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Long-Term Safety and Efficacy of Limited Vitrectomy for Vision Degrading Vitreopathy Resulting from Vitreous Floaters

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Purpose: Vitreous floaters can lower visual acuity (VA) and degrade contrast sensitivity function (CSF). Limited vitrectomy improves VA and normalizes CSF, but long-term results in a large series with objective quantitative outcome measures are lacking.

Design: Case series.

Participants: One hundred ninety-five eyes of 145 patients (87 men, age = 57.6 ± 4.3 years; 58 women, age = 61.5 ± 12.0 years) reporting bothersome vitreous floaters were compared to 70 age-matched controls. Posterior vitreous detachment (PVD) alone was the cause in 96/195 (49.2%), myopic vitreopathy alone was the cause in 30/195 (15.4%), PVD with myopic vitreopathy was the cause in 56/195 (28.7%), and asteroid hyalosis was the cause in 13/195 eyes (6.7%).

Methods: Limited vitrectomy with 25-gauge instruments was performed without surgical PVD induction, preserving 3 to 4 mm of retrolental vitreous in phakic eyes. Follow-up averaged 32.6 ± 23.5 months (range, 3–115 months), with 2 years or more in 144 eyes, 3 years or more in 69 eyes, 4 years or more in 51 eyes, and 5 years or more in 24 eyes.

Main Outcome Measures: Visual acuity, 39-item National Eye Institute Visual Function Questionnaire (VFQ) results, CSF (Weber index), and quantitative ultrasonography results.

Results: After surgery, vitreous echodensity decreased by 94.1% ($P < 0.0001$) and VFQ results improved by 19.3% ($P < 0.0001$). Preoperative VA was 0.68 ± 0.21, improving to 0.77 ± 0.19 after surgery ($P < 0.0001$). Preoperative CSF was degraded by 91.3% compared with controls ($P < 0.0001$), normalizing at 1, 3, 6, 12, 24, 36, and 48 months after surgery ($P < 0.00005$ for each). There were no cases of endophthalmitis. There were 3 retinal tears and 3 retinal detachments that underwent successful repair. Clinically significant vitreous hemorrhage developed in 2 patients, clearing spontaneously. Two macular puckers and 4 recurrent floaters from new PVD were cured by re-operation. Cataract surgery occurred in 21 of 124 patients (16.9%; mean age, 64 ± 7 years; none younger than 53 years), an average of 13.1 ± 6.8 months after vitrectomy.

Conclusions: Limited vitrectomy for Vision Degrading Vitreopathy decreases vitreous echodensity, improves patient well-being, improves VA, and normalizes CSF. The long-term efficacy and safety profiles suggest this may be a safe and effective treatment for clinically significant vitreous floaters, warranting a prospective randomized trial. *Ophthalmology Retina 2018;2:881-887 © 2018 by the American Academy of Ophthalmology*

Vitreous opacities cause floaters, which can significantly disturb some patients.[1,2] The most common causes for vitreous floaters are age-related posterior vitreous detachment (PVD),[3,4] and myopia-related vitreous gel liquefaction with collagen aggregation, known as myopic vitreopathy.[5–9] Asteroid hyalosis is an infrequent cause of significantly bothersome vitreous floaters.[10–12]

Not only have previous studies shown that patients with vitreous floaters report a significantly lower quality of life,[1,2,13] but have also shown that these patients are psychologically distressed, and the degree of psychological distress is associated significantly with the severity of floater symptoms.[14] A likely cause for dissatisfaction with vision and distress is the significant reduction in contrast sensitivity function (CSF) that has previously been detected in these patients,[15–18] probably because of scattering of incident light.[19,20]

Thus, treating vitreous floaters is increasingly considered for many patients. Current therapeutic options are observation without intervention, Neodymium:yttrium–aluminum–garnet (Nd:YAG) laser,[9,21,22] and vitrectomy surgery.[23,24] Preliminary studies have shown that vitrectomy can remove vitreous opacities safely and improve visual acuity (VA)[25] and CSF,[3,8,9,18] but long-term studies in large numbers of participants using objective quantitative outcome measures are lacking.

This study examined the long-term safety and efficacy (both structural and functional) of limited vitrectomy in a large cohort followed for 32.6 months, on average, with at least 2 years follow-up in 144 patients, at least 3 years of follow-up in 69 patients, and at least 4 years of follow-up in

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51 patients. All participants continue to be followed, and the exact duration of follow-up (to date) for all patients is demonstrated in Figure 1. Objective quantitative outcome measures were used to evaluate efficacy prospectively.

Methods

Institutional review board/ethics committee approval from St. Joseph Hospital, Orange, California was obtained and all described research adhered to the tenets of the Declaration of Helsinki. Informed consent was obtained from each participant and all study-related records were maintained according to Health Insurance Portability and Accountability Act compliance rules. Eyes with a history of previous vitrectomy, active diabetic retinopathy, age-related macular degeneration, or intravitreal injections were excluded. In patients with bilateral vitreous floaters (n = 50), each eye was considered separately. Patient satisfaction or dissatisfaction with vision was quantified using the 39-item National Eye Institute Visual Function Questionnaire, administered before and at least 1 month after surgery.

Participants

Originally, 202 eyes were enrolled, but 5 participants moved out of the area shortly after surgery, never returned for follow-up, and therefore were excluded. Two hypertensive men 69 and 73 years old chose not to return for follow-up care after developing post-op central retinal artery occlusion that was unrelated to surgery. Thus, this series consists of 195 eyes in 145 patients (87 men with a mean age of 57.6 ± 14.3 years and 58 women with a mean age of 61.5 ± 12.0 years) undergoing limited vitrectomy for vitreous opacities who had a minimum follow-up of 3 months. As reported by the patients, the average duration of coping from onset of bothersome symptoms until the time of surgery was 35 ± 14.7 months. The average post-operative follow-up was 32.6 ± 23.48 months (range, 3−115 months), with at least 1 year of follow-up in 160 eyes, 2 years or more in 144 eyes, 3 years or more in 69 eyes, 4 years or more in 51 eyes, and 5 years or more in 24 eyes (Fig 1). One participant was diagnosed with choroidal melanoma 22 months after surgery and chose not to continue in the study. No other problems have arisen, and the remaining 194 participants continue to be followed.

Demographics are presented in Table 1. Pseudophakia was present in 71 of 195 eyes (36.4%). Prophylactic cryopexy or laser retinopexy for peripheral retinal breaks was performed at least 2 months before vitrectomy surgery in 42 eyes (21.5%; 19 atrophic holes (9 with slight pigmentation) and 23 retinal tears). The most common cause of vitreous floaters was PVD alone (96/195 [49.2%]), followed by combined myopic vitreopathy with PVD (56/195 [28.7%]). Myopic vitreopathy alone was the cause in 30 of 195 eyes (15.4%). The average degree of myopia was −5.3 ± 3.4 diopters (D), with a range of −1.25 to −15 D. Asteroid hyalosis was the cause in 13 of 195 eyes (6.7%). There were 70 age-matched controls without vitreous floaters whose contrast sensitivity function was measured as a control group for this test of vision.

Objective Testing

To diagnose PVD, ultrasonography (AVISO; Quantel Medical, Clermont-Ferrand, France) was performed in each patient. SD-OCT (OPTOS, Marlborough, MA) was also performed and provided confirmation of ultrasonography results when the posterior vitreous cortex was close enough to the retina to image. Long-term effects on vision were studied prospectively by measuring VA in all 195 eyes and CSF testing in the last 139 consecutive eyes before and after surgery. Best-corrected VA was measured by a certified tester using a standardized Early Treatment Diabetic Retinopathy Study chart.

Contrast sensitivity function was measured with the computerized Freiburg Acuity Contrast Testing.[3,26−28] The Freiburg Acuity Contrast Testing test uses a light-emitting diode computer display monitor with a spatial resolution of 218 pixels per inch. Luminance calibration was performed before each evaluation by manually entering the observer distance from the display and the

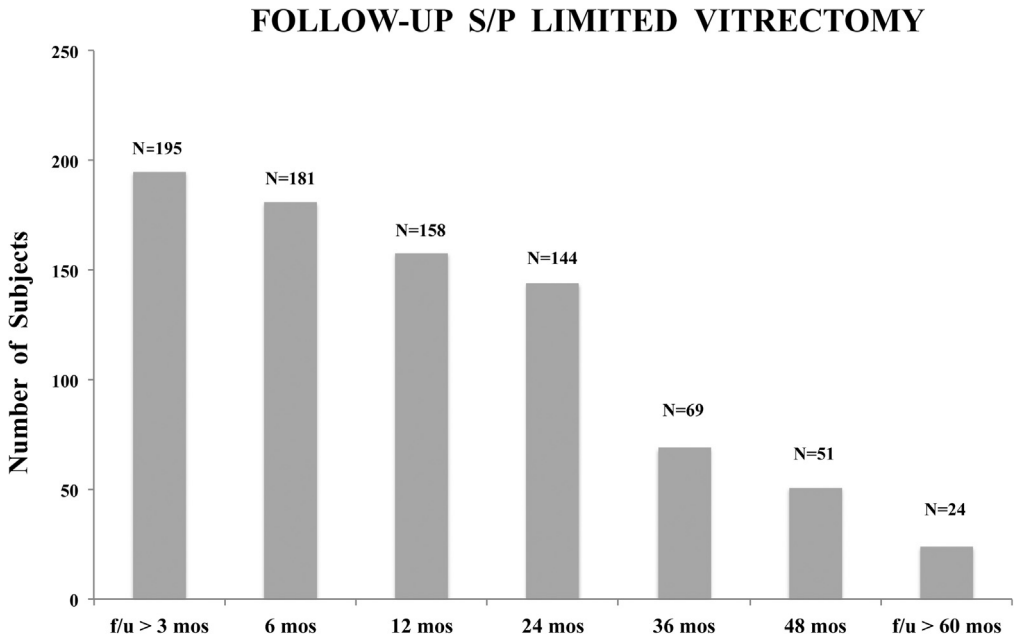

Figure 1. Duration of follow-up (f/u). S/P = status-post.

Table 1. Demographics and Clinical Characteristics

Patients or Eyes	No.	%
Patients (n = 145)		
Men	87	60
Mean age±standard deviation (yrs)	57.6 ± 14.3	
Women	58	40
Mean age±standard deviation (yrs)	61.5 ± 12.0	
Eyes (n = 195)		
Phakic	124	63.6
Pseudophakic	71	36.4
Myopia	30	15.4
PVD	96	49.2
Myopia and PVD	56	28.7
Asteroid hyalosis	13	6.7

PVD = posterior vitreous detachment.

length of a ruler line on the display, allowing the program to calculate screen resolution and visual angle of the optotypes. The same monitor was used throughout the study and testing was performed at the participant's eye level under mesopic conditions in a dark room after 3 minutes of dark adaptation. Because mesopic vision is a combination of photopic and scotopic vision in low-light settings, this likely represents what patients typically see, and thus closely approximates their reality. The test uses a tumbling gapped Landolt C presented as a gray character on a lighter background in 1 of 8 possible orientations at different contrast levels, a spatial frequency of 5 cycles per degree, and 18 trials per test. All participants were tested with their refractive correction at a distance of 2.9 meters and the fellow eye occluded. A software algorithm automatically computed the participant's CSF value in terms of the Weber index (%W), calculated as:

$$\%W = (L_{max} - L_{min}) / L_{max} \times 100,$$

where L is the luminance, min is minimum, max is maximum; lower %W values indicate better CSF. Normal CSF typically is better than conventional screen luminance resolution, which at 8 bits allows only 256 luminance levels. This is addressed by use of a technique known as dithering to improve luminance resolution.[29] Dithering involves spatial pooling of each 2×2 block of pixels to achieve intensity values intermediate to those of single pixels. This allows subthreshold contrast stimuli to be generated, thereby increasing the effective resolution and transcending the 8-bit limitation of conventional displays.[29]

The reproducibility of CSF measurements using Freiburg Acuity Contrast Testing was reported previously as 92%.[3] Repeatability in this study, defined as the standard deviation of 3 separate measurements in 20 randomly chosen eyes from 20 patients with clinically significant vitreous floaters, was ±0.26% W, which translates to a repeatability of more than 89.2% in controls and 94.4% in subjects with vitreous floaters.

Quantitative ultrasonography was obtained before and after surgery in 75 patients using an AVISO system with a 15-MHz single-element focused transducer, as described previously.[30] A horizontal longitudinal scan through the macula was obtained by placing the probe on the nasal aspect of the globe posterior to the limbus with the patient gazing temporally. The acoustic values were defined as the digitized envelope values between 0 and 255. As previously described,[30] the P50, defined as the percentage of the scanned area filled by clusters of echogenic regions larger than 50 pixels (0.069 mm), was used as the outcome measure of vitreous density before and after limited vitrectomy. Results are expressed in arbitrary units (AU).

Surgery

Each patient underwent sutureless, 25-guage 3-port vitrectomy (Accurus and Constellation; Alcon, Fort Worth, TX) performed under local anesthesia by a single surgeon (J.S.) at the Newport Bay Surgery Center (Sovereign Health & Hoag Hospital, Newport Beach, CA). Posterior vitreous detachment was not induced during surgery and peripheral vitreous was not removed. In all phakic eyes, 3 to 4 mm of retrolental vitreous was preserved. A nonhollow probe was inserted for superior cannula extraction.

Results

Prospective, quantitative ultrasonography of vitreous echodensity in 75 eyes found that after limited vitrectomy, vitreous echodensity decreased by 94.1% (7.37 AU reduced to 0.44 AU; $P < 0.0001$). Patient satisfaction after limited vitrectomy was evaluated prospectively with the 39-item National Eye Institute Visual Function Questionnaire in 75 participants. There was 19.3% improvement in the composite score ($P < 0.0001$), with 28.13% improvement in general vision ($P < 0.0001$) and 27.37% improvement in near activities ($P < 0.0001$). Best-corrected VA was 0.68 ± 0.21 before surgery. After surgery, this improved to an average of 0.77 ± 0.19 ($P < 0.0001$ at each postoperative time point after 1 month). Figure 2 illustrates significant improvement at 1 month after surgery, which was maintained at 3, 6, 12, 24, 36, 48, and 60 months after limited vitrectomy.

Contrast sensitivity function was measured in the last 139 consecutive patients and was found before surgery to be reduced by 91.3% (4.59 ± 2.34%W) compared with that of 70 age-matched controls (2.40 ± 0.90%W; $P < 0.001$). After limited vitrectomy, CSF normalized at 1 week (2.46 ± 1.46%W; n = 140; $P < 0.00005$), 1 month (2.21 ± 1.18%W; n = 140; $P < 0.00005$), 3 months (2.04 ± 0.95%W; n = 140; $P < 0.00005$), 6 months (2.30 ± 1.49%W; n = 115; $P < 0.00005$), 1 year (2.34 ± 1.98%W; n = 94; $P < 0.00005$), 2 years (2.11 ± 1.52%W; n = 65; $P < 0.00005$), 3 years (2.36 ± 1.93%W; n = 31; $P < 0.00005$), and 4 years (2.16 ± 0.11%W; n = 15; $P < 0.00005$; Fig 3).

Table 2 presents all postoperative complications in 195 eyes. There were no eyes with endophthalmitis or hypotony. Clinically significant vitreous hemorrhage developed in 2 eyes (1.03%). Each case cleared spontaneously within 6 weeks, with the patient achieving excellent vision.

Retinal tears (n = 3 [1.5%]) developed 1 day after surgery in a 53-year-old man with preoperative PVD as the cause of vitreous floaters, 6 months after surgery in a 23-year-old myopic (−6.75 D) man, and 54 months after surgery in a 46-year-old myopic (−2.75 D) woman. All were successfully repaired with retinal cryopexy. Retinal detachment occurred in 3 eyes (1.5%). One case presented 2 weeks after surgery, another 10 months after surgery, and the third 14 months after limited vitrectomy. All underwent successful surgical (vitrectomy, laser, and gas) repair, achieving excellent vision.

Clinically significant macular pucker developed at 6 and 13 months after limited vitrectomy in 2 eyes that showed no preoperative PVD or intraoperative PVD induction. These were cured successfully with vitrectomy and membrane peel surgery.

Branch retinal vein occlusion occurred in 3 eyes (1.5%) at 1 day, 18 months, and 32 months after vitrectomy. Two cases (1.03%) of central retinal artery occlusion occurred, one in a 69-year-old man and another in a 73-year-old man, both with systemic hypertension.

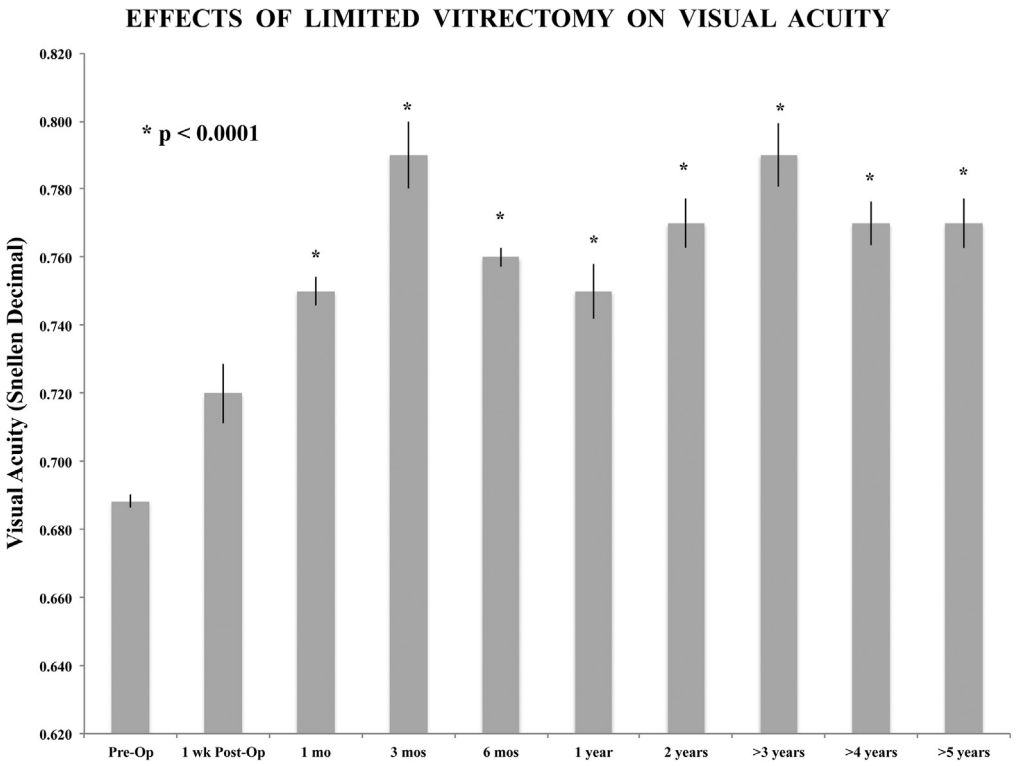

Figure 2. Visual acuity after limited vitrectomy. One month after limited vitrectomy for clinically significant vitreous floaters inducing vision degrading vitreopathy, there was significant ($P < 0.0001$) improvement of visual acuity, which was sustained for the entire follow-up period of 5 years or more. Post-Op = after surgery; Pre-Op = before surgery.

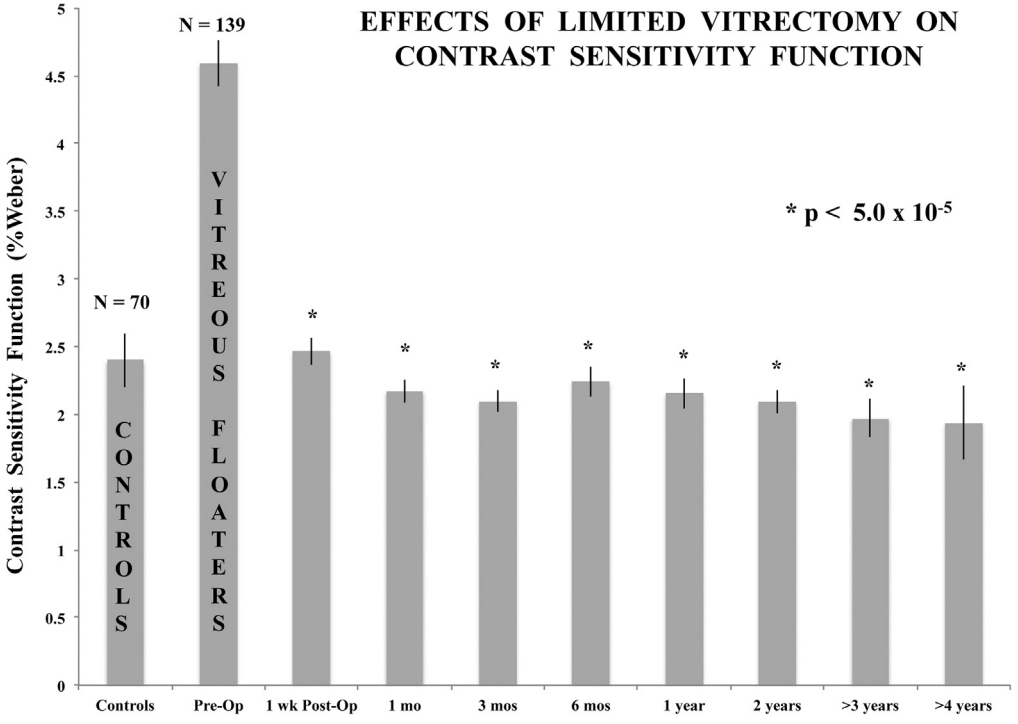

Figure 3. Contrast sensitivity function after limited vitrectomy. Contrast sensitivity function in 139 consecutive eyes (4.59 ± 2.34%W) was reduced by 91.3% compared with that of 70 age-matched controls (2.40 ± 0.90%W; $P < 0.001$). After limited vitrectomy, there was normalization in each eye, that was sustained for more than 4 years (and counting). Post-Op = after surgery; Pre-Op = before surgery; %W = Weber index (see "Methods").

Table 2. Postoperative Complications

Complication	No. (n = 195 Eyes)	%
Vitreous hemorrhage	2	1.0
Retinal detachment	3	1.5
Retinal tear	3	1.5
BRVO	3	1.5
CRAO	2	1.0
Endophthalmitis	0	0.0
Glaucoma	1	0.5
Cataract surgery (124 phakic eyes)	21/124	16.9
PVD (43 without PVD before surgery)	4/43	9.3
Macular pucker	2	1.0

BRVO = branch retinal vein occlusion; CRAO = central retinal artery occlusion; PVD = posterior vitreous detachment.

In 43 eyes without preoperative PVD, 30 had myopic vitreopathy and 13 had asteroid hyalosis. Posterior vitreous detachment was not induced during surgery. After surgery, 4 of 43 eyes (9.3%) experienced symptomatic PVD at 1 month, 5 months (2 eyes), and 13 months after limited vitrectomy. These patients were unhappy with their vision, because their average CSF diminished by 36% from 1.75 ± 0.64%W to 2.38 ± 0.12%W, as previously noted after PVD.[15,19] At their request, repeat vitrectomy was performed without complications, completely resolving floater symptoms. Mean CSF improved from 2.38 ± 0.12%W to 1.47 ± 0.36%W ($P < 0.01$), confirming previous reports.[3,8,9,18]

Cataract surgery was performed after limited vitrectomy in only 21 of 124 phakic eyes (16.9%), confirming previous findings after limited vitrectomy.[31] The mean age of these patients was 64.4 ± 6.9 years and no patient requiring cataract surgery was younger than 53 years. The mean time to cataract surgery was 13.1 ± 6.8 months (range, 5–24 months; Fig 4). Of 19 patients younger than 40 years, none have required cataract surgery after limited vitrectomy (mean follow-up time = 38.3 ± 19 months; range, 24–80 months).

Discussion

Vitreous floaters result from opacities in the vitreous body that can be imaged and quantified by ultrasonography.[8,9,30] Clinically significant cases have marked reduction in contrast sensitivity function,[3,9,15,18] and thus can be appropriately termed *Vision Degrading Vitreopathy*. This study demonstrated that limited vitrectomy achieves a substantial (94%) reduction in vitreous echodensity, improving VA as well as normalizing contrast sensitivity function, with improvements averaging 46%.

Further, this study found an acceptable safety profile because this large group of participants was followed for a long time, during which the rate of complications was relatively low. The 1.5% incidence of retinal detachment was lower than that of previous studies (10.9%[32] and 6.8%[33]). The favorable safety profile for rhegmatogenous events in this study may, in part, be the result of the avoidance of

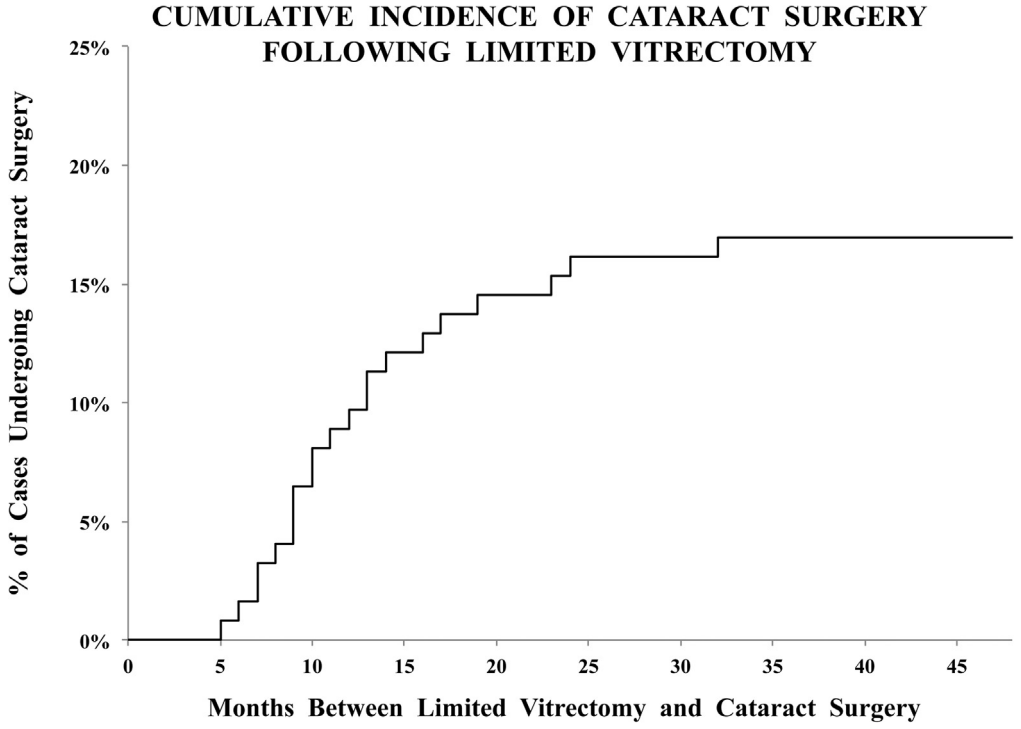

Figure 4. Cumulative incidence of cataract surgery. Kaplan-Meier curve showing the cumulative incidence of cataract surgery in 124 phakic eyes demonstrating a low incidence (16.9%), with an average time of onset of 13.1 ± 6.8 months after limited vitrectomy. Most cataract surgeries occurred within 2 years of limited vitrectomy. The mean age of those undergoing cataract surgery was 64.4 ± 6.9 years, and no patient requiring cataract surgery was younger than 53 years.

inducing surgical PVD during surgery, because this previously has been shown to increase the risk of retinal tears.[34,35] Another factor is careful preoperative examination of the peripheral fundus, performed in each eye of this study with binocular indirect ophthalmoscopy and scleral depression. Prophylactic treatment of lesions that predispose to rhegmatogenous retinal detachment, which occurred in 21.5% of the eyes in this study, also likely reduced the incidence of postoperative rhegmatogenous complications.

Clinically significant vitreous hemorrhage occurred in 2 eyes (1.03%), the same incidence as reported previously.[25] In both eyes, this cleared spontaneously without any sequelae, achieving excellent vision. The incidence of postoperative macular pucker of 1.03% was lower than the previously reported incidence of 3.6%,[33] suggesting that not inducing surgical PVD does not unduly predispose patients to the development of macular pucker.

With a mean follow-up of 32.6 months, this study found a 16.9% cumulative incidence of cataract surgery, which is much lower than that previously reported after vitrectomy for floaters (50% during a mean follow-up of 10 months,[32] and 60% during a mean follow-up of 37 months[33]). This is also true after vitrectomy for vitreomacular traction (63% during a mean follow-up of 35 months),[36] vitrectomy for macular pucker (80% during a mean follow-up of 29 months),[37] and after vitrectomy for macular holes (65% within 1 year).[38] This lower incidence of cataract surgery after limited vitrectomy confirms the findings of a recent study in which the cumulative incidence of cataract surgery after limited vitrectomy was significantly lower than that after extensive vitrectomy for vitreous floaters (35% vs. 87%, respectively; $P < 0.001$), and the time after limited vitrectomy until cataract surgery was significantly ($P < 0.002$) longer compared with that after extensive vitrectomy.[31] It has been hypothesized that not inducing surgical PVD may be associated with reduced anterior vitreous oxygen tension, thereby reducing free radical damage to lens proteins and reducing cataract formation.[8,39] Furthermore, the preservation of gel vitreous behind the lens might maintain sufficient levels of antioxidants native to vitreous that help mitigate against free radical effects and the formation of cataracts. Future studies could confirm this with in vivo measurements of vitreous oxygen tension[40,41] and measurements of lens protein aggregation with in vivo dynamic light scattering.[42–44]

The limitations of this study are that it is retrospective and not randomized. However, the findings suggest that *Vision Degrading Vitreopathy*, a condition resulting from vitreous floaters that degrade vision, can be treated safely and effectively with limited vitrectomy. This study of 195 eyes followed up for an average of 32.6 months, used objective, quantitative outcome measures, and found a marked reduction in vitreous echodensity, improved patient well-being, improvement in VA, and normalization of contrast sensitivity function that was sustained for up to 4 years after limited vitrectomy. Thus, a prospective randomized clinical trial is warranted.

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Abbreviations and Acronyms:
AU = arbitrary units; **CSF** = contrast sensitivity function; **D** = diopter; **PVD** = posterior vitreous detachment; **VA** = visual acuity; **%W** = Weber index.

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