OPHTHALMOLOGY

A CLINICAL CASE OF A COMBINED METHOD FOR CORRECTING POSTKERATOPLASTIC ASTIGMATISM OF A HIGH DEGREE IN A PATIENT WITH CATARACT

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ABSTRACT

Background. *Performing penetrating keratoplasty in 100 % of cases leads to the occurrence of induced postkeratoplasty astigmatism, which can be more than 12.0 D. If cataracts occur in this category of patients, performing cataract phacoemulsification with implantation of a toric intraocular lens (tIOL) does not completely solve the problem. The use of the method of implantation of intrastromal corneal segments at stage I before cataract phacoemulsification makes it possible to reduce the degree of postkeratoplasty astigmatism and create optimal conditions for additional correction of residual postkeratoplasty astigmatism due to the implantation of tIOL during cataract phacoemulsification.*

The aim of the study. *To analyze the clinical and functional indicators of correction of regular high-grade postkeratoplasty astigmatism in a patient with cataracts using a combined method, including first implantation of intrastromal corneal segments and subsequent cataract phacoemulsification with implantation of toric intraocular lens using the example of a clinical case.*

Material and methods. *A 55-year-old patient with cataracts, who had a history of undergoing penetrating keratoplasty, contacted us. According to the keratotopogram data, a regular postkeratoplasty astigmatism of 18.68 D was diagnosed. The patient underwent a combined method. At stage I, intrastromal corneal segments were implanted into the corneal graft, then after 6 months stage II was performed – cataract phacoemulsification with implantation of tIOL.*

Results. *Six months after intrastromal corneal segments implantation, the patient's keratometric data stabilized, and corneal astigmatism decreased to 8.98 D. Then the patient underwent cataract phacoemulsification with tIOL implantation. After 1 month, the spherical component of refraction was 0.5 D, the cylindrical component of refraction was –0.5 D, visual acuity increased to 1.0.*

Conclusion. *A combined method for correcting regular high-grade postkeratoplasty astigmatism in a patient with cataracts showed high refractive results, stability and safety in the long-term postoperative period.*

Key words: *postkeratoplastic astigmatism, intrastromal corneal segments, cataract*

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КЛИНИЧЕСКИЙ СЛУЧАЙ КОМБИНИРОВАННОГО СПОСОБА КОРРЕКЦИИ ПОСТКЕРАТОПЛАСТИЧЕСКОГО АСТИГМАТИЗМА ВЫСОКОЙ СТЕПЕНИ У ПАЦИЕНТА С КАТАРАКТОЙ

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РЕЗЮМЕ

Введение. *Выполнение сквозной кератопластики (СКП) приводит в 100 % случаев к возникновению индуцированного посткератопластического астигматизма (ПА), который может быть более 12 dптр. При возникновении у данной категории пациентов катаракты выполнение факоэмульсификации катаракты (ФЭК) с имплантацией торической интраокулярной линзы (тИОЛ) не позволяет полностью решить проблему. Применение метода имплантации интрастромальных роговичных сегментов (ИРС) на I этапе до ФЭК позволяет снизить степень ПА и создать оптимальные условия для докоррекции остаточного ПА за счёт имплантации тИОЛ во время ФЭК.*

Цель исследования. *Провести анализ клинико-функциональных показателей коррекции регулярного посткератопластического астигматизма высокой степени у пациента с катарактой комбинированным способом, включающим вначале имплантацию интрастромальных роговичных сегментов и последующее выполнение факоэмульсификации катаракты с имплантацией торической интраокулярной линзы, на примере клинического случая.*

Материал и методы. *К нам обратился пациент 55 лет с катарактой, в анамнезе у которого была выполнена сквозная кератопластика. По данным кератотопограммы был диагностирован регулярный ПА 18,68 dптр. Пациенту был выполнен комбинированный метод. На I этапе в роговичный трансплантат были имплантированы ИРС, затем через 6 мес. был выполнен II этап – ФЭК с имплантацией тИОЛ.*

Результаты. *Через 6 мес. после имплантации ИРС у пациента произошла стабилизация кератометрических данных, роговичный астигматизм снизился до 8,98 dптр. Затем пациенту была выполнена ФЭК с имплантацией тИОЛ. Через 1 мес. сферический компонент рефракции составил 0,5 dптр, цилиндрический компонент рефракции –0,5 dптр, острота зрения повысилась до 1,0.*

Заключение. *Комбинированный способ коррекции регулярного ПА высокой степени у пациента с катарактой показал высокий рефракционный результат, стабильность и безопасность в отдалённом послеоперационном периоде.*

Ключевые слова: *посткератопластический астигматизм, интрастромальные роговичные сегменты, катаракта*

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RELEVANCE

The occurrence of cataract in patients after penetrating keratoplasty (PK) reduces their visual acuity and requires its surgical treatment [1]. Conversely, an induced postkeratoplasty astigmatism (PA) is diagnosed after PK in every case, which can be high-grade and irregular [2]. This in turn leads to an increase in corneal aberrations, especially of higher orders, reducing visual acuity and leading to patient dissatisfaction with the optical outcome of surgery [3]. Performing cataract phacoemulsification (CPE) with toric intraocular lens (tIOL) implantation allows to simultaneously get rid of cataract and compensate corneal astigmatism in its regular form [4, 5]. This technique, however, is limited to the toric component of manufactured tIOLs up to and including 12 D. In summary, correction of regular PA greater than 12 D in a cataract patient requires an additional method of correction. Currently, implantation of intrastromal corneal ring segments (ICRS) into the corneal graft to increase corneal graft regularity and reduce PA is gaining popularity as a result of the lack of PA regression years after surgery compared to refractive laser surgery [6, 7]. In view of the above, the ICRS implantation method can be used in the combined treatment of such cataract patients with PA greater than 12 D.

THE AIM OF THE STUDY

To analyse the clinical and functional indices in the correction of regular high-grade postkeratoplasty astigmatism in a patient with cataract by a combined method including first implantation of intrastromal corneal ring segments using femtosecond laser followed by cataract phacoemulsification with toric intraocular lens implantation based on the example of a clinical case.

MATERIAL AND METHODS

Patient N., 55 years old, addressed the branch of the S.N. Fedorov Eye Microsurgery Centre of the Russian Ministry of Health with complaints of low vision and fog in front of the left eye for the last 2 years. Ophthalmological history: in 2002, a penetrating keratoplasty (PK) was performed on the right eye concerning stage IV keratoconus. On admission, uncorrected visual acuity (UCVA) was 0.03 i/c (incorrigible), intraocular pressure was 15 mmHg according to Maklakov, and the anteroposterior axis of the eye was 23.54 mm. At biomicroscopy, the corneal graft was transparent, had a diameter of 8.0 mm; the anterior chamber had a medium depth; pupil – 3.5 mm, photoreaction of III degree; iris was quiet, without structural changes; posterior capsular opacities were visualised in the crystalline lens, the underlying media were not clearly seen due to lens opacity. According to the keratotopogram on the TMS-4 device (Tomey, Japan), a regular high-grade PA of 18.68 D was visualised (Fig. 1).

According to the results of corneal optical coherence tomography (OCT) using an OCT Casia 2 (Tomey, Germany), the minimum thickness of the corneal graft in the centre was 457 μm. Endothelial cell density (ECD) measured on a Confoscan-4 device (Nidek, Japan) was 1925 cells/mm^2. According to the electrophysiological study on the Diopsys device (NOVA, USA), the lability of the optic nerve of the left eye was within the normal range. According to ultrasound B-scan on a Tomey UD-8000 (Tomey, Germany), the sheaths are adherent. According to the results of the examination, the diagnosis for the left eye was high-grade regular postkeratoplasty astigmatism, condition after penetrating keratoplasty, posterior capsular cataract.

Correction of regular PA was performed in 2 stages. The first stage was the implantation of two ICRS in the penetrating corneal graft using femtosecond laser

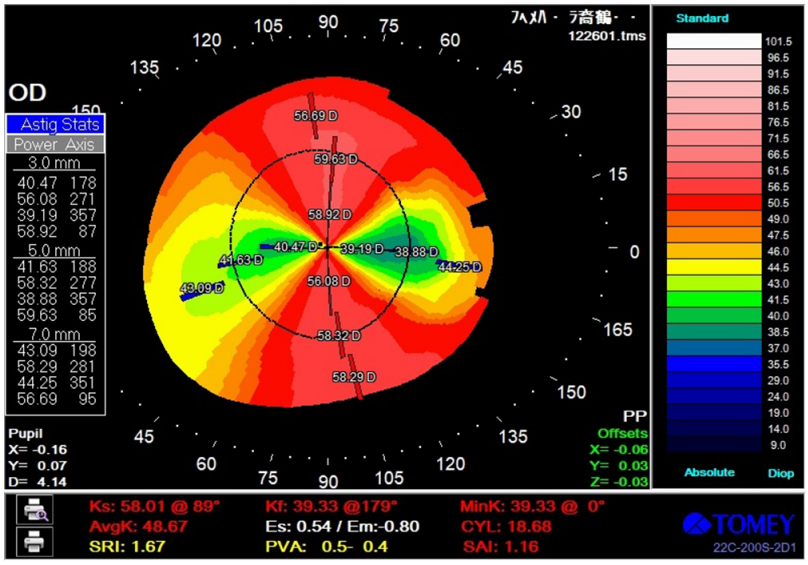

FIG. 1.

Keratotopogram of patient N. with induced regular high-grade postkeratoplasty astigmatism

(FSL) to reduce PA less than 12 D. Two identical ICRS (LLC Research and Experimental Production of Eye Microsurgery, Russia) made of polymethylmethacrylate were implanted in the patient, having the shape of a hemisphere on the cross section; inner radius – 5.0 mm, outer radius – 6.2 mm, height – 350 μm, arc length – 90°. ICRS indicators for implantation in the corneal graft were calculated according to the existing nomograms [8]. Then in the second stage, 6 months after stabilisation of clinical and functional parameters, CPE with implantation of tIOL for additional correction of residual PA was performed. This sequence was chosen not only to reduce corneal astigmatism (RA) at stage 1 by implanting ICRS in the corneal graft, but mainly to create optimal conditions for accurate tIOL calculation and centration at stage 2 by increasing the sphericity and regularity of the corneal graft.

ICRS implantation into a penetrating corneal graft was performed using the Russian 1 MHz FemtoViaisum FSL (Troitsk, Russia). Prior to surgery, the patient was marked the location of the intrastromal tunnel symmetrically relative to the patient's visual axis, which was determined by the Purkinje light reflex when the patient looked at the fixation mark of the operating microscope. The surgery involved two phases. In the first stage, an intrastromal tunnel was formed in the corneal graft with an inner resection diameter of 5.0 mm and an outer diameter of 6.2 mm, at a depth of 385 μm, using FSL. At the second stage, two ICRS with a height of 350 μm, with an arc length of 90° were implanted through the entrance vertical incision into the formed intrastromal tunnel and placed parallel to the strong axis of the PA according to the keratotopogram in order to flatten it between the implanted ICRS.

Six months after ICRS implantation in the penetrating corneal graft, the patient underwent CPE with implantation of tIOL AT Torbi 709M (Carl Zeiss, Germany) with an optical power of 16 D with a toric component of 8.0 D for additional correction of residual corneal astigmatism. Keratotopographic data, optical biometry data and online IOL calculators (Kane Formula, Barrett Universal II Formula) were used to calculate the optical power of the IOL. Prior to surgery, the patient was marked behind a slit lamp to mark the horizontal axis of the corneal graft. During preoperative pre-surgical preparation, the patient received instillation of a non-steroidal anti-inflammatory drug, and on the morning of the day of surgery, he additionally received mydriatic instillation of one drop three times 30 min before surgery. CPE with tIOL implantation was performed using the Infinity device (Alcon, USA) according to the standard technique. Using a Mendes ring on the operating table, the patient was marked with a strong corneal graft keratometry axis, along which a 1.8–2.2 mm long main tunnel incision was made, with paracenteses located at 3 and 9 o'clock. The depth of the anterior chamber was controlled at the stage of capsulorhexis by injecting viscoelastic into it. Capsulorhexis was performed with a curved insulin needle. Removal of the lens nucleus was performed using a phacoemulsifier. The cortical masses and epinuclius were removed using a coaxial irrigation-aspiration handpiece. tIOL was implanted with an injector, and then the marks of the cylindrical component of the tIOL were centred on the marks placed on the corneal graft before surgery, corresponding to the strong axis of the PA, according to the keratotopogram data. At the end of surgery, viscoelastic was flushed out of the anterior chamber using a Simcoe cannula. The main incision and paracentesis were sealed with sterile saline solution. Subconjunctival injection of antibiotic and corticosteroid was performed at the completion of surgery.

Apart from the standard methods of examination, the patient underwent: optical biometry with determination of eye length, anterior chamber depth, lens thickness on A-Scan Plus (Stormoff NRW Gmbh, Germany); keratotopography using keratotopograph Tomey 4 (Tomey, Japan); calculation of ECD on Confoscan-4 device (Nidek, Japan); keratopachymetry using OCT Casia 2 (Tomey, Germany); assessment of visco-elastic properties of the corneal graft using ORA device (Reichert, USA); measurement of protein flux and number of cells in the anterior chamber moisture using FS-2000 device (Kowa, Japan). The follow-up period after CPE was 6 months.

RESULTS

No intra- and postoperative complications were noted when performing IRS implantation into a penetrating corneal graft using FSL. At biomicroscopy on the first day after surgery, the penetrating corneal graft was transparent, ICRS were centred, posterior capsular opacities were visualised in the lens, and the underlying media were not clearly visible due to lens opacities.

At the examination on the day after ICRS implantation, the patient's UCVA increased by 0.02, corrected visual acuity (CVA) by 0.07, and these parameters did not change again during 6 months (Table 1).

The spherical component of refraction (SCR) could not be measured due to lens opacity. Corneal astigmatism (CA) decreased by 10.58 D; mean keratometry value (Km.) – by 1.42 D and did not change any more; corneal surface regularity index (SRI) – by 0.39; corneal surface asymmetry index (SAI) – by 0.3; corneal resistance factor (CRF) increased by 0.5 mmHg; corneal hysteresis (CH) – by 0.3 mmHg.

At 1 month after the surgery, CA increased by 0.45 D, SRI decreased by another 0.06, SAI by another 0.09, CRF increased by another 0.2 mmHg, and CH by 0.4 mmHg.

At 6 months after the surgery, CA increased by another 0.43 D, SRI decreased by another 0.12, SAI – by another 0.25, CRF increased by another 0.5 mmHg, CH – by 0.3 mmHg [2].

Thus, ICRS implantation into the corneal graft not only significantly decreased PA but also increased the sphericity and regularity of the corneal graft, as evidenced by decreased CA, SRI and SAI indices. This, in turn, has provided optimal conditions for complete additional correction of residual CA in CPE with IOL implantation by increasing the accuracy of IOL measurement and centring, as the keratometry value along the main meridians began to change

TABLE 1

DATA OF CLINICAL AND FUNCTIONAL PARAMETERS BEFORE AND AT DIFFERENT FOLLOW-UP PERIODS AFTER IMPLANTATION OF INTRASTROMAL CORNEAL RING SEGMENTS IN THE PENETRATING CORNEAL GRAFT WITH FEMTOSECOND LASER APPLICATION

Indicators	Before the surgery	Day 1 after the surgery	1 month after the surgery	6 months after the surgery
UCVA	0.03	0.05	0.05	0.05
CVA	0.03	0.1	0.1	0.1
SCR, D	unmeasured	unmeasured	unmeasured	unmeasured
CA, D	–18.68	–8.1	–8.55	–8.98
Km., D	48.67	47.25	47.25	47.25
SRI	1.67	1.28	1.22	1.1
SAI	1.16	0.84	0.75	0.5
KG, mmHg	8.1	8.4	8.8	9.1
CRF, mmHg	8.4	8.9	9.1	9.6
Penetrating corneal graft pachymetry minimum value in the centre, μm	457	462	459	458
ECD, cells/mm^2	1925	1925	1921	1906
Protein flux in anterior chamber moisture, f/m (focus microscope)	2.3	3.15	2.3	2.3
Number of cells in the anterior chamber moisture, cells/mm^3	1.55	2.3	1.6	1.63

Note. SCR – spherical component of refraction; Km. – mean keratometry value; SRI – Surface Regularity Index; SAI – Surface Asymmetry Index; CH – corneal hysteresis; CRF – corneal resistance factor.

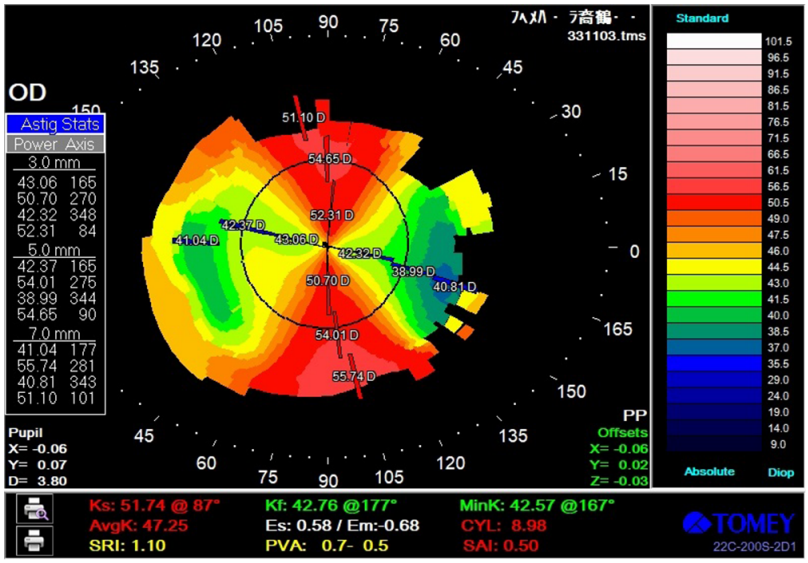

FIG. 2.

Keratotopogram of patient N. 6 months after implantation of intrastromal corneal ring segments in the through corneal graft using femtosecond laser: there is an increase in regularity and sphericity of the corneal graft with a decrease in the degree of corneal astigmatism by 9.7 D

more symmetrically, which was confirmed by the achievement of normal values of the SAI index. In contrast, ICRS implanted in the corneal graft resulted in an additional "stiffness frame" in the corneal graft, which increased its biomechanical properties. According to literature data, it is the increase of biomechanical properties of the corne-

al graft that allows to preserve the obtained refractive result in the remote postoperative period, in contrast to refractive laser surgeries, in which biomechanical properties of the corneal graft weaken when its thickness decreases, which in turn causes regression of the refractive result over the years [7].

The correct ICRS position was confirmed by OCT data of the corneal graft (Fig. 3).

In the postoperative period, corneal OCT data showed no change in corneal graft thickness at the centre.

The loss of ECD 6 months after ICRS implantation in an end-to-end corneal graft using CPE was 1.0 %, which did not exceed the physiological loss. According to the FC-2000 device, the cell count and protein flux in the anterior chamber moisture on the day after surgery increased slightly, but did not exceed the limits of normal. Laser tindalmetry values reached preoperative values within 1 month after surgery and did not increase again.

Six months after ICRS implantation in the corneal graft, the patient underwent CPE with tIOL implantation for a single-stage additional correction of residual corneal astigmatism.

No intra- and postoperative complications were observed. The patient noted subjectively a significant increase in visual acuity after surgery. On biomicroscopy, the optical media were clear and the two implanted ICRS and tIOL were centred (Fig. 4).

On examination the day after CPE, the UCVA increased by 0.85 and the CVA increased by 0.8. CA decreased by –0.48 D. The SCR was 1.0 D, and the cylindrical refractive component (CRC) was –1.0 D (Table 2).

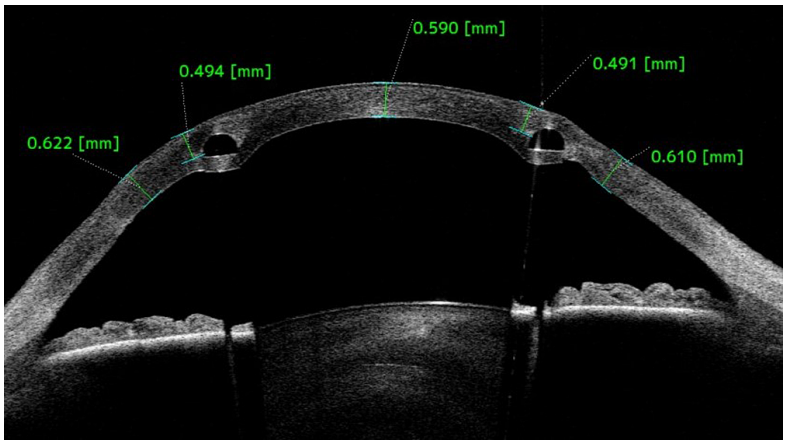

FIG. 3.

Optical coherence tomography of patient N.'s penetrating corneal graft after implantation of intrastromal corneal segments using femtosecond laser: the profile of intrastromal corneal ring segments located at a depth of 385 μm is visualised

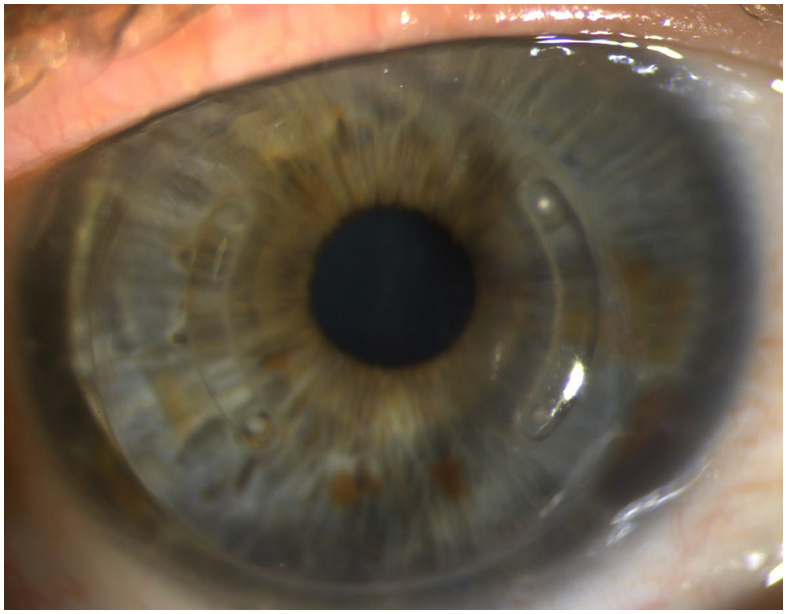

FIG. 4.

Eye appearance of patient N. on the next day after cataract phacoemulsification with toric IOL implantation after earlier implantation of intrastromal corneal ring segments into the corneal graft using femtosecond laser: symmetrically located intrastromal corneal ring segments relative to the strong vertical meridian of the corneal graft are visualised, toric IOL in the pupil projection is visualised

TABLE 2

DATA OF CLINICAL AND FUNCTIONAL INDICATORS BEFORE AND AT DIFFERENT TERMS AFTER CATARACT PHACOEMULSIFICATION WITH TORIC IOL IMPLANTATION IN A PATIENT AFTER EARLIER ICRS IMPLANTATION IN THE CORNEAL GRAFT WITH FEMTOSECOND LASER APPLICATION

Indicators	Before the surgery	Day 1 after the surgery	1 month after the surgery	6 months after the surgery
UCVA	0.05	0.9	1.0	1.0
CVA	0.1	0.9	1.0	1.0
CA, D	–8.98	–8.5	–8.25	–8.25
SCR, D	unmeasured	1.0	0.5	0.5
CRC, D	unmeasured	–1.0	–0.5	–0.5
ECD, cells/mm^2	1906	1801	1797	1781
Protein flux in anterior chamber moisture, f/m (focus microscope)	2.3	12.4	2.2	2.3
Number of cells in the anterior chamber moisture, cells/mm^3	1.63	11.1	1.68	1.65

At 1 month after surgery, the UCVA and CVA increased by another 0.1; CA decreased by another –0.25 D, SCR – by 0.5 D, CRC – by –0.5 D, and these indices remained unchanged.

In the surgical treatment of cataract in patients after PK, the initial preoperative PEC, as well as the degree of its loss after CPE, is of great importance. In the described clinical case, the preoperative ECD value of 1906 cells/mm^2 is sufficient for CPE. When ECD was measured on the day after CPE, it was observed to decrease by 5.5 % to a value of 1801 cells/mm^2, which is almost 3 times higher than its critical value of 500–700 cells/mm^2 [9]. Thus, the surgery was safe in terms of the risk of graft-versus-host disease. According to the literature, the use of modern viscoelastics during cataract surgery in patients after PK results in a loss of ECD in the range of 5–8 %, which is consistent with the results of our study [10]. ECD loss increased by another 1.1 % by 6 months postoperatively, which does not exceed the physiological loss of 2.5 % in the six months after PK [11].

On the day after CPE, when protein flux was counted in the anterior chamber using the FS-2000 device, a 5.4-fold increase was observed, and the number of cells in the anterior chamber moisture was 6.8-fold. One month after CPE, the values of these indices corresponded to preoperative values and did not change any more.

CONCLUSION

The combined method of correction of regular high-grade PA in a patient with cataract by ICRS implantation in the corneal graft followed by CPE with tIOL implantation showed a high refractive result, stability and safety in the distant postoperative period.

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Conflict of interest

The authors of this article declare no conflicts of interest.

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