https://doi.org/10.17116/oftalma2018134156-62

Evaluation of YAG-laser vitreolysis effectiveness based on quantitative characterization of vitreous floaters

V.A. SHAIMOVA[1, 2], T.B. SHAIMOV[2], R.B. SHAIMOV[2], A.YU. GALIN[2], ZH.A. GOLOSHCHAPOVA[1], P.K. RYZHKOV[3], A.V. FOMIN[4]

[1]Multipurpose Laser Medicine Center, Ministry of Health of the Chelyabinsk Region, 287 Pobedy prospect, Chelyabinsk, Russian Federation, 454138; [2]«Tsentr Zreniya» LLC, 99 Komsomolsky prospect, Chelyabinsk, Russian Federation, 454021; [3]Eyecare Clinic «Center FIS» LLC, 11 Trifonovskaya St., Moscow, Russian Federation, 125171; [4]Research Institute of Eye Diseases, 11 A, B Rossolimo St., Moscow, Russian Federation, 119021

Purpose. To develop methods for evaluating effectiveness of YAG-laser vitreolysis of vitreous floaters. **Material and methods.** The study included 144 patients (173 eyes) who had underwent YAG-laser vitreolysis and were under observation from 01.09.16 to 31.01.18. The patients were 34 to 86 years old (mean age 62.7±10.2 years), 28 (19.4%) patients were male, 116 (80.6%) — female. All patients underwent standard and additional examination: ultrasonography (Accutome B-scan plus, U.S.A.), optic biometry (Lenstar 900, Haag-Streit, Switzerland), spectral optical coherence tomography using RTVue XR Avanti scanner (Optovue, U.S.A.) in modes Enhanced HD Line, 3D Retina, 3D Widefield MCT, Cross Line, Angio Retina, and scanning laser ophthalmoscopy (SLO) using Navilas 577s system. Laser vitreolysis was performed using the Ultra Q Reflex laser (Ellex, Australia). **Results.** This paper presents methods of objective quantitative and qualitative assessment of artifactual shadows of vitreous floaters with spectral optical coherence tomographic scanner RTVue xR Avanti employing an algorithm of automatic detection of non-perfusion zones in modes Angio Retina, HD Angio Retina, as well as foveal avascular zone (FAZ) measurement with Angio Analytics® software. SLO performed with Navilas 577s was used as method of visualizing floaters and artifactual shadows in retinal surface layers prior to surgical treatment and after YAG-laser vitreolysis. **Conclusion.** Suggested methods of quantitative and qualitative assessment of artifactual shadows of the floaters in retinal layers are promising and may prove to be highly relevant for clinical monitoring of patients, optimization of treatment indications and evaluating effectiveness of YAG-laser vitreolysis. Further research of laser vitreolysis effectiveness in patients with vitreous floaters is necessary.

Keywords: *weiss ring, laser vitreolysis, Navilas 577s, myodesopsia, posterior vitreous detachment.*

Vestnik _Oftalmologii_2018-1_EN

Floating opacities in the vitreous body are a significant pathology in ophthalmology. They cause visual discomfort to a considerable number of patients.

Floaters, also called *muscae volitantes* (Latin: “flying flies”), occur mainly due to destructive changes in the vitreous body, syneresis, posterior vitreous detachment (PVD) [1—3]. Only few patients complain about them, so they do not require treatment, but in certain cases, thick or large opacities that get into the field of view can cause serious discomfort in daily life and become psychologically challenging [2, 4]. As reported by B. Webb [5], floaters provoke anxiety in 76% of patients and significantly decrease the quality of life in 33% of them. According to A. Wagle et al. [6], patients with symptomatic vitreous floaters are ready to sacrifice 1.1 year for every 10 years of their remaining life in order to get rid of the discomfort caused by the floaters. The extent of physical discomfort depends on floater’s localization relative to line of vision, their size, weight, distance from the cornea, and patient’s individual sensitivity [1].

There are currently two main methods of treating vitreous floaters: pars plana (posterior) vitrectomy and YAG-laser vitreolysis; while they both have certain indications and complication, randomized proofs of their effectiveness are lacking [2—7].

According to a number authors, pars plana vitrectomy eliminates the floaters, but considering its invasive nature and the possible complications that include endophthalmitis, retinal perforation and detachment, cataract, the method should only be used when patient’s vision is substantially impaired [2, 7].

At present, YAG-laser vitreolysis can be considered alternative treatment for symptomatic vitreous floaters [4, 8, 9]. It has several advantages: non-invasive nature, low complication rate, absence of post-surgical limitations, economic viability [7, 8]. Reintroduction of YAG-laser vitreolysis became possible thanks to a newly developed system called Reflex (Ultra Q Reflex laser), which allows axial (coaxial) lighting – when the light source is positioned on the same optical axis of slit-lamp microscope and radiated laser beam [7].

The mechanism of modern laser vitreolysis involves vaporization that happens due to laser-induced breakdown: a high frequency electromagnetic field with temperature of more than 4000°C forms in a short period of time over an area of 4–8 μm, creating plasma which converts the floater into gas [7].

Correspondence mail:
Shaimova Venera Airatovna – Doctor of Medicine
e-mail: shaimova.v@mail.ru

There is a relevant need for methods of objective assessment of vitreous floaters for dynamic observation and treatment strategy selection. Floaters were discovered to reduce vision due to artifactual shadows [1, 3] dropping on the optical zone of retina and the development of floater scotomas [10].

The available literature, however, does not cover the problem in sufficient detail: there are no objective methods of quantitative assessment of vitreous floaters [1, 4, 11], and only single studies analyze contrast sensitivity [2] or try to visualize artifactual shadows from the floaters in retinal layers before and after surgical treatment (pars plana vitrectomy) [3].

In this regard, it is important to find ways of objective quantitative and qualitative evaluation of YAG-laser treatment effectiveness.

The purpose of this study is develop methods for evaluating effectiveness of YAG-laser vitreolysis of vitreous floaters.

Material and methods

The study included 144 patients (173 eyes) who had undergone YAG-laser vitreolysis were observed from 01.09.16 to 31.01.18. The patients were 34 to 86 years old (mean age 62.7±10.2 years, Me (LQ; UQ) 61.0 (56; 68)), 28 (19.4%) patients were male, 116 (80.6%) — female.

All patients were examined upon initial visit and after YAG-laser vitreolysis, including standard additional procedures: ultrasonography (Accutome B-scan plus, U.S.A.), optical biometry (Lenstar 900, Haag-Streit, Switzerland), spectral optical coherence tomography using RTVue XR Avanti scanner (Optovue, U.S.A.) in Enhanced HD Line, 3D Retina, 3D Widefield MCT, Cross Line, and Angio Retina modes, and scanning laser ophthalmoscopy (SLO) using Navilas 577s system.

Criteria for YAG-laser vitreolysis were: presence of symptomatic Weiss Ring floaters at least 3 mm away from the retina and 5 mm away from the crystalline lens, PVD, adequate patient's condition [7, 8]. Statistical analysis of the results was performed using Excel (Microsoft Office Professional 2013, Microsoft, U.S.A.) and Statistica 12.5 SP1 (StatSoft, U.S.A.) software.

Results

After analyzing refraction of 173 eyes, 18 (10.4%) were found to be emmetropic, 124 (71.7%) — myopic, and 31 (17.9%) — hypermetropic. Low myopia was observed in 42 (24.3%) eyes, moderate myopia — in 29 (16.8%) eyes, high myopia — in 53 (30.6%) eyes; low hypermetropy was noted in 26 (15.0%) eyes, moderate — in 5 (2.9%) eyes. Thirty-four (19.7%) eyes were pseudophakic.

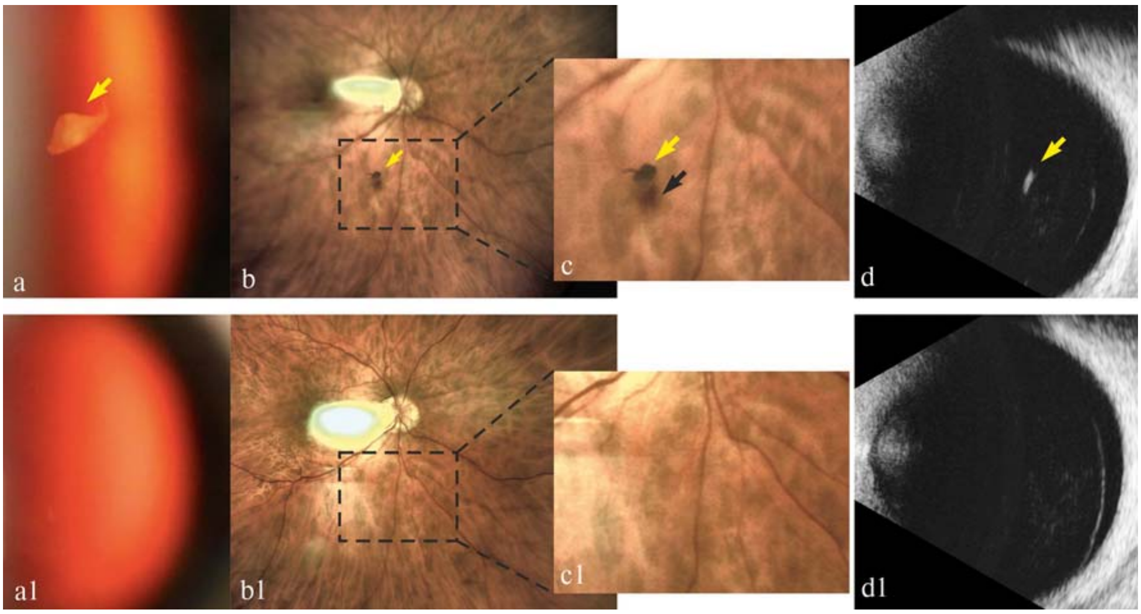

Figure 1. Multimodal image of a Weiss ring floater in the right eye of patient G. (62 y.o.) before and after YAG-laser vitreolysis.

In the upper half are images before the surgery: a — colored photo of the vitreous body: in the lower segment of the eyeball a thick, irregularly shaped Weiss ring opacity can be seen (indicated by yellow arrow); b — wide-field colored image of the eye fundus acquired with Navilas 557s: in the lower segment, near the vascular arcade, a floating opacity is dropping shadow on the retinal surface; c — enlarged part of that image — the floating opacity (indicated by yellow arrow) and its shadow on the retinal surface (indicated by black arrow); d — ultrasonographic image of the eye: a mobile hyperechoic structure (indicated by yellow arrow) 2.4x0.6 mm in size associated with partial detachment of posterior hyaloid membrane (PHM), located 5.7 mm away from the retina, surrounded by multiple isolated hyperechoic destructive changes of the vitreous body. In the lower half are images after YAG-laser vitreolysis: a1 — photo of the vitreous body: absence of the thick Weiss ring opacity; b1, c1 — colored image of the eye fundus acquired with Navilas 557s: absence of Weiss ring or shadow on the retinal surface; d1 — ultrasonographic image of the eye: multiple isolated hyperechoic structural changes associated with partial detachment of PHM.

Complex examination before the treatment revealed the following comorbid eye pathologies: lamellar macular hole – in 2 eyes, early cataract – in 127, early age-related macular degeneration – in 27; peripheral degeneration was observed in 116 eyes: lattice degeneration – 8, tear flap – 3, button-holed flap – 4, cystoid degeneration – 12, white-without-pressure – 10, honeycomb degeneration – 27, frosted degeneration – 7, peripheral drusen – in 45 eyes. Therapeutic peripheral laser coagulation of the retina was performed in 15 eyes 1 month prior to YAG-laser vitreolysis.

Laser vitreolysis of vitreous floaters was performed in 173 eyes. Technical parameters of the procedure were: wave length 1064 nm, impulse duration 4 ns, spot size 8 μm, laser beam energy 5—7 mJ. At start, the laser energy was lower (3 mJ), it was gradually increased until the appearance of vaporization signs (easily observable bubbles). When necessary, double and triple pulse modes were used (2 or 3 pulses per shot); total number of pulses were 36—414, maximum total energy for one procedure was 2116 mJ. Considering the large amount of floaters in 46 eyes, YAG-laser vitreolysis for those patients was done in several sessions: 2 sessions were required in 34 eyes, 3 sessions – in 11 patients, 5 sessions – for one patient. Thirty-two patients had both of their eyes treated. The following contact lenses were used during the procedures: Peyman-18, Karickhoff-21, Karickhoff-25 off-axis (Ocular, U.S.A.).

All patients were examined before the surgery, on the next day, then after 7 days, 1, 3, 6 months and after 1 year. Two complications arose during the procedure: partial discission of the posterior capsule in the form of a circular opening, and punctate hemorrhage in the lower-inner segment of the retina 3 mm from the optic nerve. Since the complications were insignificant, visual function remained intact. Effectiveness of the treatment was assessed using patient questionnaire and based on objective data: photo-registration, SLO imaging on Navilas 577s, ultrasound examination, OCT angiography.

Results of the objective qualitative evaluation by visualizing the state of vitreous floaters before and after YAG-laser vitreolysis can be seen as a multimodal image in **Figure 1**. Apart from the described visualization method for floater and artefact shadows that drop on surface

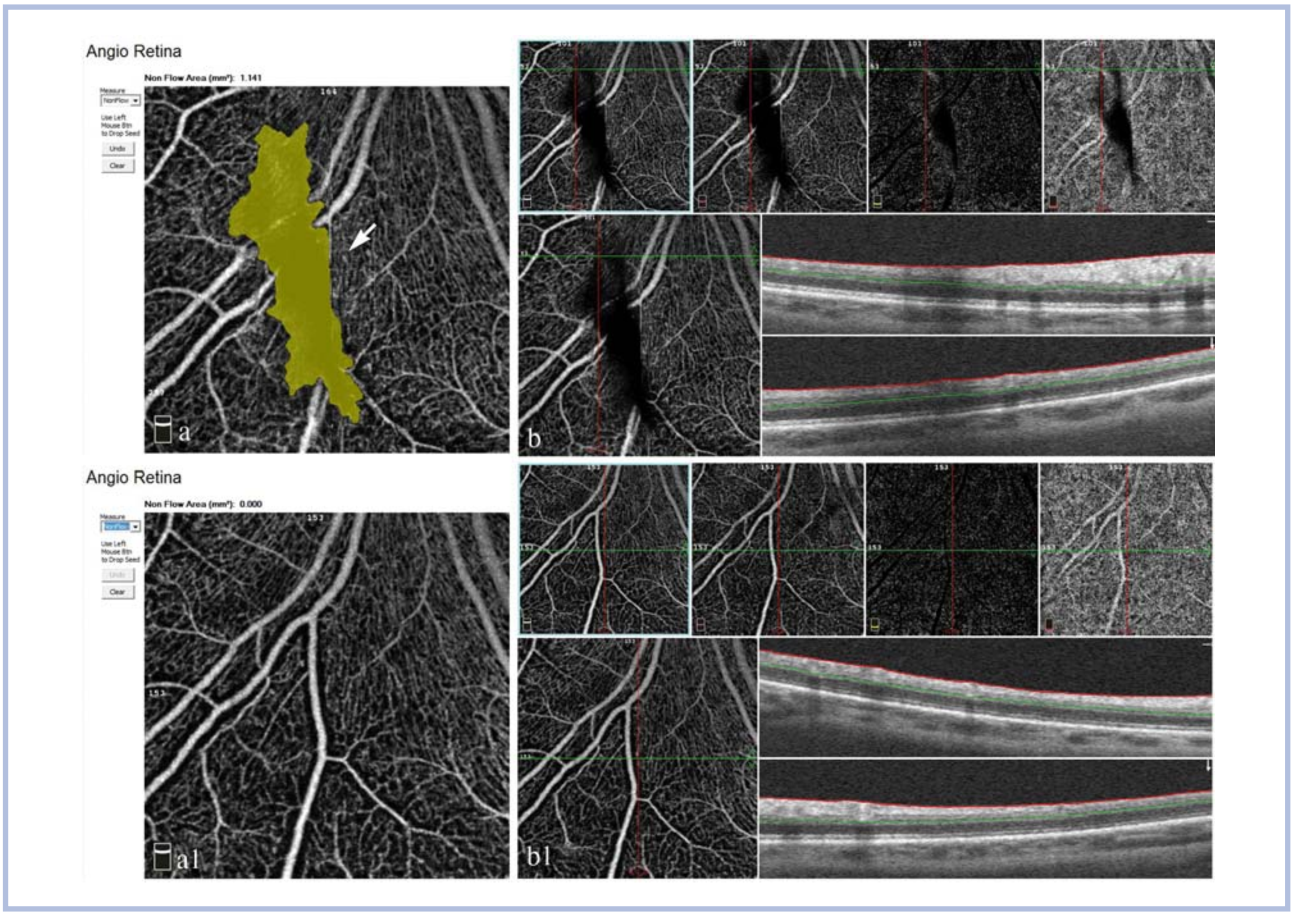

Figure 2. Quantitative and qualitative per-layer assessment of artifactual shadow from Weiss ring opacity performed with OCT angiography of the left eye of patient M. (60 y.o.) before and after YAG-laser vitreolysis.

a — image at inner limiting membrane level (superficial inner vascular plexus): artifactual shadow 1.141 mm2 in area can be seen as false zone of nonperfusion, corresponding to Weiss ring projection; b – automatic per-layer segmentation of vascular plexus by AngioVue software before the surgery: false zone of non-perfusion can be seen in all layers; a1 – image at inner limiting membrane level (superficial inner vascular plexus): no artifactual shadow as false nonperfusion zone of Weiss ring can be seen; b1 – automatic per-layer segmentation of vascular plexus by AngioVue software before the surgery: no false zone of nonperfusion can be seen in any layer.

retinal layers, we have studied the possibilities of using scanning laser ophthalmoscopy for quantitative assessment of artefact shadows in retinal layers. For that purpose, we used the spectral optical coherence tomograph RTVue xR Avanti (Optovue, U.S.A.) in Angio Retina and HD Angio Retina modes to determine the area of false nonperfusion (**Figure 2**), as well as automatic measurement feature included in Angio Analytics software version 2017.1.151 (**Figure 3**) to determine foveal avascular zone (FAZ) area.

Discussion

This study showcases the method of objective quantitative assessment of the size of artifactual shadows from floating opacities dropping on the retina. The method is highly significant for clinical purposes of dynamic observation, optimization of indications for treatment and assessment of YAG-laser vitreolysis effectiveness.

Some researchers have found direct correlation between quantitative ultrasound measurements, contrast sensitivity and quality of life [12].

In recent years, spectral OCT have seen wide-spread application as it can provide non-invasive and detailed per-layer visualization of intraocular structures [13, 14].

The first studies have been conducted that analyze the application of OCT for visualization, objective and qualitative assessment of scotomatic obscurations in the central retina caused by vitreous haze [3, 10, 15], and detailed evaluation of architectonics of the cortical layers of the vitreous body and vitreoretinal interface of the central, as well as peripheral areas using Enchanced HD Line mode [16]. L. Huang et al. [3] was able to observe the artifactual shadows from vitreous floaters by combining spectral OCT and scanning laser ophthalmoscopy methods for pre-surgery examination, and identify the absence of obscurations after vitrectomy.

We managed to measure the area of artifactual shadow from Weiss ring floaters in retinal layers using the modern tomograph RTVue xR Avanti (Optovue, U.S.A.), which can automatically detect nonperfusion zones in Angio Retina and HD Angio Retina modes, and its software Angio Analytics includes a feature to help measure foveolar avascular zone (FAZ).

Conclusions

Algorithm of automatic area measurement of retinal avascular zones of RTVue xR Avanti (Optovue, U.S.A.) tomograph and its Angio Analytics software allow quantitative assessment of the area of artifactual shadows that appear on OCT angiograms as false zones of non-perfusion.

The described method of quantitative evaluation of vitreous floaters by their artifactual shadows in retinal layers has great potential and clinical significance for dynamic observation, optimization of indications for treatment and assessment of YAG-laser vitreolysis effectiveness, but it requires further research.

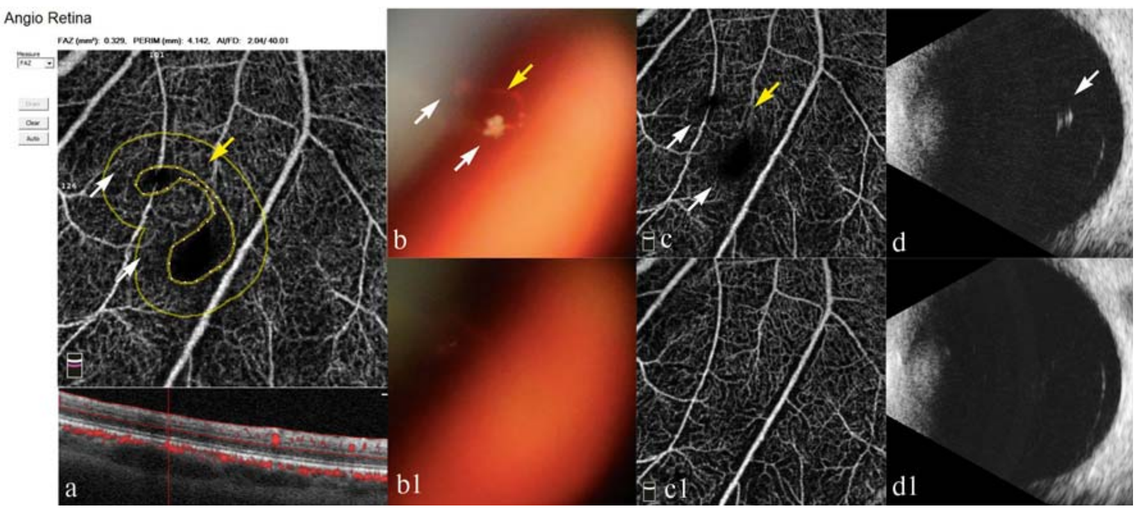

Figure 3. Multimodal image of artifactual shadow of Weiss ring before and after YAG-laser vitreolysis of the left eye of patient C. (58 y.o.).

Left part: a – OCT angiography scan in Angio Retina mode: at the level of inner neurosensory retinal layers (superficial inner vascular plexus) an artifactual shadow 0.329 mm2 in area can be seen in Weiss ring projection in the form of false nonprefusion zone. The upper half contains images before the surgery: б – colored photo of the vitreous body: two thick irregularly shaped opacities can be seen, connected by a thin threadlike structure (Weiss ring), in the lower segment; в – artifactual shadow (indicated by white arrows), half-shadow (indicated by yellow arrow) from the connecting structure on OCT angiography in Angio Retina mode corresponding to Weiss ring projection; г – ultrasonographic image of the eye: a mobile hyperechoic structure 1.5x1.7 mm in size associated with partial detachment of PHM, located 4.2 mm away from the retina, surrounded by multiple isolated hyperechoic destructive changes of the vitreous body. In the lower half are images after YAG-laser vitreolysis: б1 – a photo of transparent vitreous body; в1 – OCT angiography scan at inner limiting membrane level: no artifactual shadow in the form of false nonperfusion zone; г1 – ultrasonographic image of the eye: individual isolated hyperechoic structural changes associated with partial detachment of PHM.

Author contributions:

Study conception and design: V.Sh., T.Sh., A.G.

Acquisition and processing of data: A.G., T.Sh., R.Sh., Zh.G.

Drafting of manuscript: V.Sh., T.Sh., R.Sh., P.R.

Critical revision: V.Sh., P.R., A.F.

The authors declare that there are no conflicts of interest.

REFERENCES

1. Milston R, Madigan MC, Sebag J. Vitreous floaters: Etiology, diagnostics, and management. *Surv Ophthalmol.* 2016;61(2):211-227. https://doi.org/10.1016/j.survophthal.2015.11.008
2. Sebag J, Yee KM, Wa CA, Huang LC, Sadun AA. Vitrectomy for floaters: prospective efficacy analyses and retrospective safety profile. *Retina.* 2014; 34(6):1062-1068. https://doi.org/10.1097/iae.0000000000000065
3. Huang LC, Yee K, Wa CA, Nguyen JN, Sadun AA, Sebag J. *Vitreous Floaters and Visiond-Current Concepts and Management Paradigms.* In: Sebag J, ed. Vitreous — in Health and Disease. New York: Springer; 2014. https://doi.org/10.1007/978-1-4939-1086-1_45
4. Ivanova T, Jalil A, Antoniou Y, Bishop PN, Vallejo-Garcia JL, Patton N. Vitrectomy for primary symptomatic vitreous opacities: an evidence-based review. *Eye (Lond).* 2016;30(5):645-655. https://doi.org/10.1038/eye.2016.30
5. Webb BF. Prevalence of vitreous floaters in a community sample of smartphone users. *Int J Ophthalmol.* 2013;6(3):402-405. https://doi.org/10.3980/j.issn.2222-3959.2013.03.27
6. 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. https://doi.org/10.1016/j.ajo.2011.01.026
7. Karickhoff JR. *Laser Treatment of Eye Floaters.* Washington: Medical Publishing LLC; 2005.
8. Shah CP, Heier JS. YAG Laser Vitreolysis vs Sham YAG Vitreolysis for Symptomatic Vitreous Floaters: A Randomized Clinical Trial. *JAMA Ophthalmol.* 2017;135(9):918-923. https://doi.org/10.1001/jamaophthalmol.2017.2388
9. Little HL, Jack RL. Q-switched neodymium: YAG laser surgery of the vitreous. *Graefes Arch Clin Exp Ophthalmol.* 1986;224(3):240-246. https://doi.org/10.1007/bf02143063
10. Schwartz SG, Flynn HW, Fisher YL. «Floater scotoma» demonstrated on spectral domain optical coherence tomography and caused by vitreous opacification. *Ophthalmic Surg Lasers Imaging Retina.* 2013;44(4):415-418. https://doi.org/10.3928/23258160-20130715-14
11. Vandorselaer T, Van De Velde F, Tassignon MJ. Eligibility criteria for Nd-YAG laser treatment of highly symptomatic vitreous floaters. *Bull Soc Belge Ophtalmol.* 2001;280:15-19.
12. Mamou J, Wa CA, Yee KM, Silverman RH, Ketterling JA, Sadun AA, Sebag J. Ultrasound-based quantification of vitreous floaters correlates with contrast sensitivity and quality of life. *Invest Ophthalmol Vis Sci.* 2015;56(3):1611-1617. https://doi.org/10.1167/iovs.14 —15414
13. Huang D, Swanson EA, Lin CP, Schuman JS, Stinson WG, Chang W, Hee MR, Flotte T, Gregory K, Puliafito CA, Fujimoto JG. Optical coherence tomography. *Science.* 1991;254(5035):1178-1181.
14. Adhi M, Duker JS. Optical coherence tomography — current and future applications. *Curr Opin Ophthalmol.* 2013;24(3):213-221. https://doi.org/10.1097/icu.0b013e32835f8bf8
15. Kennelly KP, Morgan JP, Keegan DJ, Connell PP. Objective assessment of symptomatic vitreous floaters using optical coherence tomography: a case report. *BMC Ophthalmol.* 2015;15:22. https://doi.org/10.1186/s12886-015-0003-5
16. Shaimova V. *Peripheral Retinal Degenerations: Optical Coherence Tomography and Retinal Laser Coagulation.* Cham: Springer International Publishing; 2017.