

Novel OCT Application and Optimized YAG Laser Enable Visualization and Treatment of Mid- to Posterior Vitreous Floaters

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ABSTRACT: Vitrectomy is an effective treatment for visually disabling vitreous opacities (floaters) but carries significant surgical risk. Nd:YAG laser vitreolysis using newer technology has been shown safe and effective in treating symptomatic Weiss ring vitreous floaters. These Weiss rings, as well as amorphous opacities in the mid- to posterior vitreous, can be impossible to visualize or treat using conventional YAG lasers. In the cases presented here, undetected symptomatic amorphous type posterior vitreous floaters were confirmed with assistance of a novel optical coherence tomography application and successfully treated using a YAG laser optimized for vitreolysis. These cases suggest that with proper technology and technique, laser vitreolysis may be safer and more effective than previously recognized.

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INTRODUCTION

Vitreous strands and opacities, also known as floaters, are among the most common ocular conditions. Often viewed as minor annoyances, floater symptoms such as scotomas that interfere with reading or driving can adversely affect quality of life and may persist for long periods in some patients.¹ Pars plana vitrectomy is an effective treatment, yet carries significant surgical risk, including cataract and retinal tears and detachments.² Nd:YAG laser vitreolysis is attractive because it is less-invasive, and recently has been shown safe and effective for treating Weiss ring floaters.^{3,4} However, amorphous floaters in the mid- to posterior vitreous are clinically significant and difficult to visualize and treat using lasers, lenses, and illumination systems designed for anterior segment use. In two cases presented here, we describe a novel application of optical coherence tomography (OCT) technology helpful for objectively confirming the presence, effect on the visual system, and vaporization or severing of symptomatic / disabling floaters, as well as techniques for using a YAG laser, illumination system, and lenses optimized for vitreolysis to both visualize and safely treat them. Approval was obtained from the local ethics committee, and all procedures were carried out in accordance with the guidelines of the Declaration of Helsinki. Written informed consent was obtained from all participants.

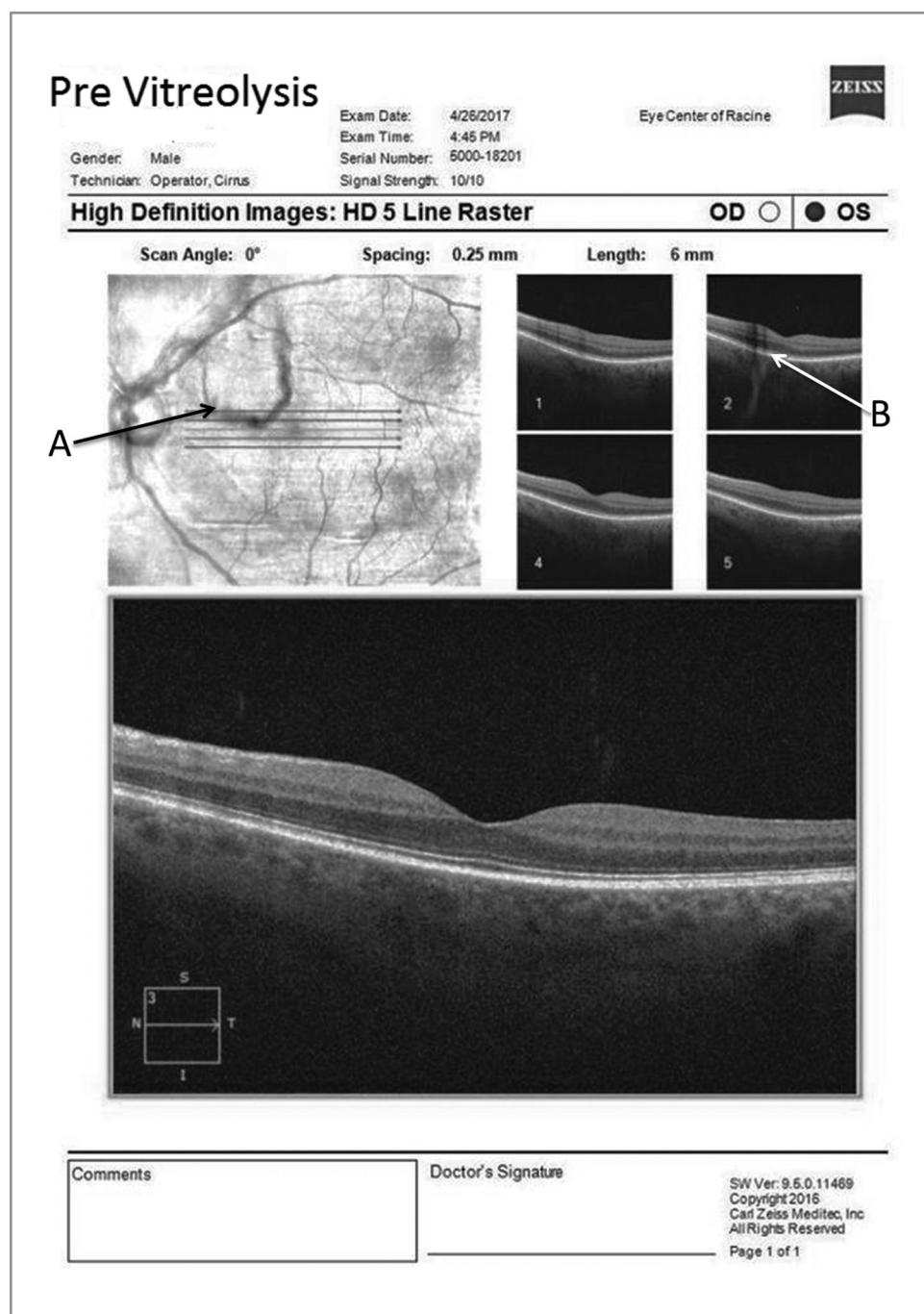
CASE REPORTS

Case 1

A 64-year-old white male complaining of a blind spot and distorted vision was referred by a clinician who found no retinal abnormality, corneal or lens opacity, or other condition that could account for the scotoma. He had a mild myopia of -0.5 in the right eye and -1.50 in the left eye. Visual field testing was normal, including visual evoked potential and electroretinogram; however, Amsler grid testing revealed a defect in the paracentral vision. Baseline intraocular pressure (IOP) was 17 mm Hg.

The patient underwent slit-lamp examination including scleral depression, which revealed a healthy retina, macula, and periphery. Dilation initially revealed a posterior vitreous detachment (PVD) and upon further inspection, a large amorphous cloud in the middle of the vitreous over the macula. B-scan was performed and confirmed a PVD with vitreous opacity. OCT demonstrated a shadow on the retina that corresponded with the location of the patient-reported scotoma, confirming it as the cause of reported symptoms (Figure 1). Further assessment using an Nd:YAG laser with coaxial illumination (Ultra Q Re-

Figure 1. Pre-vitreolysis, patient reported “distortion and shadow in central vision.” (A) Floater over the macula. (B) Shadow cast from the floater.



flex; Ellex Medical, Adelaide, Australia) and a 24-mm lens designed for mid-vitreous use (Singh MidVitreous Lens; Volk Optical, Mentor, OH) determined the clearance between the floater and the retina. Using on-axis coaxial illumination that made the red reflex visible, the laser was focused on the retina, then gradually defocused anteriorly until the floater was in focus and the retina was out of focus. This indicated sufficient separation between target and retina to safely treat the floater. Titrating the illumination by mov-

ing the slit lamp 5° to 10° off-axis oblique improved visibility of the floater during treatment by removing excess glare while leaving enough red reflex to continuously view the retina to confirm a safe separation of the target and retina throughout the procedure. Using a Volk mid-vitreous lens, the floater was treated with 680 single-pulse shots at 7 mJ, vaporizing the portion of the opacity visibly obstructing the macula.

Thirty minutes after treatment, the patient reported his symptoms resolved, except for a few peripheral

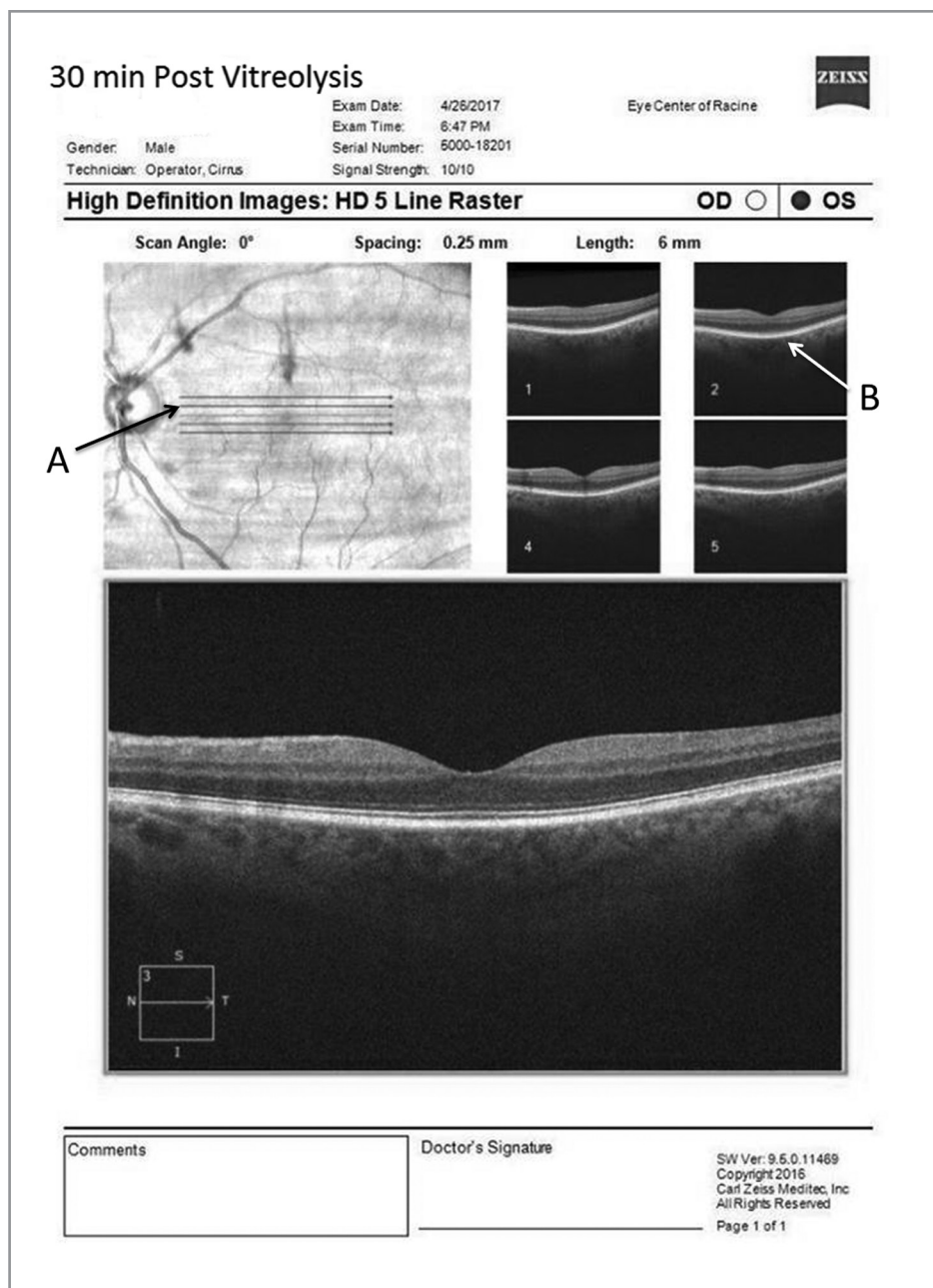


Figure 2. Thirty minutes post-vitreolysis, the patient stated symptoms of distortion were gone and that he saw a few “specks.” (A) Most of the floater is gone. (B) The shadow is now gone.

specks (Figure 2). OCT confirmed 80% of the floater was eliminated, with small remnants peripheral to the fovea and no visible shadow on the retina. No retinal damage or ocular inflammation was observed. IOP was normal directly following the procedure and three months postoperatively. The patient reported high satisfaction, stating 80% improvement in visual symptoms overall, including better ability to read sheet music, drive at night, and read.

Two months after initial treatment, a second procedure was performed with 400 single-pulse shots at 6.5 mJ to treat the remaining small pieces of floater.

He was seen 1 month following this procedure, where IOP remained normal and full scleral depressed exam revealed no changes from baseline. He stated at this time that his symptoms were 90% resolved, endorsing satisfaction with his results and deferring further treatment.

At 1-year follow-up, the patient had experienced no complications. There were no changes to the retina or lens compared to baseline. Furthermore, subjective questionnaire utilizing a visual analog scale indicated a high degree of satisfaction (nine out of 10). The patient reported being very satisfied with his treatment.

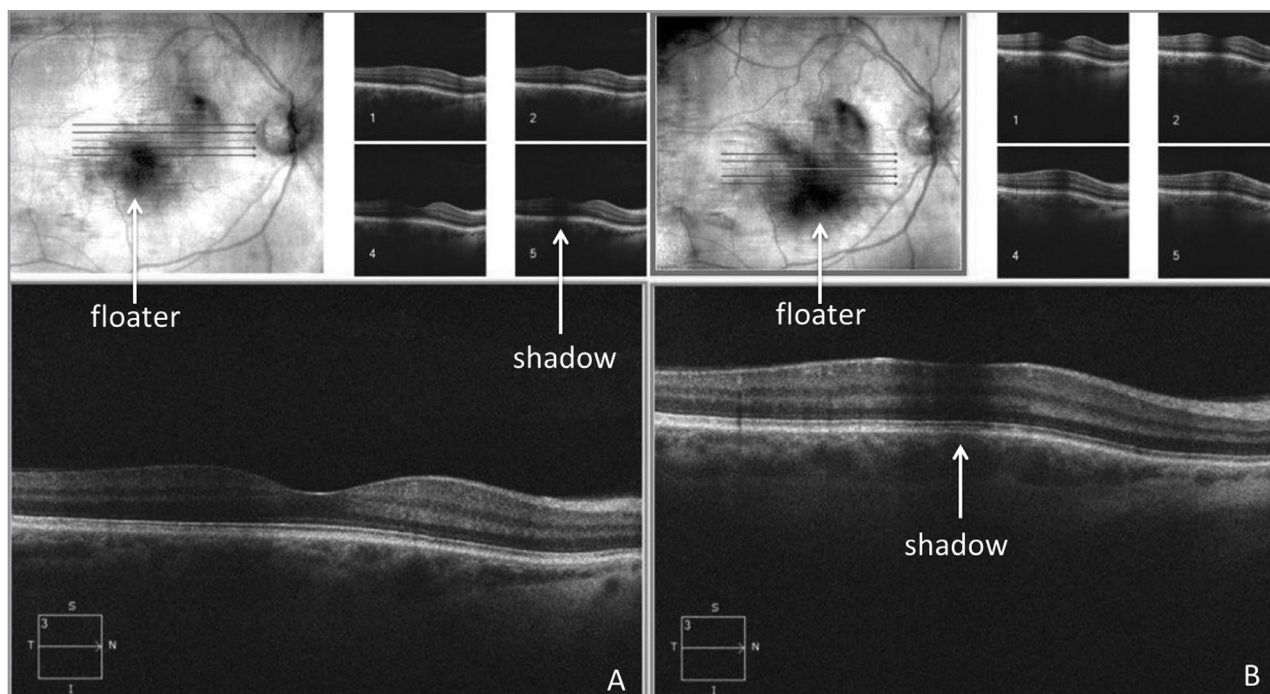


Figure 3. Pre-laser floater removal optical coherence tomography (OCT) on two separate days. (A) Preoperative OCT taken on June 5 and (B) preoperative OCT taken on June 13.

Case 2

A 48-year-old white female complaining of blurry vision and a shadow obscuring her vision was examined after three other practitioners were unable to identify a cause. Visual fields were normal, but the patient was able to map out the distortion on an Amsler grid.

Slit-lamp examination revealed no retinal, corneal, or lens abnormalities, but a significant amorphous floater was observed in the middle to posterior vitreous. OCT examination revealed a shadow on the retina corresponding to the patient-reported scotoma (Figure 3A). One week later, the patient reported the shadow had grown larger, and a second OCT showed a larger, darker shadow on the retina and a more distinct vitreous opacity (Figure 3B). Using on-axis coaxial illumination, a YAG laser and lens optimized for vitreolysis confirmed safe separation of the floater from the retina, and illumination was then titrated off-axis as needed to better visualize the floater and provide necessary spatial context. Treatment consisted of 845 single-pulse shots at 7 mJ.

Thirty minutes after treatment, the floater and shadow were no longer visible on OCT (Figure 4). Four days later, the patient reported the shadow and blurry vision resolved. No retinal damage or ocular inflammation was observed. IOP was normal directly following the procedure. The patient was seen 2 weeks later to recheck retina and IOP, which were both stable.

This patient also experienced no complications at 1-year follow-up. She indicated a similarly high degree of satisfaction on the questionnaire at this visit.

DISCUSSION

Here I present a novel use of OCT, demonstrating its ability to objectively show improvement in floater resolution post-laser vitreolysis. At most, physicians must rely on subjective evaluations from the patient regarding the efficacy of treatment. With the OCT imaging presented here, we have been able to both objectively demonstrate that floaters can negatively impede functional vision (as shown by the shadow over the macula) and show objective improvement in floater symptoms post-laser vitreolysis.

Earlier case series reported limited efficacy treating floaters,^{5,6} or recommended limiting vitreolysis to cases where floaters are readily visualized, often in the anterior vitreous.³ Shah and Heier's randomized trial demonstrated the safety and efficacy of Nd:YAG laser vitreolysis for well-formed, fibrous Weiss ring-type floaters.⁴ However, it does not address other types of floaters, specifically amorphous floaters. Their successful resolution in these cases suggests that, with specified YAG lasers and lenses specially designed for vitreous use, a broader range of floaters can be safely and successfully treated. Though it is possible that the natural vitreosynere-

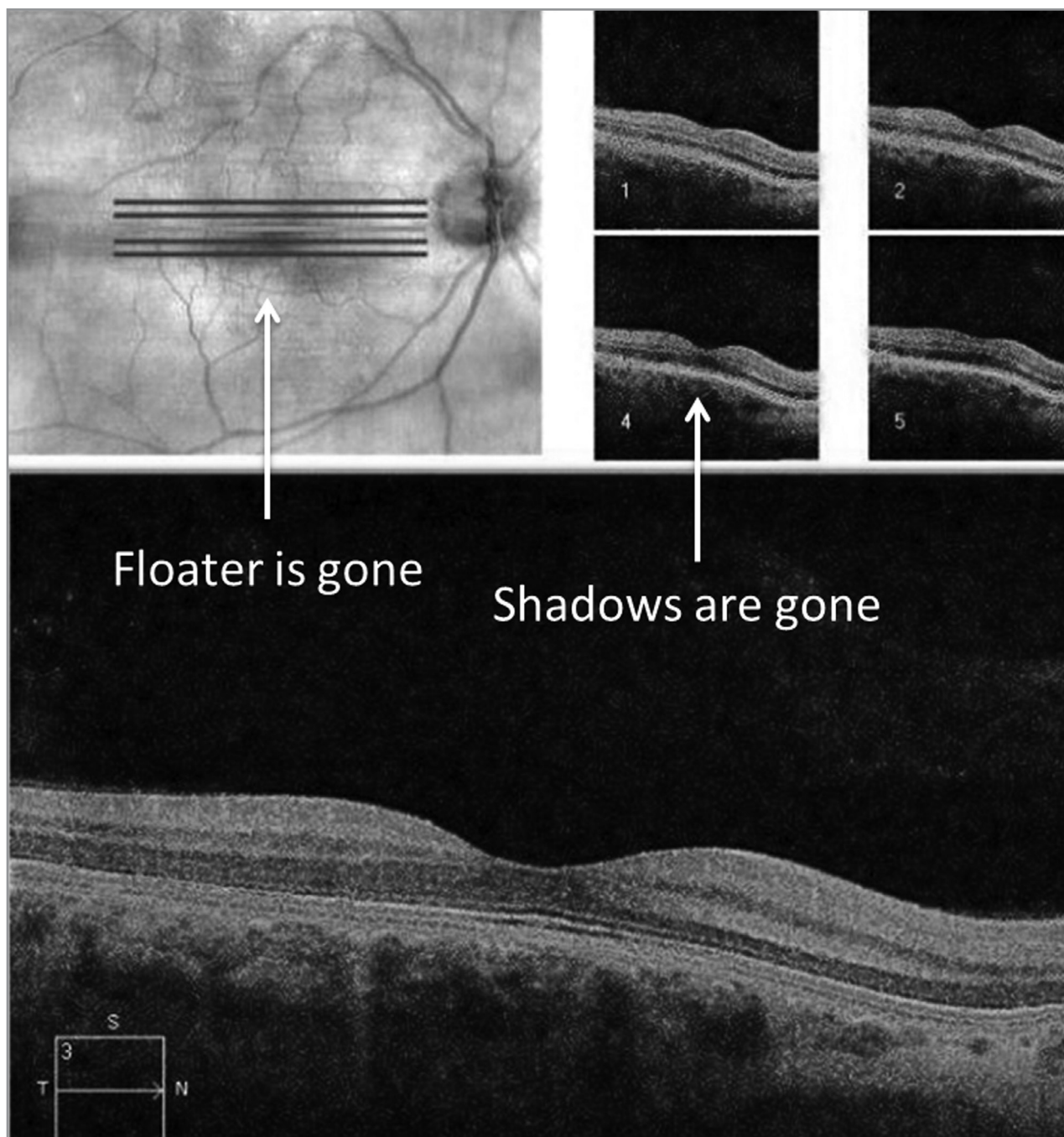


Figure 4. Post- laser floater removal optical coherence tomography 30 minutes after the procedure.

sis of the eye and movement of the floater outside the visual axis alone might account for these findings, the use of OCT imaging to help confirm the symptomatic nature of these floaters as well as their elimination after treatment is a reasonable technique.

A major reason many floaters in mid- and posterior vitreous have not been considered treatable is lacking visibility using YAG lasers designed for anterior segment use. Light sources on these legacy systems

are not coaxial, rather are usually 20° or more off the ocular and laser-firing axis. Off-axis illumination works well for visualizing the iris and posterior capsule; however, it is difficult to illuminate the mid- to posterior vitreous due to the illumination beam and the laser cross in the posterior vitreous. Therefore, off-axis illumination does not allow the operator to visualize the floater and the retina at the same time to provide the necessary spatial context needed to determine if it is safe to fire the laser.

By contrast, the coaxial illumination available on the YAG system used in the current cases allows visualization of the entire vitreous from behind the lens to the retina. It also provides precise spatial information confirming a safe separation between the target and the retina, as detailed in Case 1. For anterior floaters, spatial separation from the crystalline lens can be confirmed by moving illumination off axis, much as it is for posterior capsulotomy. This ability to accurately assess spatial context is essential for safe vitreolysis, particularly of floaters close to the retina or phakic lens. This new illumination technology allows the ability to titrate the amount of coaxial illumination. For those floaters in mid- and posterior vitreous, we must use coaxial illumination to identify the opacities, but if the glare associated with the red reflex causes poor contrast, we can maximize target visibility by moving the slit-lamp slightly oblique off axis to titrate a small amount of illumination to provide the necessary contrast.

A contact lens of a focal length appropriate for visualizing vitreous, rather than the posterior capsule or iris, is required. Several lenses are available that can be adjusted for a sharp focus from the posterior capsule surface to the retina.

OCT played a role both before and after treatment. In both cases, symptomatic floaters were missed on slit-lamp examination by at least one experienced eye care professional. Shadows observed on retinal OCT images suggested the presence of potentially symptomatic floaters independent of the slit-lamp exam. Floaters were also seen directly in OCT imaging of the vitreous.

These OCT shadows also helped confirm that the floaters caused the reported visual disturbances. Their positions correlated closely with the scotomas the patients described. Post-treatment OCT confirmed elimination of the floaters consistent with patient-reported resolution of visual disturbances. OCT was not intended to replace a scleral depressed exam but was used to demonstrate the shadow cast.

Understanding the exact extent of the acoustic shockwave YAG lasers create is for safe operation. Vitreolysis does not break apart the opacities; rather, it vaporizes them within a small area. To fully vaporize the opacities can require hundreds of shots over two or more treatments, typically starting at 4.0 mJ to 6.0 mJ.

The potential impact of this energy on the eye is a source of concern. However, the “shockwave” does not increase linearly with pulse power; it is a non-linear relationship. The convergence zone in which energy is dispersed at 1.0 mJ is typically about 110 μm but increases to only 150 μm at 5.0 mJ and 220 μm at 10 mJ. A small laser spot combined with an ultra-short pulse power rise and fall totaling about 4.0 nanoseconds, as used in these cases, also reduces the total energy need-

ed to vaporize tissue, and with it the shockwave area. As a result, a small amount of energy is introduced, and this limits the potential effects on peripheral tissue even for targets close to the retina.

Roughly 25% to 30% of the floaters treated by the author fit this amorphous mid-vitreous floater scenario. We typically require a higher number of shots than when treating a solitary Weiss ring type of floater, 500 or more pulses per treatment session, and a higher energy level, averaging 5.0 mJ to 6.0 mJ. We have seen a high safety profile using these parameters. In 1,272 consecutive cases followed for more than 1 year using an Nd:YAG laser optimized for vitreous floater treatment, we observed 10 significant adverse events, all within the first 50 cases, indicating a learning curve. These included seven IOP spikes, two phakic lens hits, and one retinal hemorrhage with no retinal breaks, for a total adverse event rate of 0.8%. Six of seven IOP spike cases were resolved with topical drug treatment, whereas one requires continuing treatment. In two cases of phakic lens damage, one later required cataract surgery and the other, in which the laser strike was peripheral, remains under observation. There were no signs of anterior chamber or vitreous inflammation, and OCT of the macula did not reveal changes to macular contour post-treatment.⁷ It is also important to be aware that the amorphous cloud can migrate during the procedure posteriorly or anteriorly and that the surgeon must be able to titrate the illumination in real time by using the slit-lamp on a fully coaxial to fully oblique setting.

These results suggest that, with proper equipment, training and technique, laser vitreolysis may be an effective and safe treatment for mid- to posterior vitreous floaters. Prospective, randomized clinical trials are in progress and needed to confirm these findings.

REFERENCES

1. Wagle AM, Lim WY, Yap TP, Neelam K, Au Eong KG. Utility values associated with vitreous floaters. *Am J Ophthalmol*. 2011;152(1):60-65.
2. Inova T, Jalil A, Bishop PN, Vallejo-Garcia JL. Vitrectomy for primary symptomatic vitreous opacities: An evidence-based review. *Eye (Lond)*. 2016;30(5):645-655.
3. Vandorselaer T, Van De Velde F, Tassignon MJ. Eligibility criteria for Nd-YAG laser treatment of highly symptomatic vitreous floaters. *Bull Soc Belge Ophthalmol*. 2001;(280):15-19.
4. Shah CP, Heier JS. YAG laser vitreolysis vs sham vitreolysis for symptomatic vitreous floaters: A randomized clinical trial. *JAMA Ophthalmol*. 2017;135(9):918-923.
5. Delaney YM, Oyinloye A, Benjamin L. Nd:YAG vitreolysis and pars plana vitrectomy: Surgical treatment for vitreous floaters. *Eye (Lond)*. 2002;16(1):21-26.
6. Milston R, Madigan MC, Sebag J. Vitreous floaters: Etiology, diagnostics, and management. *Surv Ophthalmol*. 2016;61(2):211-227.
7. Tsai WF, Chen YC, Su CY. Treatment of vitreous floaters with neodymium YAG laser. *Br J Ophthalmol*. 1993;77(8):485-488.
8. Singh IP. Neodymium: YAG Laser Vitreolysis: A Retrospective Safety Study. Paper presented at American Society of Cataract and Refractive Surgery Symposium; May 6, 2017; Chicago, IL.