vitreous surgery, whereas 8 cases involved combined sur-

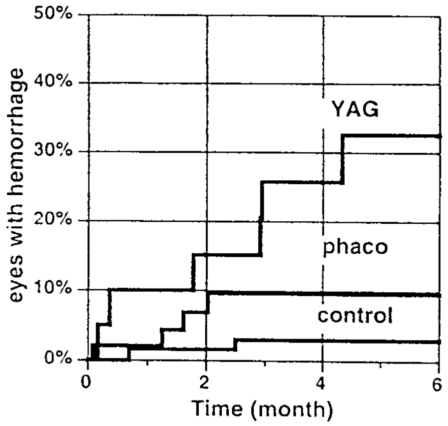

Fig. 7 Cumulative proportion of vitrectomized eyes presenting with hemorrhage into the vitreous cavity following YAG-laser capsulotomy (*YAG*, $n = 21$), phacoemulsification with IOL implantation (*phaco*, $n = 54$), as compared with controls without cataract surgery (*control*, $n = 69$)

gery. The interval between vitrectomy and capsulotomy averaged 23±12 (range 5±46; median 23) months, and the average interval was 11±6 (range 1±22; median 11) months between cataract surgery and capsulotomy. Within 6 months of YAG-laser capsulotomy for posterior-capsule opacification, vitreous hemorrhage associated with a decrease in visual acuity to hand motion occurred in 6 eyes. In 1 eye it was associated with neovascular glaucoma, and in another eye it was associated with a complete retinal detachment due to reproliferation and hypotony. In 2 cases the hemorrhage cleared spontaneously, whereas in 4 cases, vitreous surgery was performed. Vision was at least partially restored in all eyes. There was no correlation between the interval between cataract surgery and YAG-laser capsulotomy and the occurrence of complications (9±8 months for eyes with complications and 12±5 months for eyes without complications).

As a control for the occurrence of vitreous hemorrhage after vitrectomy without cataract surgery or capsulotomy we analyzed 69 phakic eyes without silicone for the 6-month period between 18 and 24 months after vitrectomy. Of these 69 eyes, 2 had a spontaneously clearing vitreous hemorrhage in the 6-month period of evaluation. Figure 7 shows the Kaplan-Meier curves generated for the occurrence of vitreous hemorrhage in controls, in eyes that had undergone cataract surgery, and in eyes treated with YAG-laser capsulotomy. The difference observed in the occurrence of vitreous hemorrhage between control eyes and eyes treated by YAG-laser capsulotomy was statistically significant ($P = 0.0001$). The difference seen between control eyes and eyes undergoing cataract surgery was not statistically significantly different ($P = 0.32$).

Discussion

Cataract formation is the most common complication of vitrectomy in phakic eyes, regardless of the indication for vitrectomy [6, 28]. Cataract formation after vitrectomy is even more common in diabetic eyes than in non-diabetic vitrectomized eyes [8]. Previous reports on diabetic eyes have discussed the percentage of eyes developing cataract with widely differing follow-up periods after vitrectomy [23, 25] without focusing on the time course of cataract formation. In the present study we analyzed the time course and found that the proportion of vitrectomized eyes that underwent cataract surgery increased nearly linearly with time, approaching 75% after 5 years.

In diabetic patients in general, cataract surgery is common. The risk of developing a cataract is 5 times higher in diabetic patients as compared with a nondiabetic population [7, 14]. The Wisconsin Epidemiologic Study of Diabetic Retinopathy found a cumulative 10-year incidence of 8% for type 1 diabetics and 24% for type 2 diabetics [14]. These rates, however, are much lower than the rate of 75% after 5 years found in the present study after vitrectomy, indicating that vitrectomy significantly increases the risk of developing a cataract.

Although we performed fewer cataract surgeries in younger patients, nearly 70% of the patients younger than 60 years had their lenses operated on within 5 years. In diabetic patients younger than 55 years who did not undergo vitrectomy the 10-year incidence of cataract surgery was only about 15% [14]. Thus, it is obvious that vitrectomy in diabetic eyes markedly accelerates the opacification of the lens, even in younger patients. This finding contrasts with the results of a recent study in younger patients without diabetes, where vitrectomy with fluid-gas exchange was shown to be only minimally cataractogenic [20].

In the present study the main risk factor for opacification of the lens after vitreous surgery was the use of liquid silicone as a vitreous substitute. Rapid development of a cataract is essentially inevitable following silicone tamponade, and about 60% of silicone-filled eyes need cataract surgery within 2 years [18]. The comparison between eyes receiving gas and those receiving BSS as a vitreous substitute showed that only a slightly higher proportion of eyes required cataract surgery after gas tamponade, but this difference was not statistically significant. In other studies, no lens change was seen at 2 years after the injection of gas into the vitreous without vitrectomy [22], and gas tamponade after vitrectomy had an effect on posterior subcapsular lens opacities but not on nuclear sclerosis [23]. Our data support the view that removal of the vitreous is the main cataractogenic factor, and the use of SF_6 gas has only a minor additional effect on the development of cataracts.

The association observed between retinal cryosurgery and subsequent cataract operation could possibly reflect a causal correlation. Transscleral cryotherapy leads to intraocular inflammation and cataract is a complication of intraocular inflammation, regardless of the cause. On the other hand, there is a potential bias, since the surgeon might less commonly perform laser surgery and be more apt to use cryotherapy in eyes in which visualization of the fundus is poor due to early cataract.

Posterior capsular opacification is a common problem after extracapsular cataract surgery. The reported incidence and time course vary widely, with the age of the patient being the most important risk factor [2]. Proliferative diabetic retinopathy has been postulated to represent a risk factor for the development of posterior-capsule opacification [11]. Our comparison with an age-matched nondiabetic control group shows a clearly higher rate of posterior capsular opacification in vitrectomized diabetic eyes. An increased concentration and facilitated diffusion of growth factors in vitrectomized eyes with proliferative diabetic retinopathy could explain the enhanced proliferation of lens epithelial remnants [13].

It is well established that intracapsular cataract extraction, especially in combination with vitrectomy, in diabetic eyes increases the risk for development of neovascular glaucoma and vitreous hemorrhage [5]. The risk for progression of the retinopathy or development of neovascular glaucoma is much lower after extracapsular surgery than after intracapsular surgery [24]. Most authors agree that complications after extracapsular cataract surgery in diabetics are rare and that implantation of an IOL is well tolerated [4, 29]. However, extracapsular cataract surgery has also been shown to be associated with progression of the retinopathy [10, 12] and with an increased incidence of postoperative anterior-segment inflammatory complications [16].

Eyes that have undergone prior vitrectomy can be considered to represent a group of particularly severe cases of diabetic retinopathy. Although extracapsular cataract surgery is technically more difficult in vitrectomized eyes [26], only few complications were observed after extracapsular cataract surgery with IOL implantation following vitrectomy in the present study and in the literature [4, 9], indicating that previous vitrectomy may not represent a particular risk factor. In eyes with proliferative retinopathy, cataract surgery may be performed even more safely after vitrectomy, since the retinopathy may become more stable after vitreous surgery [4, 9].

In the literature we found contradictory statements concerning the frequency of complications following YAG-laser posterior capsulotomy in diabetic eyes. Several authors have reported only few complications after YAG-laser capsulotomy and concluded that YAG-laser capsulotomy was not associated with a higher rate of progression of retinopathy [4, 12, 24]. In contrast, other investigators have described cases of neovascular glaucoma and progression of diabetic retinopathy after YAG-laser capsulotomy [17, 30]. For eyes that have undergone vitrectomy and extracapsular cataract surgery, only very few reports on YAG-laser capsulotomy are available in the literature [9, 15].

In the present study we found a significantly increased risk for vitreous hemorrhage following YAG-laser capsulotomy in vitrectomized diabetic eyes. The interval between capsulotomy and the occurrence of complications suggests that chronic changes, possible progression of the retinopathy, were responsible for the observed complications. The development of neovascular glaucoma after cataract surgery or posterior capsulotomy can be convincingly explained by facilitated diffusion of vasoproliferative factors [1] from the ischemic retina to the iris and the alteration in the oxygen supply [27]. In the pathophysiology of the progression of the retinopathy after cataract surgery or capsulotomy, other mechanisms must play a role. Possibly, the surgically induced production of inflammatory mediators [21] contributes to worsening of the retinopathy [3], a mechanism similar to that postulated for the development of cystoid macular edema after cataract surgery or capsulotomy [21].

The rapid development of significant cataracts after vitrectomy for diabetic retinopathy is a good reason to perform phaceoemulsification with IOL implantation simultaneously with vitreous surgery, especially in eyes of elderly patients with intended silicone tamponade or early cataracts. The combined procedure is well tolerated, leads to a better visual rehabilitation, and spares the patient from additional surgery [15]. However, posterior capsular opacification is very common in this subset of eyes, especially in young patients, and secondary YAG-laser capsulotomies seem to be associated with an increased rate of postoperative complications. Kokame et al. [15] have suggested the performance of a primary posterior capsulotomy during combined vitreous and cataract surgery. If this combined procedure results in fewer complications, this question can be answered only with further studies.

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