VITRECTOMY FOR FLOATERS

Prospective Efficacy Analyses and Retrospective Safety Profile

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Purpose: Floaters impact vision but the mechanism is unknown. We hypothesize that floaters reduce contrast sensitivity function, which can be normalized by vitrectomy, and that minimally invasive vitrectomy will have lower incidences of retinal tears (reported at 30%) and cataracts (50–76%).

Methods: Seventy-six eyes (34 phakic) with floaters were evaluated in 2 separate studies. Floater etiologies were primarily posterior vitreous detachment in 61 of 76 eyes (80%) and myopic vitreopathy in 24 of 76 eyes (32%). Minimally invasive 25G vitrectomy was performed without posterior vitreous detachment induction, leaving anterior vitreous, and using nonhollow probes for cannula extraction. Efficacy was studied prospectively (up to 9 months) in 16 floater cases with Freiburg Acuity Contrast Testing (Weber index [%W] reproducibility = 92.1%) and the National Eye Institute Visual Function Questionnaire. Safety was separately evaluated in 60 other cases followed up on an average of 17.5 months (range, 3–51 months).

Results: Floater eyes had 67% contrast sensitivity function attenuation (4.0 ± 2.3 %W; control subjects = 2.4 ± 0.9 %W, $P < 0.013$). After vitrectomy, contrast sensitivity function normalized in each case at 1 week (2.0 ± 1.4 %W, $P < 0.01$) and remained normal at 1 month (2.0 ± 1.0 %W, $P < 0.003$) and 3 months to 9 months (2.2 ± 1.5 %W, $P < 0.018$). Visual Function Questionnaire was 28.3% lower in floater patients (73.2 ± 15.6, N = 16) than in age-matched control subjects (93.9 ± 8.0, N = 12, $P < 0.001$), and postoperatively improved by 29.2% ($P < 0.001$). In the safety study of 60 floater cases treated with vitrectomy, none developed retinal breaks, infection, or glaucoma after a mean follow-up of 17.5 months. Only 8 of 34 cases (23.5%) required cataract surgery (none younger than 53 years) at an average of 15 months postvitrectomy.

Conclusion: Floaters lower contrast sensitivity function, which normalizes after vitrectomy. Visual Function Questionnaire quantified improvement in satisfaction. Not inducing posterior vitreous detachment reduced retinal tear incidence from 30% to 0% ($P < 0.007$). Postvitrectomy cataract incidence was reduced from 50% to 23.5% ($P < 0.02$). This approach thus seems effective and safe in alleviating the visual dysfunction induced by floaters.

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Floaters are entopic phenomena observed by patients as hairlike, flylike gray linear obscurations to vision that move with ocular saccades and demonstrate an overdamping behavior described by patients as "floating" in and out of their vision. Most commonly, the etiology of floaters is age-related and/or myopia-induced alteration of vitreous macromolecular organization that results in the liquefaction of the gel, aggregation of collagen into visible fibers, and ultimately collapse of the vitreous body.[1] Resultant posterior vitreous detachment (PVD)[2] is the most common cause of floaters, followed by myopic vitreopathy,[3] and asteroid hyalosis.

To date, most practitioners have not considered floaters a significant clinical problem and thus have not often contemplated therapeutic intervention. However, recent studies[4–6] found that floaters are perceived by patients as a serious medical condition that has a significant negative impact on the quality of life. Increasingly, therapy for floaters is being considered[7–12] but patients with clinically bothersome floaters have limited treatment options: eye drops, neodymium-doped yttrium-aluminum-garnet (YAG) laser, or vitrectomy. Eye drops have never been scientifically shown to be effective and conflicting results have been reported with the YAG laser.[7,13] Furthermore, posteriorly located vitreous opacities cannot be safely treated by the YAG laser.[14]

Although floaters are curable by vitrectomy,[7–12] this procedure is invasive and iatrogenic retinal tears and cataracts are concerns.[15] If the untoward visual effects of floaters could be objectively quantified and if the risks of surgery could be lessened, then the risk:benefit ratio of vitrectomy for floaters might be more favorable than currently perceived. Concerning the former, we hypothesize that floaters decrease contrast sensitivity to a level that can be quantified objectively and that this will result in an untoward effect on patient well-being that can similarly be quantified by National Eye Institute-validated Visual Function Questionnaire (VFQ) testing. Concerning the latter, studies[16] have shown that not inducing PVD during vitrectomy for macular pucker lowers the incidence of retinal breaks from 32% to 2.1% ($P = 0.006$) and in macular holes from 12.7% to 3.1% ($P = 0.008$). Similar studies[17] of floater vitrectomy found iatrogenic breaks in 30.1% of cases when PVD was induced intraoperatively when compared with 11.1% without PVD induction ($P < 0.02$). Furthermore, the use of nonhollow probes for cannula extraction at the end of surgery has been shown to decrease vitreous incarceration in the sclerotomies, a risk factor for endophthalmitis and retinal tears.[18,19]

Regarding cataracts after vitrectomy, studies[20–22] have shown that the vitreous contains antioxidants and that vitrectomy as well as PVD increase intravitreal oxygen levels, postulated to be the cause of cataract formation. Thus, leaving anterior vitreous intact and not inducing PVD during vitrectomy might lower the incidence of postvitrectomy cataract formation from the previously reported levels of 50% to 76%.[17,23,24]

This study was undertaken to determine whether floaters impact contrast sensitivity and if vitrectomy can normalize contrast sensitivity function (CSF) and alleviate visual dissatisfaction measured objectively with VFQ testing. It is further hypothesized that performing surgery with 25 gauge instruments, not inducing PVD, not removing anterior vitreous, and using nonhollow probes for cannula extraction will have an acceptably low incidence of postoperative complications, particularly endophthalmitis, retinal tears/detachments, and cataracts requiring surgery.

Materials and Methods

Institutional review board approval was obtained and the study adhered to the tenets of the Declaration of Helsinki. A total of 114 eyes in 99 subjects were enrolled: 38 control eyes and 76 eyes of floater patients (26 women and 35 men; mean age, 59 ± 14 years) who underwent 25 G vitrectomy for floaters. Surgery was performed on an average of 24 months after the onset of bothersome floaters, constituting a considerable period of attempted coping. Exclusion criteria were eyes that received intravitreal injections or a history of vitrectomy before floater vitrectomy. One eye had a scleral buckle surgery 7 years ago and 6 eyes had a YAG laser treatment to floaters a minimum of 2 years before undergoing vitrectomy for floaters.

Minimally invasive sutureless 3-port vitrectomy was performed under local anesthesia by a single surgeon (J.S.) with 25G instruments (Accurus; Alcon, Fort Worth, TX). Peripheral vitreous was not removed, and in no case was a PVD induced intraoperatively. A nonhollow probe was inserted for superior cannula extraction in all cases. During surgery in phakic eyes, great care was taken to avoid removing the vitreous within 3 mm to 4 mm behind the lens. Two separate studies were conducted. Efficacy was tested in 16 cases and safety was evaluated in 60 separate cases.

Efficacy Study

Efficacy was studied in 16 floater eyes of 16 subjects (10 men, 6 women, mean age, 54.3 ± 18.8 years, age range, 23–88 years; phakic eyes, 15 of 16). In the case of bilateral floaters, only one eye per subject (chosen randomly) was enrolled in this study. The most common identifiable etiologies of floaters in this group were PVD in 10 of 16 cases (63%), myopic vitreopathy in 2 of 16 cases (13%), and asteroid hyalosis in 1 of 16 cases (6%). Prophylactic retinopexy (cryopexy or laser) had been performed for retinal breaks a minimum of 3 months before vitrectomy in 4 of 16 cases (25%).

Contrast sensitivity. Contrast sensitivity function was evaluated using computer-based Freiburg Acuity Contrast Testing.[25–27] Control subjects (16 randomly chosen eyes in 16 normal subjects) were age-matched (mean age, 52.6 ± 14.6 years) to the 16 floater patients. All subjects were dark adapted for 3 minutes and then tested

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at a distance of 2.9 m in a dark room while wearing correction if ametropic. The Weber index [%W = $(Luminance_{max} - Luminance_{min})/Luminance_{max}$][28,29] was defined as the outcome measure in all CSF studies. Reproducibility studies in 10 eyes (randomly selected left or right eyes) of 10 subjects (4 men, 6 women; mean age, 54.3 ± 16 years) determined a coefficient of variance = 0.079 (92.1% reproducibility). Eyes with floaters were tested before vitrectomy and the results were compared with age-matched control subjects. Patients with floaters were reevaluated 1 week, 1 month, and 3 months to 9 months postoperatively.

Subjective visual function evaluation. All floater patients were evaluated for subjective well-being preoperatively and at 1 week, 1 month, and 3 months to 9 months postoperatively using the standardized National Eye Institute VFQ. Preoperative VFQ indices in floater patients (N = 16) were compared with age-matched control subjects (N = 12). In case of subjects who had both eyes treated (N = 4; only one [randomly chosen] eye was included in the efficacy study), the results after the second procedure were compared with the preoperative values obtained before the first procedure.

Statistical analyses were performed using Fisher exact test of equal proportions and independent samples *t*-test. Values of $P < 0.05$ were considered significant.

Safety Study

Safety was studied separately in 60 additional cases from 49 patients (11 bilateral) with a minimum follow-up of 3 months (mean, 17.5 months; standard deviation, 13.1; range, 3–51 months). There were 25 men and 24 women (mean age, 59.3 ± 14.1 years; 34 phakic eyes; 26 pseudophakic eyes). Of the 60 eyes, the etiology of floaters was PVD in 41 (68.3%), myopic vitreopathy in 20 (33.3%), asteroid hyalosis in 6 (10%), and old vitreous hemorrhage that had cleared but left cellular debris in 2 (3.3%). Prophylactic retinopexy (cryopexy or laser) was performed for retinal breaks at a minimum of 3 months before vitrectomy in 15 of 60 cases (25%).

Ultrasound imaging was obtained with the AVISO B-Scan (Quantel Medical, Clermont-Ferrand, France) to diagnose PVD preoperatively and postoperatively. Spectral domain optical coherence tomography was performed with the combined optical coherence tomography–scanning laser ophthalmoscope (Optos, MA) to assess the vitreoretinal interface preoperatively and postoperatively.

Results

Efficacy Study

At presentation, CSF was diminished by 67.4% in patients with floaters (4.0 ± 2.3 %W, N = 16) compared with age-matched control subjects (2.4 ± 0.9 % W, N = 16, $P < 0.013$) (Figure 1). In each case, postoperative CSF normalized at 1 week (2.0 ± 1.4 %W, $P < 0.01$) and remained normal at 1 month (2.0 ± 1.0 %W, $P < 0.003$) and 3 months (2.2 ± 1.5 %W, $P < 0.018$). Table 1 contains CSF data.

All but one patient had a complete resolution of floater symptoms. Visual function was evaluated by VFQ testing and 8 of the 11 subindices of this questionnaire showed an average of 28.3% diminution in floater patients as compared with control subjects without floaters ($P < 0.001$). One month after vitrectomy, there was an improvement in each of these 8 subindices on an average of 29.18% ($P < 0.001$, Table 1) as compared with preoperative values. The individual improvements were mental health (46.1%, $P < 0.001$), general vision (34.6%, $P < 0.004$), role difficulties (32.4%, $P < 0.002$), driving (26.2%, $P < 0.004$), near activities (17.2%, $P < 0.035$), dependency (13.6%, $P < 0.034$), social functioning (12.9%, $P < 0.017$), and peripheral vision (10.7%, $P < 0.029$) (Figure 2).

Safety Study

Minimum follow-up was 3 months in all cases and mean follow-up was 17.5 ±13.1 months (range, 3–51 months). No patient developed retinal breaks, retinal detachments, endophthalmitis, intraocular hemorrhage, or glaucoma. Of the 19 eyes without PVD preoperatively, only 1 (5.3%) developed PVD postoperatively,

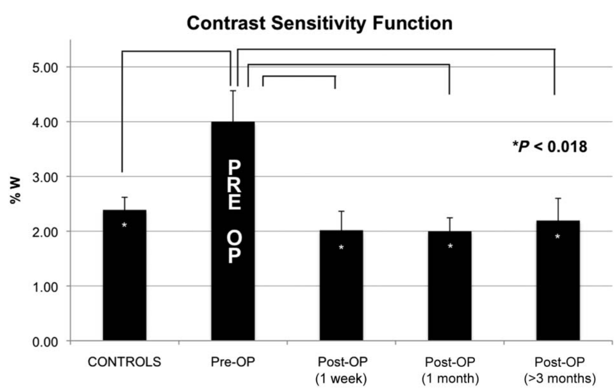

Fig. 1. Preoperative CSF was 67.4% worse in floater subjects (4.00 ± 2.26 %W) compared with age-matched control subjects (2.39 ± 0.92 % W, $P < 0.013$). After vitrectomy, CSF normalized at 1 week and remained normal 1 month and 3 months to 9 months postoperatively. Pre-OP, preoperative; Post-OP, postoperative.

Table 1. Efficacy of Vitrectomy for Floaters

Demographics			CSF (%W)					VFQ		
No.	Age, Years	Eye	Preoperative (CSF)	Postoperative (1 Week)	Postoperative (1 Month)	Postoperative (≥3 Months)	% Improvement at ≥3 Months, %	Preoperative (VFQ)	Postoperative (1 Month)	% Improvement, %
1	56	OD	3.78	2.7	2.37	2.36	37.57	80.68	68.44	–15.17
2	67	OS	5.44	1.78	2.46	3.61	33.64	85.16	93.23	9.48
3	88	OS	10.4	6.97	5.28	6.97	32.98	73.07	82.81	13.33
4	46	OD	3.77	2.44	2.44	2.03	46.15	62.14	77.08	24.06
5	58	OS	5.7	1.78	1.8	2.03	64.39	41.88	100.00	138.81
6	53	OD	7.05	1.92	1.66	1.99	71.77	78.44	84.48	7.70
7	77	OS	3.08	1.61	2.01	2.01	34.74	96.25	95.42	–0.87
8	23	OD	1.6	1.05	1.17	1.1	31.25	88.80	97.81	10.15
9	63	OD	3.01	1.72	1.72	1.24	58.80	74.27	98.85	33.10
10	25	OS	2.17	1.19	1.19	1.19	45.16	63.02	86.85	37.81
11	32	OD	2.59	1.3	1.45	1.42	45.17	45.05	88.33	96.07
12	63	OD	2.88	1.53	2.45	1.99	30.90	86.35	98.85	14.48
13	30	OD	1.88	1.52	1.46	1.46	22.34	59.11	87.50	48.02
14	71	OS	2.74	1.65	1.52	—	—	81.46	84.48	3.71
15	56	OD	4.6	1.27	1.32	1.32	71.30	69.06	91.25	32.13
16	61	OD	3.32	1.85	1.68	—	—	86.09	98.18	14.04
Average			4.00	2.02	2.00	2.19	44.73	73.18	89.60	29.18
P				<0.01	<0.003	<0.018				<0.001

OD, right eye; OS, left eye.

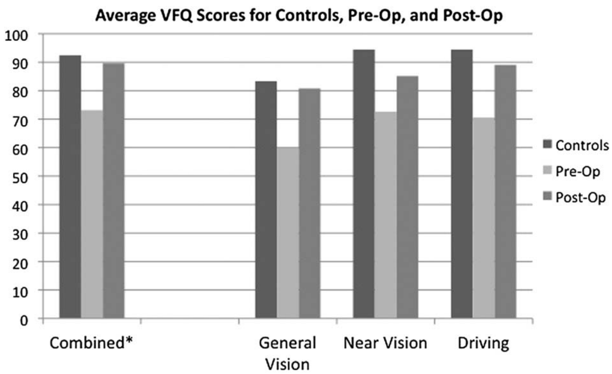

Fig. 2. *The average improvement of all statistically significant sub-indices was 29.2% at 1 month postoperatively, which was sustained at 3 months to 9 months. General vision, near vision, and driving improved 34.6% ($P < 0.004$), 17.2% ($P < 0.035$), and 26.2 % ($P < 0.004$), respectively. Of note, the postoperative VFQ scores not only improved but approximated control levels. Pre-Op, preoperative; Post-Op, postoperative.

occurring after 13 months. This resulted in floaters that were sufficiently bothersome to the patient to prompt reoperation, performed with good results and no untoward sequelae. Only the first procedure was included in this study. In the remaining 18 of 19 eyes (94.7%), the absence of postoperative PVD was confirmed by ultrasound and optical coherence tomography imaging and followed up on an average of 18.4 months (range, 3–48 months). In 1 case, macular pucker developed 13 months postoperatively. The patient underwent successful membrane peel surgery attaining final visual acuity of 20/25.

Clinically significant cataracts requiring surgery developed in 8 of 34 phakic eyes (23.5%). This occurred at an average of 14.9 months postvitrectomy. The mean age of this subgroup was 60.5 years and the range was 53 to 66 years.

Discussion

These studies found that symptomatic vitreous floaters interfere with vision by markedly lowering CSF, presumably because of light scattering with altered diffraction patterns of incident light. Contrast sensitivity function is as important to visual performance as visual acuity and visual field.[28–30] The real world seldom offers the 100% contrast that is used for clinical visual acuity testing, explaining why the 67% average loss of CSF that was found in this study of patients with floaters eroded the patient's visual abilities (especially general vision) substantially impacting role difficulties and well-being (Figure 2). This effect was documented by the National Eye Institute-validated VFQ testing. Both CSF measurements and VFQ assessments of visual well-being normalized after vitrectomy. Contrast sensitivity function improvement was observed in each patient after 1 week and was sustained at 1 month and 3 months. A similar observation has been made for stray light measurements, which also quantify the visual effects of light scattering by vitreous opacities,[31] but vitrectomy in the 39 floater cases of that study only improved stray light measurements by 18.2%.[32] The reasons for this relatively limited response are unclear but may relate to the fact that 21% of their cases had preoperative stray light measurements that were within the normal range.

Patients perceive floaters as a significant health problem,[4] and there is a growing demand for safe and effective therapies.[6] Eye drops and neodymium-doped YAG laser treatments have no proven efficacy.[7,13,14] Vitrectomy, however, offers a definitive cure. Given the invasive nature of vitrectomy, there are risks of endophthalmitis, retinal tears and detachments, and cataract formation. The risks can be mitigated with modern surgical instrumentation and judicious technique. Indeed, this study found that treating floaters with sutureless 25G vitrectomy without PVD induction can be uniformly safe. There were no cases of endophthalmitis, perhaps partly because of the use of beveled incisions and nonhollow probes for cannula extraction, which have been shown[18] to decrease vitreous incarceration in sclerotomies, a finding associated with postoperative endophthalmitis.[19] Vitreous incarceration also increases the risk of postoperative retinal tears,[18] but there were no cases of retinal tears and detachments in this study with an average follow-up of 17.5 months.

The absence of retinal breaks in this series contrasts favorably with the previous studies[17] in which PVD was induced at the time of vitrectomy and retinal breaks occurred in 9 of 30 cases (30%) compared with 0 of 19 cases in this study ($P = 0.008$). Thus, performing vitrectomy without inducing PVD during surgery may have reduced retinal tear incidence. Indeed, a study[16] of 311 patients undergoing vitrectomy for macular pucker and macular holes found that not inducing PVD was associated with a significantly lower incidence of retinal tears as compared with those cases that underwent intraoperative PVD induction. Another salubrious contributing factor may be the use of small gauge instruments, which in a study of 695 cases, reduced the risk of retinal detachment from 4.9% (20G instruments) to 1.1% (23G).[33] In this study, the last important factor might be that 15 of 60 eyes (25%) had localized prophylactic laser or cryopexy to peripheral retinal breaks, performed at a minimum of 3 months before undergoing vitrectomy for floaters. Predictably, identifying and treating peripheral retinal breaks before vitrectomy has been shown to decrease the incidence of retinal detachments postoperatively.[34]

The downside of not inducing PVD is the possibility that a PVD after floater vitrectomy will be anomalous and cause retinal breaks, vitreomaculopathy, or bothersome floaters. This study found that no case developed retinal breaks, only one case had macular pucker that was successfully treated with surgical peeling, and only one case developed clinically significant floaters requiring repeated vitrectomy. Thus, patients without PVD preoperatively who choose this approach should be counseled about the 5% risk that PVD will develop during the second postoperative year and cause recurrent floaters.

Studies have shown that cataracts form within 12 months in 63% of cases after vitrectomy for retinal detachment[23] and within 24 months after vitrectomy after macular pucker (53%) and macular hole (76%).[24] This is probably because of the increased intravitreal levels of oxygen.[20,21] Tan et al[17] found that cataracts formed in 18 of 36 phakic eyes (50%) undergoing floater vitrectomy. In this study, leaving the anterior vitreous in situ to protect the lens against oxygen free radicals and not inducing PVD during vitrectomy to limit the intravitreal oxygen levels may have been responsible for the decreased cataract incidence of 23.5% (8 of 34 eyes; $P = 0.0003$ compared with 18 of 36 eyes in the previous studies[17]). The 17.5-month follow-up in this study of 60 eyes is less than the 21-month follow-up of a Swedish study[8] of 73 eyes, but longer than the 11.5-month follow-up by Pardo-Muñoz et al[22] and 10.1-month follow-up by Tan et al.[17] Mean ages of patients requiring cataract surgery after floater vitrectomy were around 60 years in all studies. Of note, in this study, is that none of the 5 eyes in young (younger than 30 years) subjects have required cataract surgery after a follow-up of up to 36 months. Nonetheless, patients should be counseled that even at the lower level of 23.5% this represents an increased risk of cataract as compared with not having vitrectomy for floaters, and thus the benefits of vitrectomy need to be balanced against this.

Limitations of this study include a relatively few patients evaluated prospectively with contrast sensitivity testing and standardized VFQ testing, and the relatively short follow-up in young subjects. Nonetheless, treating symptomatic floaters by 25G posterior vitrectomy without inducing PVD, leaving anterior vitreous, and using nonhollow probes for cannula extraction seems to be effective in improving CSF and patient well-being, and is safe. Further study of this approach is thus warranted.

Key words: vitreous, floaters, vitreous opacities, PVD, myopic vitreopathy, minimally invasive vitrectomy, visual function questionnaire, contrast sensitivity, retinal detachment, cataracts.

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