Modern vitreolysis—YAG laser treatment now a real solution for the treatment of symptomatic floaters

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Historically, the only treatment offered for symptomatic vitreous floaters has been pars plana vitrectomy. This procedure works well to eliminate the symptoms associated with floaters, but there are risks involved with the procedure, such as cataract progression and the possibility of a retinal detachment. Although recent advances in technology have significantly improved the safety profile of vitrectomy, there still is a postoperative recovery period, which may result in time away from work. For some patients, the potential cost of pars plana vitrectomy also remains an issue. Therefore, most doctors decide to observe many of the common types of floaters, such as a Weiss ring or other solitary vitreous opacities. Unfortunately, these floaters can sometimes negatively affect patients’ daily functioning and quality of life.

A study by Wagle and coworkers addressed the impairment on functional quality associated with floaters in 311 outpatient. The utility values of floaters were equal to those of age-related macular degeneration and similar to those of glaucoma, mild angina, stroke, and asymptomatic HIV. This demonstrates that floaters do have a similar impact on quality of life as other ocular and systemic diseases.
Furthermore, a study by Webb and coworkers demonstrated that floaters are common in the general population, irrespective of age, race, gender, and eye color. In a review of 603 smartphone users, 76% (n = 458) indicated that they notice floaters, with 19% of these individuals citing noticeable vision impairment as a result of their floaters. Furthermore, myopes and hyperopes were 3.5 and 4.4 times, respectively, more likely to report moderate severe floaters. A 2016 study by Garcia and coworkers showed that there was a 52.5% reduction in contrast sensitivity function after posterior vitreous detachment.

Recent advances in laser technology have improved the adverse event profile associated with laser-based floater treatment. The procedure also offers the potential benefit of a simplified postoperative course. Smaller floaters, such as Weiss rings and other types of floaters (amorphous clouds and strings), that are often considered to be not clinically significant to warrant surgery may now be treated. It is important to note that laser floater treatment (LFT) is not intended to replace or compete with vitrectomy. The ideal patient for LFT is quite different from a vitrectomy patient. Laser vitreolysis may be a reasonable option in select group of pseudophakic and phakic patients.

LFT for symptomatic floaters, also known as vitreolysis, was first introduced in 1993 by Tsai and coworkers. Older data sets suggested only modest efficacy and possible safety concerns that led many doctors to be skeptical about the procedure. It is important to note these older studies were using laser technology not optimized for LFT. Furthermore, the treatment protocol was not optimized. The reason for the variable outcomes in some of the earlier studies was the limitations of traditional YAG lasers. There were three main limiting factors when performing LFT with traditional YAG lasers: 1) lack of visualization of the entire vitreous and mandatory spatial awareness between lens and retina; 2) suboptimal power usage during the procedure thus limiting vaporization of the floater; 3) inability to apply sufficient number of laser because of older cooling cavities and thus the instability/inconsistency of energy delivery through the entire procedure.

So, how has technology changed to now allow us to perform LFT with better safety and efficacy?

1. **Visualization**

Optimal visualization is key to performing LFT. Appreciating spatial context is crucial for safety and efficacy. The illumination systems on traditional YAG lasers were not optimized to visualize and treat floaters in the middle or posterior vitreous, as they have primarily devised for capsulotomies and laser peripheral iridotomy, procedures requiring visualization of the anterior chamber only. These YAG lasers use noncoaxial illumination towers, in which the illumination is coming from one pathway of the optical system and the laser and oculars are coming from a different optical pathway, converging at the posterior capsule. Therefore, one could not see beyond a few millimeters behind the posterior capsule. This limited the ability of the surgeon to view or identify floaters in the middle and posterior vitreous. In addition, surgeons need to be able to determine where they are within the vitreous in relation to other ocular structures, such as retina and lens. This limitation of visualization is a reason why some of the earlier studies demonstrated variable efficacy and safety (Fig. 1).

Owing to the limitations of previous YAG lasers, a new YAG laser illumination system in the form of True Coaxial Illumination (TCI™; Ellex Medical, Adelaide, Australia) has been developed. Using new midvitreous contact lenses, this illumination system provides surgeons with full visualization of the entire vitreous cavity from the lens to the retina. This is achieved by using a retractable, reflecting mirror designed to move out of the laser pathway during the treatment. The laser, the oculars, and the illumination tower use the same

![Fig. 1 – Left: Standard YAG laser tower; the laser beam and the illumination beam converge when focused on the posterior capsule. Right: The laser beam and illumination beam cross when attempting to focus on a floater in the posterior vitreous, thus not allowing a view of the floater and the relationship between the floater and the retina.](image-url)
optical pathway, allowing for simultaneous visualization of both the retina and the floater. This is important to minimize the risk of inadvertent damage to the retina (Fig. 2).

The True Coaxial illumination design also enables titration of the red reflex by moving the slit lamp obliquely or off axis because the laser can be applied at any position of the slit lamp. For example, a floater in the middle of the vitreous that is seen using coaxial positioning with a full red reflex can occasionally have a lot of glare (Fig. 3). To maximize the contrast in the vitreous to best visualize this type of floater, while maintaining adequate coaxial illumination to also locate the retina, the surgeon can titrate the degree of illumination by moving the slit lamp slightly oblique, around 10° to 15°. This allows for optimal visualization and identification of the location of the floater. This technique is not possible with standard YAG lasers (Fig. 4).

An important clinical pearl: If the floater is in focus and retina is out of focus, you have enough spatial distance from the retina to apply the laser (Fig. 5).

It is critically important for the surgeon to understand how far behind the lens one can treat, which is of great importance when treating phakic patients. The on-axis slit lamp position can be used to visualize the floater against the red-glow background (to help visualize floaters in the middle and posterior vitreous), then advance further off-axis to determine how far behind the lens it is. If the floater is difficult to see in the off-axis position, then it is safe to treat because the off-axis position only allows for visualization a few millimeters behind the lens. Using off-axis slit lamp position allows the surgeon to identify the posterior capsule with better clarity than when the slit lamp is the center on-axis position (Figs. 6 and 7).

1.1. Energy delivery

Previous studies that reported marginal results with YAG laser vitreolysis often set the energy level to 1–2 millijoules, which is much less than the 4–8 millijoules typically required to vaporize floaters. I conducted a study using a B-scan probe to view the behavior of the vitreous during LFT. At an energy setting of 7 mJ, I did not see movement of the vitreous 1 mm or greater from the plasma creation. There was also no movement seen of the posterior hyaloid face. (This study was accepted and presented at American Society of Cataract and Refractive Surgery 2019 in San Diego.)

Recent refinements in YAG laser technology have resulted in less energy required to achieve the optical breakdown necessary to vaporize the floater(s) (Fig. 8). There is a non linear rise in dispersion of energy in the vitreous (convergence zone) with energy setting on the laser (see Fig. 9). At 1 mJ, the movement of fluid was 110 microns, and only increased to 220 microns at 10 mJ.

Plasma is the fourth state of matter; solid is being transformed into gas which is then absorbed by the tissues. Therefore, during LFT, there is both vaporization and fractionation. Owing to the short duration of the pulse (4 ns), heat is
dissipated before the next shot is fired. Therefore, treatment is doing more than merely breaking up floaters; the laser actually removes some of the solid matter, and heat does not build up because of the short duration. These new advanced YAG lasers also feature a specially designed active cooling cavity.

1.2. Recent publications

Shah and Heier were the first to conduct a randomized placebo-controlled trial evaluating the safety and efficacy of LFT using advanced YAG technology specifically designed for laser-based floater treatment. This study involved 52 eyes treated with the Reflex Technology™ platform (Ellex Medical, Adelaide, Australia). The study concluded that 54% of patients in the YAG laser group experienced symptomatic improvements compared with 9% of patients in the control group. The YAG laser group also showed greater improvement in the 10-point visual disturbance score than the control group.

This study also demonstrated no retinal adverse events in the treatment group, although a retinal defect was seen in the control group. This is an important point because the cause of retinal defects is often the result of vitreous traction.

According to the American Academy of Ophthalmology, the definition of YAG vitreolysis is the "severing of vitreous strands and opacities with a laser." One cannot assume the traction on the retina is the same or more than a vitrector. This study was not designed for a follow-up treatment session. Multiple sessions are common with LFT as it is not always possible to vaporize the entire floater in one session.

In 2016, we presented an article at American Society of Cataract and Refractive Surgery that investigated patient satisfaction, complication rates and treatment specifics associated with LFT in a prospective review of patients undergoing the procedure. This observational study included 130 patients (mean age, 61 years [range, 28–92 years]) who underwent LFT with the Ultra Q Reflex system (Ellex Medical, Adelaide, Australia). Patient satisfaction was assessed with a 1–10 self-rated scale, with higher values indicating greater patient satisfaction as well as a “Yes” or “No” indicating whether they were satisfied with improvement in daily functioning. Information on complications was recorded for all patients. We found 91% of patients stated that they were
Fig. 8 – Arrows point to the narrow Gaussian curve of the energy delivery using the new reflex cavity. There is a sharper rise and fall of the energy with limited waste.

Fig. 9 – The size of the convergence zone increases in a nonlinear fashion as the power on the laser is increased. At 1 mJ, the size of the convergence zone is 110 microns, and increasing power to 10 mJ increases the size to 210 microns (less than 50% increase).
satisfied with their improvement in daily visual functioning. The noted average degree of improvement was 8.5 out of 10 (after multiple sessions in some patients). Patients with a Weiss ring required 1.3 sessions as compared to 3.2 sessions in patients with amorphous clouds. The number of laser shots to sufficiently vaporize floaters amorphous clouds was 568 shots (vs. 186 for Weiss rings). Power settings also varied depending on floater type, with the average setting at 5.8 mJ (range, 2.9–9 mJ). Best results and higher patient satisfaction scores were notably seen with solitary Weiss rings versus amorphous clouds. The adverse event profile included 2 lenticular damage, 3 intraocular pressure (IOP) spikes, and one retinal hemorrhage. The 2 cases of lenticular damage (both in the first 50 cases) were before we appreciated the importance of using the laser slit lamp in the oblique position to view the posterior capsule and properly gauge the distance of the floater from the lens. The retinal hemorrhage occurred when the retina was in focus at the same time as the floater. The 3 IOP spikes occurred in the post YAG cap patients where the amorphous clouds were right behind the lens. Now we decrease the number of shots to 300 or less if the floaters are close to the lens in a post YAG laser capsulotomy patient.

At American Society of Cataract and Refractive Surgery 2017, I also presented my analysis of all consecutive patients who underwent YAG laser vitreolysis for the treatment of symptomatic floaters and had at least 1–4 years of follow-up. This retrospective study included 1,272 procedures performed in 680 patients. In all cases, the Ellex Ultra Q Reflex YAG laser was used to vaporize floaters; an average power of 6 mJ per laser shot was used with an average of 564 shots per treatment session. Patients with both amorphous and solitary Weiss ring type of floaters were included. Ten adverse events were recorded, comprising 7 cases of IOP spikes, two cases of native lens damage (Fig. 10), and 1 retinal hemorrhage (this included the adverse events from the 130 cases in the 2016 prospective article), representing a total adverse event rate of 0.8%. Patients with IOP spikes were placed on topical antihypertensive medications (average postmedication IOP, 19 mm Hg). One of the phakic patients subsequently required cataract surgery and achieved a corrected visual acuity of 20/20. The other patient, where the lenticular burn was in the periphery, is still being observed. The case of retinal hemorrhage resolved in 3 months with no long-term negative effects. There was no ocular inflammation, exacerbation of diabetic retinopathy, progression of epiretinal membrane, or cystoid macular edema. Postoperative regimen for all cases included IOP checks immediately after the procedure, at 1 week, and 1 month. No antiinflammatory drops used. Topical IOP-lowering agents were used in cases with IOP spikes. Preoperative, 1-month, and 3-month macular optical coherence tomography was obtained for all patients (Fig. 11).

Qualitative analyses of the effects of LFT have been performed with spectral domain optical coherence tomography and scanning laser ophthalmoscopy by comparing shadows on the retina created by floaters before and after treatment. A recent study published in OSLI Retina October, 2018, on novel optical coherence tomography applications, including shadow changes on a 5-line raster scan after vitreolysis, described cases with persistent scotoma. Once initial testing did not reveal a clear etiology, further evaluation using spectral domain-optical coherence tomography demonstrated a large floater overlying the macula. After YAG vitreolysis, patients described resolution of the symptoms, and the spectral domain-optical coherence tomography scans revealed resolution of the shadow that was cast on the retina (Fig. 12).

The utilization of ray-tracing aberrometry beyond anterior segment needs further investigation before one can claim that

Fig. 10 – Left: Graph demonstrates a stable delivery of energy over hundreds of shots when using active cooling cavity. Right: Graph demonstrates the same when using a passive cooling cavity, the delivery of energy is not stable over hundreds of shots fired. (Poster presented at American Society of Cataract and Refractive Surgery 2019).
it “offers true analysis and objective benefits.” I would still include the discussion (Ray tracing has been well established to analyze the entire optical system). Since 256 beams reach the retina, they have to pass through the entire optical system, including the vitreous. The difference between the iTrace (Tracey Technologies LLC, Houston Texas, USA) and other aberrometers is the ability of the iTrace to separate the corneal contribution versus intraocular contributions to higher order aberrations, such as the lens and vitreous. In fact, there are studies that have shown significant improvement in

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**Fig. 11** — Two cases of phakic lens damage with the laser. A: Patient is asymptomatic and being observed. B: The patient was symptomatic and required cataract removal with IOL.

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**Fig. 12** — Vitreous opacity overlying the macula (arrow A). Presumed floater shadow on raster scans (arrow B).
higher order aberrations after pars plana vitrectomy, as well as using the same device. Our study demonstrated no change in topography, and patient lens status did not change after vitreolysis; therefore, the improvement in higher order aberrations could only be the vitreous opacity.

Ray-tracing aberrometry offers a potential objective measurement of the effect floaters have on quality of vision. This device fires 256 laser beams parallel to the line of sight, distributed over the entrance pupil, and images where these lasers hit the retina. The laser beams are fired one at a time, in quick succession so that high levels of aberrations or scatter that might be caused by floaters does not cause confusion in the detection system. The pattern where the lasers hit the retina allows an accurate calculation of the point spread function of the eye to be determined, therefore an MTF can be calculated. Furthermore, the device measures the topography of the anterior surface of the cornea. Any aberrations that are not explained by the anterior surface topography must have been created inside the eye.

The iTrace software characterizes the effect of these internal aberrations on quality of vision with a single number called dysfunctional lens index. This dysfunctional lens index score has excellent correlation with visual acuity loss due to cataract formation.11,12 The internal aberrations have also been used to characterize the aberrations induced by tilted IOLs and the improved quality of vision after Nd:YAG capsulotomy.13 A comparison of preoperative and postoperative internal aberrations obtained from ray tracing aberrometry should provide a good objective measure of quality of vision improvements after LFT. I presented an article on this topic at American Society of Cataract and Refractive Surgery 2017, demonstrating a significant improvement higher order aberrations, MTF area under the curve, and dysfunctional lens index score after LFT.

1.3. Patient selection

Patient selection is extremely important. Like any other procedure, not all patients are good candidates or qualify for the procedure. For LFT, solitary opacities may be the best candidates. If the floater is too close to the lens or retina, or if the patient has new onset of floaters and/or flashes suggestive of recent posterior vitreous detachment, observation remains the best option. Patients also need to be informed of the possible need for multiple sessions and/or possible failure to resolve symptoms completely.

2. Conclusion

The new illumination design, coupled with the modified laser energy delivery system, may represent an alternative option to vitrectomy in management of clinically significant floaters in carefully selected patients; however, randomized, controlled clinical trials with large cohorts and long-term follow-up are necessary to optimally assess the efficacy and safety of laser vitreolysis.

3. Disclosure

I.P.S. is a speaker and consultant for Ellex, Zeiss, and Tracey Technologies.

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