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OPTIMIZATION OF ENERGY PARAMETERS DURING SURGERY OF HIGH-DENSITY CATARACT

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✧ ***The goal*** is to develop a combined technique for preliminary YAG laser fragmentation and Femto laser exposure on a CATALYS device and to evaluate its role in reducing the time and energy parameters of a surgery of high-density cataract. ***Material and methods.*** The study included 118 patients (118 eyes) with age-related cataracts of the 3rd and 4th degrees of lens nucleus density. In the main group, before phacoemulsification (PE) with a Femto laser support and IOL implantation, preliminary YAG laser phacofragmentation of the lens nucleus was performed. In the first control group, PE was performed with Femto laser support and IOL implantation. In the second control group – PE with IOL implantation. ***Results.*** A 35% decrease in the energy of the Femto laser action at a 3rd degree of lens nucleus density was achieved, and 40% – at the 4th degree, in comparison with the PE with the Femto laser support without preliminary YAG laser phacofragmentation, a 38% decrease in the cumulative ultrasound energy at 3rd degree of the lens nucleus density, and 42% at 4th degree compared with isolated ultrasonic cataract phacoemulsification. ***Conclusion.*** The proposed modification of the technique of combined YAG laser and Femto laser exposure allows achieving during cataract surgery a complete fragmentation of the lens nucleus of a high degree of density, helps minimizing the risk of complications and reaching quick postoperative rehabilitation of patients.

✧ ***Keywords:*** cataract; phacoemulsification; YAG laser phacofragmentation; femtosecond laser support.

ОПТИМИЗАЦИЯ ЭНЕРГЕТИЧЕСКИХ ПАРАМЕТРОВ В ХОДЕ ХИРУРГИИ КАТАРАКТЫ ВЫСОКОЙ СТЕПЕНИ ПЛОТНОСТИ

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✧ ***Цель*** — разработать комбинированную методику предварительной ИАГ-лазерной фрагментации и фемтолазерного воздействия на приборе CATALYS и оценить её роль в уменьшении временных и энергетических параметров хирургии катаракты высокой степени плотности. ***Материал и методы.*** В исследование были включены 118 пациентов (118 глаз) с возрастной катарактой 3-й и 4-й степени плотности ядра хрусталика. В основной группе перед факоэмульсификацией катаракты (ФЭК) с фемтолазерным сопровождением и имплантацией интраокулярной линзы (ИОЛ) проводили предварительную ИАГ-лазерную факофрагментацию ядра хрусталика. В первой контрольной группе выполняли ФЭК с фемтолазерным сопровождением и имплантацией ИОЛ. Во второй контрольной группе — ФЭК с имплантацией ИОЛ. ***Результаты.*** Достигнуто снижение энергии фемтолазерного воздействия на 35 % при 3-й степени плотности ядра хрусталика и на 40 % — при 4-й степени по сравнению с проведением ФЭК с фемтолазерным сопровождением без предварительной ИАГ-лазерной факофрагментации; снижение кумулятивной энергии ультразвука на 38 % при 3-й степени плотности ядра хрусталика и на 42 % — при 4-й степени по сравнению с изолированной ультразвуковой ФЭК.

Заключение. Предложенная модификация методики комбинированного ИАГ-лазерного и фемтолазерного воздействия позволяет достичь полноценной фрагментации ядра хрусталика высокой степени плотности в ходе хирургии катаракты, способствует минимизации риска осложнений и быстрой послеоперационной реабилитации пациентов.

✧ ***Ключевые слова:*** катаракта; факоэмульсификация; ИАГ-лазерная факофрагментация; фемтолазерное сопровождение.

INTRODUCTION

Background. Ultrasound phacoemulsification (PE) of cataract is currently the most common and carefully developed method of surgical treatment of this condition [1]. However, PE in cases with high-degree density of the lens nucleus still deserves special attention, because it requires an increase in energy, in time parameters of ultrasound exposure, and in number of surgical manipulations [2, 3].

In this regard, a search for pre- and intraoperative methods of affecting the high-density nucleus of cataractous lens to decrease the ultrasound energy load on ocular structures, to reduce the time of procedure, and to minimize the risk of complications during surgery.

Of particular interest is the use of preliminary YAG-laser phacofragmentation that was developed in 2002 at the Kaluga branch of the S. Fyodorov Eye Microsurgery Federal State Institution; it remains successfully used to date. This method allows an effective peeling of layers of the lens fibers in high-density nuclei by means of local and dosed YAG-laser action. This method significantly reduces the total energy load during the subsequent PE [4].

The trend in cataract surgery during the last decade was an active use of femtosecond laser (FSL) support. This allows the automation of critical stages of the procedure, including femtolaser fragmentation of the lens nucleus, and thus reducing the total ultrasound energy during PE, as well as the time of surgery, leading to more accurate and predictable functional results and to lower incidence of complications [5].

However, the energy of FSL radiation must be increased to fragment lenses with high degree of nucleus density. This causes excessive cavitation bubbles' formation, which could lead to the rupture of posterior lens capsule (capsular block syndrome) and to the dislocation of lens fragments into the vitreal cavity [6].

In addition, attempts to fragment high-density nuclei with femtolaser result in partial fragmentation or pseudo-fragmentation of the lens nucleus in the vast majority of cases.

This study aimed to develop a combined method of preliminary YAG laser phacofragmentation and femtolaser impact using the CATALYS device and to evaluate its role in reducing the time and energy parameters of high-density cataract surgery.

MATERIALS AND METHODS

The study included 114 patients (114 eyes) with age-related cataracts with 3rd and 4th degree of lens nucleus density, according to the classification by K.V. Boyko (2013). The median age was 64 $\pm$ 12 years. All patients were divided into the main and two control groups depending on the method of surgical treatment. In the main group (21 eyes with a third-degree cataract and 17 eyes with a fourth-degree cataract), preliminary YAG laser phacofragmentation of the lens nucleus was performed before PE with femtolaser assistance and IOL implantation. In the first control group (19 eyes with a third-degree cataract and 19 eyes with a fourth-degree cataract), PE was performed with femtolaser support and IOL implantation. In the second control group (20 eyes with third-degree cataract and 18 eyes with a fourth-degree cataract), PE with IOL implantation was performed.

In addition to standard preoperative examinations, special methods, namely, measurement of the lens optical density, specular microscopy and ultrasound biomicroscopy, were used. The optical density of the lens was quantified using an Oculus Pentacam HR system (USA). Preliminary YAG laser fragmentation of the lens nucleus was performed using a Visulas YAG III YAG laser (Carl Zeiss Meditec AG, Germany).

During preliminary YAG laser PE, laser impacts were applied to the lens nucleus periphery with minimal YAG laser energy and with a gradual increase in energy until the lens nucleus was delaminated. Then, the laser impacts were transferred to the central nucleus area.

The femtolaser action on the lens nucleus in the main and the first control groups was achieved using the femtolaser CATALYS Precision Laser

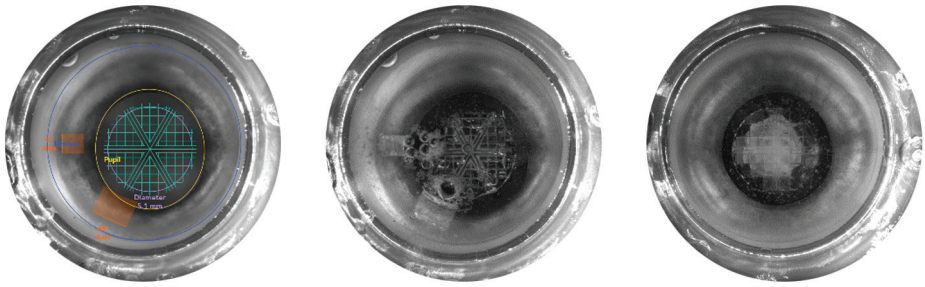


Fig. 1. Fragmentation of the lens into 6 equal fragments with an additional grid for lens softening

Рис. 1. Фрагментация хрусталика на 6 равных фрагментов с дополнительной решеткой для размягчения хрусталика

System (Optimedica, SantaClara, CA, USA). The advantages of this femtolaser system are the wide range of lens fragmentation patterns and the capability to change the dose parameters of femtolaser pulse energy in the anterior and posterior layers of the lens and the distance between impacts. Fragmentation can occur along the lines of the lens splitting into segments and additionally in the form of a mesh structure between segments. In addition, the number of repetitions of processing the selected segmentation lines in the lens fragmentation pattern can be changed as the laser passes through the segmented part of the pattern depending on lens density and thickness.

In the main group, the femtolaser support of PE was held the day after preliminary phacofragmentation (PP). The energies at the stage of the anterior capsule opening in all cases were the same (0.2 J). The lens nucleus was fragmented along three meridians into six equal segments. Femtolaser cuts were located in a safe zone at a distance of 500 microns from the anterior lens capsule and corresponded to the lens nucleus height calculated using the INTEGRAL GUIDANCE System, which excluded femtolaser effects on less dense cortical layers and excessive formation of vacuoles. Additional fragmentation to soften the lens was performed in the form of cuts in the mesh structure. The distance between grid lines was 350 microns, and that between segmentation and softening was 200 microns (Fig. 1).

The energy parameters recommended by the manufacturer of the femtolaser were insufficient for full fragmentation of the nuclei of cataractous lenses with 3rd and 4th degrees of density. Therefore, we developed an algorithm for optimizing these parameters, which consisted in increasing the pulse energy in increments of 0.5 MJ and the number of repetitions of segmentation with a minimal energy load on ocular structures. Thus, for the fragmentation of a lens nucleus with a third-degree density, we used 5.4 J femtolaser energy (the single pulse energy was 8 and 10 MJ in the anterior and posterior layers of the lens, respectively) and 4–5 repetitions of segmentation. For the fragmentation of the lens nucleus with fourth-degree density, 8.17 J energy (the single-pulse energies were 8 and 10 MJ in the anterior and posterior layers of the lens, respectively) and 6–7 repetitions segmentation were used.

Subsequent PE was performed in accordance with the standard “phaco chop”method.

During PE, the completeness and quality of laser cuts in the thickness of the lens nucleus were evaluated in accordance with the classification we proposed earlier [7–9]. A complete fragmentation was considered satisfactory. In addition, the ultrasound energy parameters and the amount of fluid used were evaluated intraoperatively.

In the first control group, 8.4 J femtolaser energy was used for fragmentation of the lens nucleus with a third-degree density, and 13.6 J energy was used for the lens nucleus with a fourth-degree density.

In the second control group, we performed a single PE by the standard “phaco chop” method with IOL implantation.

RESULTS

In the main group, preliminary YAG laser destruction provided a uniform stratification of lens fibers along the formed cavitation vacuoles. Third-degree density was characterized by the mixed-type destruction of the nucleus in the form of “bubbles” and “petals.” For the fourth-degree density, “petals” were predominant (Fig. 2).

Cavitation vacuoles, which were obtained as a result of PP by YAG laser, did not interfere with the high quality visualization of the anterior segment structures by the optical coherence tomog-

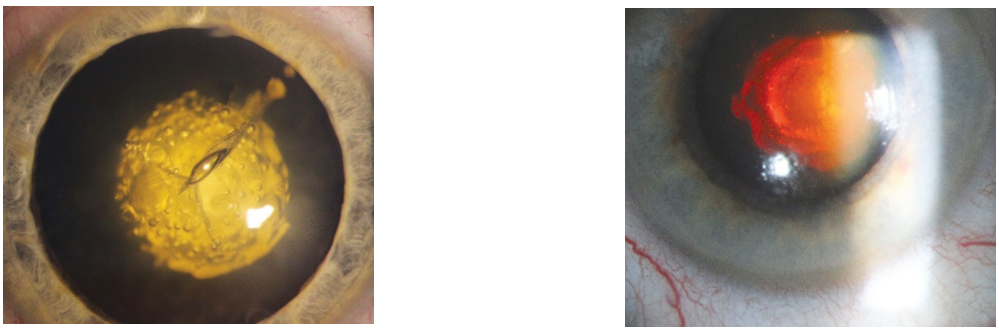
raphy (OCT) system of the FSL and the accuracy of planned femtosecond action (Fig. 3).

The evaluation of the results of femto-assisted cataract surgery after preliminary YAG laser exposure showed that the fragmentation of lens nuclei with third- and fourth-degree densities using 3.5 and 8.17 J femtolaser energy achieved complete separation of the lens nucleus (Fig. 4). The use of the selected FSL parameters allowed the fragmentation of the lens nucleus along its entire thickness, excluding excessive formation of cavitation bubbles, which technically caused no complication in the subsequent stages of hydrodissection and hydrodelineation.

In the first control group, in which PE was performed with laser assistance but without PP by YAG laser, after FSL fragmentation of the nuclei with third-degree density, we observed partial fragmentation of the lens nucleus in 60% of the cases, whereas in the nuclei with fourth-degree density, fragmentation of the surface layers of the crystalline lens or pseudofragmentation occurred in 80% of the cases.

Comparative analysis of the obtained laser energy values in the main and control groups showed that for patients with a cataract of third-degree density, conducting an YAG laser PP with 0.1 J energy allowed the reduction of the total laser energy from 8.4 J when performing PE with a femtolaser support to 5.4 J when using the combined technique that we developed, thus reducing the total energy load by 35%. For patients with cataracts of fourth-grade density, performing YAG laser PP with energy of 0.2 J reduced the total laser energy from 13.6 J when performing PE with femtolaser support to 8.17 J when using the combined technique that we developed, thus reducing the total energy load by 40%.

Comparison of the parameters of PE in the main and control groups in third-degree density of the lens nucleus revealed that in the main group, the cumulative ultrasound energy decreased by 38%, the total time of ultrasound exposure by 48%, and the volume of the aspirated fluid by 28%, compared with the second control group, in which PE was performed without additional laser actions.



a *b*

Fig. 2. Preliminary YAG laser fragmentation: *a* — nuclei of the cataractous lenses of the 3rd degree of density; *b* — nuclei of the cataractous lenses of the 4th degree of density

Рис. 2. Предварительная ИАГ-лазерная фрагментация: *a* — ядра катарактального хрусталика 3-й степени плотности; *b* — ядра катарактального хрусталика 4-й степени плотности

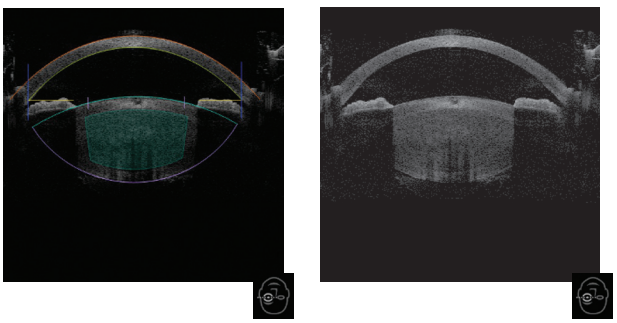


Fig. 3. Optical coherence tomography of the anterior segment of the eye

Рис. 3. Оптическая когерентная томограмма переднего отрезка глаза

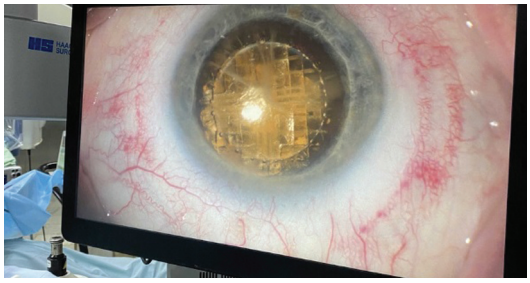


Fig. 4. Uniform distribution of cavitation bubbles. Complete fragmentation without excessive pneumodissection

Рис. 4. Равномерное распределение кавитационных пузырьков. Полноценная фрагментация без избыточной пневмодиссекции

Table 1 / Таблица 1

Comparison of laser energies and PE parameters in the main and control groups with third degree of lens nucleus density
Сравнение значений лазерной энергии и параметров факоэмульсификации катаракты в основной и контрольных группах при 3-й степени плотности ядра хрусталика

Parameters	Main group	Control group 1	Control group 2
Total laser energy, J	5.4 (↓35%) (5,3 FSL + 0,1 YAG)	8.4	–
Type of fragmentation	Full	Partial in 60% of cases	–
Pneumodissection	Safe	Excessive	–
Cumulative ultrasound energy, J	7.1 ± 1.9 (↓38%)	9.8 ± 1.3 (↓16%)	11.6 ± 2
Total time of ultrasound exposure, sec	45 ± 7 (↓48%)	52.4 ± 6 (↓39%)	86 ± 7
Volume of aspirated fluid, ml	70 ± 7 (↓28%)	82 ± 5 (↓16%)	98 ± 10

Table 2 / Таблица 2

Comparison of laser energies and PE parameters in the main and control groups with fourth degree of lens nucleus density
Сравнение значений лазерной энергии и параметров факоэмульсификации катаракты в основной и контрольных группах при 4-й степени плотности ядра хрусталика

Parameters	Main group	Control group 1	Control group 2
Total laser energy, J	8.37 (↓40%) 8.17 FSL + 0,2 YAG)	13.6	–
Type of fragmentation	Full	Pseudo-fragmentation in 80% of cases	–
Pneumodissection	Safe	Excessive	–
The cumulative ultrasound energy, J	9.7 ± 1.6 (↓42%)	12.8 ± 1.8 (↓24%)	16.9 ± 1.8
The total time of ultrasound exposure, sec	51 ± 4 (↓47%)	59 ± 6 (↓39%)	97 ± 7
The volume of aspirated fluid, ml	78 ± 6 (↓28%)	93 ± 4 (↓14%)	108 ± 9

In the first control group, after isolated femtolaser fragmentation, we noted a decrease in the cumulative ultrasound energy by 16%, the total time of ultrasound exposure by 39%, and the volume of aspirated fluid by 16% compared with the second control group (Table 1).

In the fourth-degree density lens nucleus in the main group, the cumulative energy of ultrasound during PE decreased by 42%, the total time of ultrasound exposure by 47%; the volume of the aspirated fluid by 28%. In the first control group, after isolated femtolaser fragmentation of the nuclei, the cumulative energy of the ultrasound decreased by 24%, the total time of ultrasound exposure by 39%; the volume of aspirated fluid by 14%, compared with the second control group (Table 2).

DISCUSSION

The modern technology of cataract surgery provides high visual functions in the early postoperative period. This enables the transfer of PE to the category of outpatient surgery [1].

However, at PE for the complete fragmentation of the lens nucleus with third and fourth-degree density, the ultrasound energy must be increased, which is associated with a high risk of complications, such as intraoperative ones (injury to the corneal endothelium, zonules, and posterior capsule of the lens), and postoperative ones, at early (reactive hypertension, iridocyclitis, and hyphema), and late (epithelial-endothelial dystrophy, Irvine–Gass syndrome) stages [2, 3]. Therefore, we developed a combined method for preliminary YAG laser fragmentation and intraoperative femtolaser exposure [7–10].

Previous studies of specialists of the Kaluga branch of the S. Fyodorov Eye Microsurgery Federal State Institution proved that the use of PP by YAG laser reduces the total ultrasound energy but causes no changes in hydrodynamic parameters; this method is also safe for ocular structures [4].

New opportunities for optimizing and reducing the energy load during the PE of dense cataracts opened with the use of the femtolaser system CATALYS Precision Laser System (OptiMedica, USA). This system combines a FSL, a soft liquid optic interface, and an integrated three-dimensional full-volume OCT to create precise laser cuts in the lens and cornea. Ultra-short pulses of an infrared laser are used to perform the procedure; the energy of one pulse is 1–10 mJ. Each FSL pulse causes a strictly localized plasma formation followed by cavitation, which destroys only micron-level tissues [11].

With this laser system, lens nucleus fragmentation can occur not only along the lines of the lens splitting into segments but also in the form of a mesh structure between segments. In addition, the number of processing repetitions of selected segmentation lines can be changed depending on the lens density and thickness [12–14].

In this paper, we proposed a combined method of preliminary YAG laser fragmentation and femtolaser action using the CATALYS unit and evaluated its role in reducing the energy parameters at high-density cataract surgery.

The preliminary YAG laser fragmentation of the cataractous lens nucleus caused no interference with the high quality visualization of the anterior segment structures by the OCT system of the FSL and did not reduce the accuracy of subsequent femtolaser exposure.

Comparison of energy parameters in the study groups showed that for patients with third-degree density cataracts, the use of the combined technique reduced the cumulative ultrasound energy by 38%, the total time of ultrasound exposure by 48%, and the volume of aspirated fluid by 28% compared with the isolated PE.

For patients with fourth-grade cataracts, the combined use of the preliminary YAG laser exposure the day before surgery and FSL tracking of the PE reduced the cumulative ultrasound energy by 42%, the total time of ultrasound exposure by 47%, and the volume of aspirated fluid by 28% in comparison with the PE performed without additional laser actions on the nucleus of the cataractous lens.

CONCLUSION

The proposed modification of the method of combined YAG laser and femtolaser exposure achieved full-fledged fragmentation of the lens nucleus with a high-degree density during cataract surgery.

The use of this technique reduced the energy of femtolaser exposure by 35% for third-degree density lens nucleus and by 40% for the fourth-degree density lens nucleus compared with the PE with femtolaser support but without PP by YAG laser. As a result, the cumulative energies of ultrasound reduced by 38% and 42% in the lens nucleus with third- and fourth-degree densities, respectively, compared with isolated ultrasound PE of cataracts, which minimizes the risk of complications and allows rapid postoperative rehabilitation of patients.

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Conflict of interest. The authors declare no conflict of interest.

Author's contributions.

A.V. Tereschenko, I.G. Trifanenkova – research concept and design and text writing;

A.M. Ivanov, M.V. Okuneva, and *N.V. Orlova* – data analysis, surgical treatment and diagnostic studies, and text writing;

M.V. Okuneva and *N.V. Orlova* – collection and processing of materials, surgical treatment and diagnostic research, writing, and literature review.

REFERENCES

1. Chan E, Mahroo OA, Spalton DJ. Complications of cataract surgery. *Clin Exp Optom.* 2010;93(6):379-389. https://doi.org/10.1111/j.1444-0938.2010.00516.x.

2. Daien V, Le Pape A, Heve D, et al. Incidence, risk factors, and impact of age on retinal detachment after cataract surgery in France: a national population study. *Ophthalmology*. 2015;122(11): 2179-2185. https://doi.org/10.1016/j.ophtha.2015.07.014.
3. Blomquist PH, Morales ME, Tong L, Ahn C. Risk factors for vitreous complications in resident-performed phacoemulsification surgery. *J Cataract Refract Surg.* 2012;38(2):208-214. https://doi.org/10.1016/j.jcrs.2011.10.001.
4. Терещенко А.В. Оптимизация энергетических параметров ультразвуковой и лазерной хирургии катаракты с помощью предварительного транскорнеального эндокапсулярного ИАГ-лазерного воздействия на ядра катарактальных хрусталиков // Вестник офтальмологии. – 2003. – Т. 119. – № 5. – С. 22–24. [Tereshchenko AV. Optimization of energy parameters of ultrasound and laser cataract surgery with a preliminary transcorneal endocapsular yag-laser impact exerted on the cataract lens nuclei. *Vestnik oftal'mologii*. 2003;119(5):22-24. (In Russ.)]
5. Hatch KM, Schultz T, Talamo JH, Dick HB. Femtosecond laser-assisted compared with standard cataract surgery for removal of advanced cataracts. *J Cataract Refract Surg.* 2015;41(9): 1833-1838. https://doi.org/10.1016/j.jcrs.2015.10.040.
6. Анисимова С.Ю., Анисимов С.И., Новак И.В., и др. Результаты факоэмульсификации катаракты с фемтолазерным сопровождением // Современные технологии катарактальной и рефракционной хирургии: Сб. научных статей. – М., 2013. – С. 31–35. [Anisimova SYu, Anisimov SI, Novak IV, et al. The results of phacoemulsification of cataract with femtosecond laser accompaniment. In: Sovremennyye tekhnologii kataraktal'noy i refraktsionnoy khirurgii*:* Sb. nauchnykh statey. Moscow; 2013. P. 31-35. (In Russ.)]
7. Окунева М.В., Терещенко А.В., Гречанинов В.Б., Сидорова Ю.А. Фемто- и YAG-лазерные техники факофрагментации в хирургии катаракты // Современные технологии в офтальмологии. – 2016. – № 5. – С. 67–69. [Okuneva MV, Tereshchenko AV, Grechaninov VB, Sidorova YuA. Femto- and YAG-laser techniques of phacofragmentation in cataract surgery. *Sovremennye tekhnologii v oftal'mologii.* 2016;(5):67-69. (In Russ.)]
8. Терещенко А.В., Трифаненкова И.Г., Романенко С.Я., и др. Фемтолазерная хирургия катаракты при различной степени плотности ядра хрусталика // Современные технологии в офтальмологии. – 2016. – № 5. – С. 93–95. [Tereshchenko AV, Trifanenkova IG, Romanenko SYa, et al. Cataract femtolaser surgery for varying degrees of lens core density. *Sovremennye tekhnologii v oftal'mologii.* 2016;(5):93-95. (In Russ.)]
9. Романенко С.Я., Терещенко А.В., Трифаненкова И.Г., и др. Энергетические параметры фемтолазерного сопровождения хирургии катаракты при различной степени плотности ядра хрусталика // Практическая медицина. – 2016. – № 6. – С. 145–148. [Romanenko SYa, Tereshchenko AV, Trifanenkova IG, et al. Energy parameters of femtosecond laser cataract surgery support at different degrees of the lens nucleus density. *Prakticheskaya meditsina*. 2016;(6):145-148. (In Russ.)]
10. Гречанинов В.Б., Терещенко А.В., Белый Ю.А., Демьянченко С.К. Лазерная деструкция катарактальных хрусталиков высокой степени плотности // Современные технологии в офтальмологии. – 2016. – № 4. – С. 66–68. [Grechaninov VB, Tereshchenko AV, Belyi YuA, Dem'yanchenko SK. Laser destruction of high-density cataract lenses. *Sovremennye tekhnologii v oftal'mologii.* 2016;(4):66-68. (In Russ.)]
11. Abell RG, Kerr NM, Vote BJ. Femtosecond laser-assisted cataract surgery compared with conventional cataract surgery. *Clin Exp Ophthalmol.* 2013;41(5):455-462. https://doi.org/10.1111/ceo.12025.
12. Abell RG, Kerr NM, Vote BJ. Toward Zero Effective Phacoemulsification Time Using Femtosecond Laser Pretreatment. *Ophthalmology*. 2013;120(5):942-948. https://doi.org/10.1016/j.ophtha.2012.11.045.
13. Conrad-Hengerer I, Hengerer FH, Schultz T, Dick HB. Effect of fs laser fragmentation on EPT in cataract surgery. *J Refract Surg.* 2012;28(12):879-884. https://doi.org/10.3928/1081597X-20121116-02.
14. Conrad-Hengerer I, Hengerer FH, Schultz T, Dick HB. Effect of fs laser fragmentation of the nucleus with different softening grid sizes on effective phaco time in cataract surgery. *J Refract Surg.* 2012;38(11):1888-1894. https://doi.org/10.1016/j.jcrs.2012.07.023.

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