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Infrared Video Imaging for the Identification and Quantification of Macula-Involving Symptomatic Vitreous Opacities

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Abstract

Purpose: To evaluate whether infrared video imaging can supplement traditional examination and imaging methods to identify and quantify symptomatic vitreous opacities. **Methods:** A prospective nonrandomized nonmasked series was performed that included eyes of consecutive patients with a primary complaint of symptomatic vitreous opacities. A macular vitreous opacity score (0–4) was developed to grade the size of the opacities in relation to the macula after refixation of up, down, left, and right saccades. Grade 0 indicated an absence of opacities. Grades 1 to 4 represented how many quadrants of the macula were obscured by opacities for more than 50% of the total video capture time (grade 1 = 1%–25%; grade 2 = 26%–50%; grade 3 = 51%–75%; grade 4 = 76%–100%). Grade 2 opacities were divided into subcategories 2A and 2B depending on whether they were central enough to obscure the fovea for more than 50% of the time. **Results:** The study comprised 52 eyes of 40 patients. Thirty-two eyes (62%) with symptomatic vitreous opacities were grade 1, 6 (11%) were grade 2A, 6 (11%) were grade 2B, 5 (10%) were grade 3, and 3 (6%) were grade 4. **Conclusions:** Infrared video imaging is a useful supplement to traditional examination and imaging methods for the identification and quantification of symptomatic vitreous opacities. The macular vitreous opacity score can help standardize vitreous opacity documentation in the clinical setting for future case selection.

Keywords

imaging, posterior vitreous detachment, vitreous, vitreous opacities, vitrectomy

Introduction

Symptomatic floaters affect patients of all ages and backgrounds and are among the most common patient complaints in a retina practice.[1] However, traditional examination and imaging modalities have limitations in terms of the identification of vitreous opacities.[2] The best-corrected visual acuity (BCVA) is often unaffected by vitreous opacities.[3] Without appropriate imaging, correlating patient symptoms with objective findings is clinically challenging.[2–4] Established diagnostic methods include indirect and slitlamp biomicroscopy, color and infrared still fundus photography, ultrasound, and optical coherence tomography (OCT) of the posterior vitreoretinal interface.[2,5]

Stereopsis and dynamic assessment are advantages of fundus biomicroscopy but can cause significant patient discomfort. The examiner's assessment of the opacities may be limited by patients squeezing their eyelids shut as well as saccadic movements away from the light source. Color fundus photography has the advantage of widefield capability; however, opacities are less visible against the red reflex than with infrared photography, which enhances the contrast of the black opacities against a white fundus background. However, both color and infrared still photography are limited by a single, static identification of opacity location, which may fail to capture intermittent macular and foveal obscuration. Quantitative ultrasound has also been used to measure echo densities in the vitreous cavity.[6] Although OCT of the posterior vitreoretinal interface is useful for capturing the posterior hyaloid location and confirming the status of a posterior vitreous detachment (PVD), it often fails to visualize and identify the largest and most symptomatic opacities.[7]

Infrared video imaging highlights the opacities by rendering them black in front of a bright-gray fundus. The intensity of reflected confocal laser light at each position of a 2-dimensional retinal image is measured with a light-sensitive detector.[7] Reduced light is reflected in the area of the dense opacities. The infrared video function allows for the identification of foveal obscuration by the black opacities after blinks and directional

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Table 1. Macular Vitreous Opacity Scores.

Score	Macula Obscured (%)	Fovea Obscured >50% of the Time
1	1–25	No
2A	26–50	No
2B	26–50	Yes
3	51–75	Yes
4	76–100	Yes

saccades, creating a more complete presentation of how much of the macula is obscured by the opacities. Infrared video, therefore, may be the ideal imaging modality for the evaluation of symptomatic vitreous opacities.

Methods

This prospective nonrandomized nonmasked series included eyes of consecutive patients with a chief complaint of symptomatic vitreous opacities in 1 or both eyes. Symptomatic vitreous opacities were the result of PVDs without or with vitreous hemorrhage (ie, hemorrhagic PVD). Eyes with diabetic vitreous opacities or a history of vitrectomy or laser vitreolysis were excluded. There was no specific exclusion based on axial length (AL), and patients with high myopia were included. Informed consent was obtained from the patients, and procedures were conducted in accordance with the Declaration of Helsinki.

Infrared video acquisition using the Spectralis device (software version 6.13.3.0, Heidelberg Engineering) was performed during a 10- to 15-second period and incorporated the patient's blink and refixation after up, down, left, and right saccades as instructed by the photographer. All pupils were dilated for at least 10 minutes before video acquisition. All eyes were imaged with fluorescent overhead lights off and yellow overhead can lights set to dim, per standard clinic imaging protocol.

A macular vitreous opacity score was developed to grade the size of the opacities in relation to the macula for more than 50% of the video acquisition time and determine whether the opacities obscured the infrared reflection of the foveal center for more than 50% of the time (Table 1). The designated numeric grade 1 to 4 reflected the size of the opacities in relation to quadrants of the macula. In grade 1, 1% to 25% of the macula was obscured. In grade 2, 26% to 50% was obscured. In grade 3, 51% to 75% was obscured. In grade 4, 76% to 100% was obscured. The A and B subcategories for grade 2 opacities reflected whether or not opacities obscured the fovea for more than 50% of the video time.

The initial macular vitreous opacity score comprised the following 8 categories: 1A, 1B, 2A, 2B, 3A, 3B, 4A, and 4B. The A subcategories reflected foveal obscuration for less than 50% of the video time while the B subcategories reflected foveal obscuration for more than 50% of the video time. The macular vitreous opacity score evolved to its final iteration based on the results in the patient series of foveal obscuration.

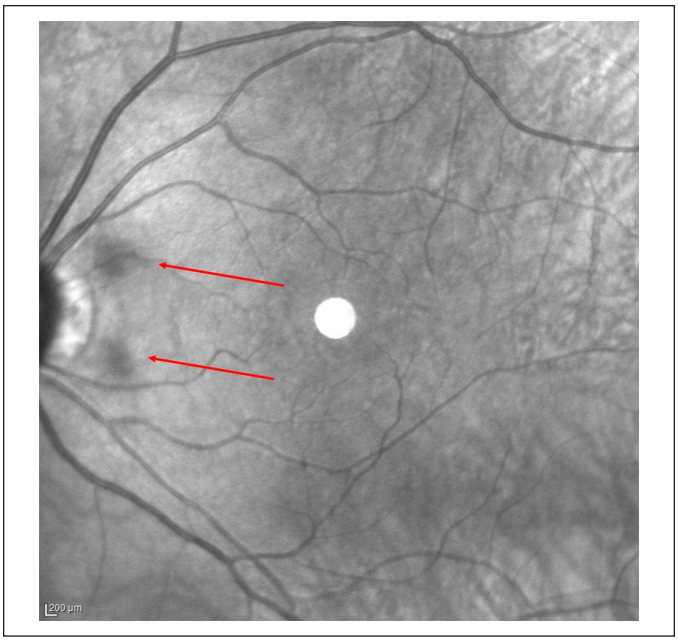

Figure 1. Screenshot of a 30-degree infrared imaging video of an eye with a grade 1 macular vitreous opacity score. Less than 25% of the macula is obscured by vitreous opacities (red arrows). (See Supplemental Video 1.) (*Color figures available online.*)

None of the grade 1 eyes had foveal obscuration more than 50% of the time; therefore, there was no need for opacities to be split into A and B subcategories. Similarly, grade 3 and grade 4 eyes, which had the largest and densest opacities, had foveal obscuration more than 50% of the time. There was no need to split these patients' opacities into A and B subcategories because a large enough portion of the macula was obscured to sufficiently conceal the fovea as well. Only grade 2 eyes with 26% to 50% of the macula obscured required a split into subcategories A and B because some of the opacities were central enough to involve the fovea more than 50% of the video time.

A patient comfort score was obtained at the time of video acquisition, with a score of 1 being extremely comfortable, 2 being somewhat comfortable, 3 being somewhat uncomfortable, and 4 being extremely uncomfortable.

Results

The study comprised 52 eyes of 40 patients. Thirty-two eyes (62%) with symptomatic vitreous opacities were grade 1 (Figure 1 and Supplemental Video 1). Six eyes (11%) were grade 2A (Figure 2 and Supplemental Video 2A), 6 (11%) were grade 2B (Figure 3 and Supplemental Video 2B), 5 (10%) were grade 3 (Figure 4 and Supplemental Video 3), and 3 (6%) were grade 4 (Figure 5 and Supplemental Video 4).

The mean logMAR BCVA (±SD) was 0.04 ± 0.03 (Snellen equivalent, 20/20) in grade 1 patients, 0.07 ± 0.04 (Snellen equivalent, 20/25) in grade 2A patients, 0.18 ± 0.11 (Snellen

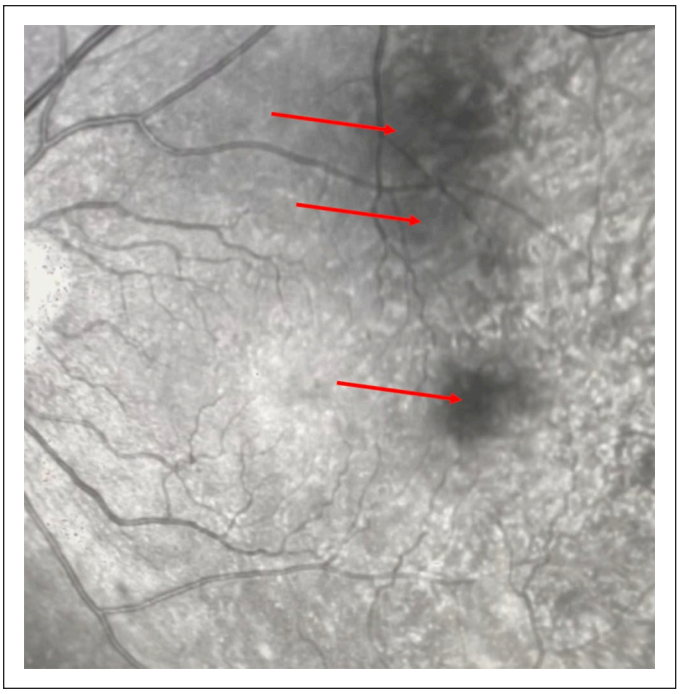

Figure 2. Screenshot of a 30-degree infrared imaging video of an eye with a grade 2A macular vitreous opacity score. Less than 50% of the macula is obscured by vitreous opacities (red arrows). The fovea is obscured for less than 50% of the video time. Motion in the video clip identifies additional adjacent opacities not visible in the still photograph. (See Supplemental Video 2A.) (*Color figures available online*.)

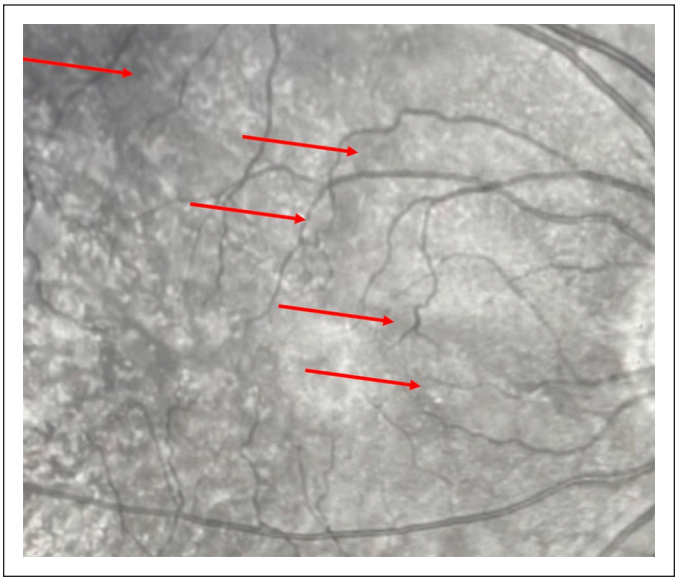

Figure 3. Screenshot of a 30-degree infrared imaging video of an eye with a grade 2B macular vitreous opacity score. Less than 50% of the macula is obscured by faint-gray vitreous opacities (red arrows). The fovea is obscured for more than 50% of the video time because of the central location of the opacities. Motion in the video clip identifies additional adjacent opacities not visible in the still photograph. (See Supplemental Video 2B.) (*Color figures available online*.)

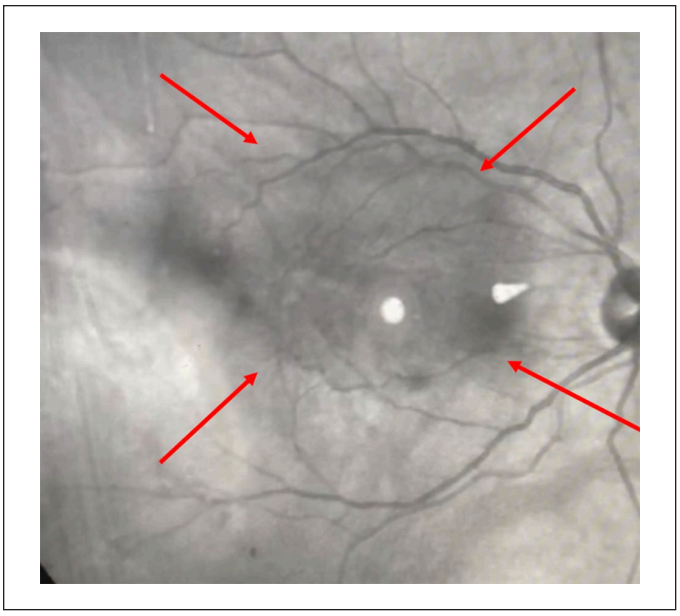

Figure 4. Screenshot of a 55-degree infrared imaging video of an eye with a grade 3 macular vitreous opacity score. More than 50% of the macula is obscured by an aggregate of dark-gray vitreous opacities (red arrows). The fovea is obscured for more than 50% of the video time. (See Supplemental Video 3.) (*Color figures available online*.)

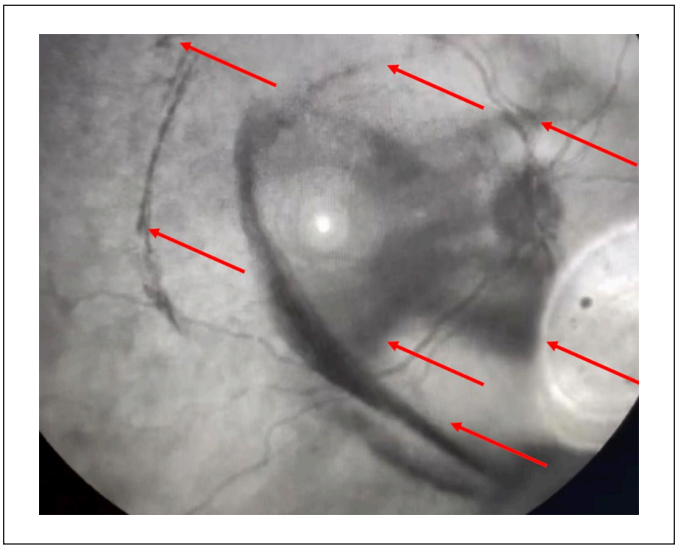

Figure 5. Screenshot of a 55-degree infrared imaging video of an eye with a grade 4 macular vitreous opacity score. More than 75% of the macula is obscured by an aggregate of dark vitreous opacities (red arrows) in the setting of a hemorrhagic posterior vitreous detachment. The fovea is obscured for more than 50% of the video time. (See Supplemental Video 4.) (*Color figures available online*.)

equivalent, 20/30) in grade 2B patients, 0.38 ± 0.15 (Snellen equivalent, 20/50) in grade 3 patients, and 1.1 ± 0.23 (Snellen equivalent, 20/250) in grade 4 patients (Table 2).

Table 2. Patients' Macular Vitreous Opacity Scores and BCVA.

Score	Macula Obscured (%)	Fovea Obscured >50% of the Time	Eyes, n (%)	Mean BCVA ± SD	
				LogMAR	Snellen[a]
1	1–25	No	32 (62)	0.04 ± 0.03	20/20
2A	26–50	No	6 (11)	0.07 ± 0.04	20/25
2B	26–50	Yes	6 (11)	0.18 ± 0.11	20/30
3	51–75	Yes	5 (10)	0.38 ± 0.15	20/50
4	76–100	Yes	3 (6)	1.1 ± 0.23	20/250

Abbreviation: BCVA, best-corrected visual acuity.
[a]Equivalent.

Thirty-four of 40 patients (85%) reported a comfort score of 1. The remaining 6 patients (15%) reported a comfort score of 2.

Conclusions

Recent studies have reported that symptomatic vitreous opacities are increasingly prevalent, with a more negative impact on quality of life than previously appreciated.[4,5] In a study by Webb et al,[8] one third of 603 smartphone users surveyed reported visual impairment caused by floaters. Symptomatic vitreous opacities after a PVD can be responsible for a reduction in contrast sensitivity of more than 50%.[9] The most common cause of symptomatic vitreous opacities is vitreous liquefaction with age, in which collagen is dissociated from hyaluronan and collagen fibrils aggregate.[5] The resultant scattering of light is amplified after PVD, when additional collagen from the posterior hyaloid face becomes visible, and can be exacerbated by trauma, inflammation, and hemorrhaging.[5] Despite the use of biomicroscopy and ophthalmoscopy, patients often experience frustration when their consulting ophthalmologists are unable to identify the source of their symptoms.[1]

Infrared video imaging is a useful supplement to traditional examination and imaging methods for the identification and quantification of symptomatic vitreous opacities. By rendering them black in front of a white fundus, the opacities are highlighted, while the video function allows for the identification of foveal obscuration after blinks and directional saccades. This active and dynamic examination technique can be performed on what is traditionally considered to be primarily a static imaging module.

Infrared video imaging is well-tolerated from the patient's perspective. Because the blue light of infrared acquisition is gentler than the traditional light source used in indirect or slitlamp biomicroscopy, patient compliance and comfort during an examination for floaters is enhanced. Infrared video imaging also assists communication between physician and patient by potentially matching objective findings with subjective complaints. Not all vitreous opacity complaints are described as floaters, and infrared video helps localize and confirm the source of patient variations in the description of opacities (eg, clouds, smudges, blobs). Furthermore, the absence of significant opacities on infrared video imaging would prompt further assessment of other ocular structures.

No specific range of AL was excluded from the study, and extreme ALs had no apparent influence on the quality of the video. Increased technician skill is useful in imaging myopic eyes, and adjusting the video focus anteriorly in these eyes can help achieve sharper focus of the opacities.

Additional vitreous opacity grading systems have been proposed that use other imaging techniques, including scanning laser ophthalmoscopy (SLO), to document the distribution of floaters on infrared static imaging.[10] In the current study, the cumulative size of shadow areas on the infrared photo was inversely related to Visual Functional Questionnaire-25 scores. This technique has also been used to document the size and location of opacities before and after laser vitreolysis.[11]

The use of spectral-domain OCT has also been proposed to compare vitreous signal intensity with retinal pigment epithelium (RPE) intensity for an optical density ratio, termed the *vitreous/RPE-relative intensity*.[12] In a study by Keane et al,[12] this ratio was significantly higher in eyes with vitreous opacities than in eyes of healthy controls and an increased ratio correlated with diminished VA.[10] Jiang et al[13] successfully tracked vitreous opacity movements and the effects on retinal shadowing with patient eye movements during dynamic OCT imaging. Garcia-Aguirre et al[14] reported 21 patients who had dynamic infrared SLO performed using the Mirante device (Nidek Co Ltd). Because the software (Navis Ex Extra, version 1.11.0.6) did not offer video capture, a cell phone camera was used to record video. Opacities were graded from 1 to 5 based on a combination of whether they were considered diffuse or dense and whether or not they crossed the center of the macula in primary gaze or with eye movement. Marquez et al[15] have proposed an alternate grading scale.

The macular vitreous opacity score devised for the current study grades opacities based primarily on opacity size relative to the macula. In this patient population, the mean objective BCVA decreased with each category. The visual and quantitative findings obtained from infrared video imaging and the macular vitreous opacity score help correlate the subjective decrease in VA with the objective features of the patient's vitreous.

Limitations of the current study include the examiner's visual estimations of macular and foveal obscuration and that it was performed at a single site. Foveal tracking software of timed interference per 15-second period is a potential area of development that could assist the examiner in assigning the

macular vitreous opacity score with greater precision, especially when discerning patients with subcategory 2A and 2B opacities. Although all patients had a recorded chief complaint of symptomatic vitreous opacities, the relationship between the severity of the reported symptoms and the macular vitreous opacity score was not evaluated in this study. Future studies will correlate the macular vitreous opacity score and subjective symptom scoring with methods such as the Visual Functional Questionnaire-25.

The clinical documentation of symptomatic vitreous opacities can be standardized using the macular vitreous opacity score. The severity categories of the score can assist with future case selection and in the assessment of outcomes of therapeutic interventions, including the patient's response to laser and surgical treatments.

Ethical Approval

This study was conducted in accordance with the Declaration of Helsinki.

Statement of Informed Consent

Informed consent, including permission for publication of all photographs and images included herein, was obtained before the procedure was performed.

Declaration of Conflicts of Interest

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Supplemental Material

Supplemental material is available online with this article.

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