COMPARATIVE ANALYSIS OF THE CORRECTION OF IRREGULAR POSTKERATOPLASTIC ASTIGMATISM WITH SCLERAL LENSES AND INTRASTROMAL RING IMPLANTATION

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ABSTRACT

Background. *Many patients after penetrating keratoplasty (PK) experience induced postkeratoplastic astigmatism, which is often irregular and causes an increase in corneal aberrations that reduce visual acuity and quality.*

The aim of the study. *To conduct a comparative analysis of the effect of rigid gas permeable scleral lenses and the MyoRing implantation method on clinical and functional parameters in patients with IPA.*

Material and methods. *The clinical study included 60 patients (60 eyes). The age of patients with IPA was from 25 to 42 years. All patients underwent penetrating keratoplasty. All patients were divided into two groups depending on the method for irregular postkeratoplastic astigmatism correction. Group I included 30 patients (30 eyes) who were fitted with rigid gas permeable scleral lenses. Group II consisted of 30 patients (30 eyes) who underwent implantation of the MyoRing into a penetrating corneal graft. The observation period was 1 year.*

Results. *After 12 months of observation, there was a greater increase in uncorrected visual acuity by an average of 3 lines, in corrected visual acuity – by 2 lines; a greater decrease in corneal aberrations in photo- (root mean square (RMS) of total aberrations (RMS total) by 0.30 ± 0.08 μm, RMS of higher order aberrations (RMS HOA) – by 1.01 ± 0.24 μm) and mesopic conditions (RMS total – by 0.33 ± 0.09 μm, RMS HOA – by 0.08 ± 0.03 μm) in patients wearing rigid gas permeable scleral lenses compared with patients after MyoRing implantation into a penetrating corneal graft.*

Conclusion. *Patients of group I, wearing rigid gas permeable scleral lenses, showed a greater improvement in visual acuity and a decrease in corneal aberrations in photo- and mesopic conditions compared to the patients of group II (after MyoRing implantation) at a follow-up period of 12 months.*

Key words: *irregular postkeratoplastic astigmatism, MyoRing, scleral lens*

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СРАВНИТЕЛЬНЫЙ АНАЛИЗ КОРРЕКЦИИ ИРРЕГУЛЯРНОГО ПОСТКЕРАТОПЛАСТИЧЕСКОГО АСТИГМАТИЗМА СКЛЕРАЛЬНЫМИ ЛИНЗАМИ И ИМПЛАНТАЦИЕЙ ИНТРАСТРОМАЛЬНОГО КОЛЬЦА

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РЕЗЮМЕ

Введение. *Многие пациенты после сквозной кератопластики (СКП) сталкиваются с индуцированным посткератопластическим астигматизмом, который нередко бывает иррегулярным (ИПА) и вызывает увеличение роговичных аберраций, снижающих остроту и качество зрения.*

Цель исследования. *Провести сравнительный анализ влияния жёстких газопроницаемых склеральных линз (ЖГСЛ) и метода имплантации кольца MyoRing на клинико-функциональные показатели у пациентов с ИПА.*

Материал и методы. *В клиническое исследование вошли 60 пациентов (60 глаз). Возраст пациентов с ИПА составил от 25 до 42 лет. У всех пациентов в анамнезе была выполнена СКП. Все пациенты в зависимости от метода коррекции ИПА были разделены на две группы. В I группу вошли 30 пациентов (30 глаз), которым были подобраны ЖГСЛ. II группу составили 30 пациентов (30 глаз), которым была выполнена имплантация кольца MyoRing в сквозной роговичный трансплантат. Срок наблюдения составил 1 год.*

Результаты. *Через 12 месяцев наблюдения было отмечено большее повышение некорригированной остроты зрения в среднем на 3 строки, корригированной остроты зрения – на 2 строки; большее снижение роговичных аберраций в фото- (среднеквадратичное отклонение волнового фронта (RMS, root mean square) суммарных аберраций (RMS total) на 0,30 ± 0,08 мкм, RMS аберраций высших порядков (RMS HOA, RMS of higher order aberrations) – на 1,01 ± 0,24 мкм) и мезопических условиях (RMS total – на 0,33 ± 0,09 мкм, RMS HOA – на 0,08 ± 0,03 мкм) у пациентов, носящих ЖГСЛ, по сравнению с пациентами после имплантации кольца MyoRing в сквозной роговичный трансплантат.*

Заключение. *У пациентов I группы, носящих ЖГСЛ, было отмечено большее улучшение остроты зрения и снижение роговичных аберраций в фото- и мезопических условиях по сравнению со II группой (после имплантации кольца MyoRing) при сроке наблюдения 12 месяцев.*

Ключевые слова: *иррегулярный посткератопластический астигматизм, кольцо MyoRing, склеральная линза*

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RELEVANCE

Performing penetrating keratoplasty (PK), especially in patients with keratoconus and pellucid marginal corneal degeneration, leads to induced postkeratoplastic astigmatism (PA), which is often irregular [1]. The greater the degree of irregular PA, the higher the value of corneal aberrations, especially of higher order aberrations, which reduce the acuity and quality of vision of patients and eventually lead to their dissatisfaction with the functional result of PK [2]. Thus, the correction of PA and especially its irregular form is an important task in the treatment of this category of patients. Currently, the leading position in correcting the irregular shape of PA is occupied by contact correction with rigid gas permeable scleral lenses [3]. Rigid gas permeable scleral lenses smooth out all the irregularities of the corneal graft with a tear meniscus located in the space under the lens, and at the same time correct postkeratoplastic ametropia [4]. However, rigid gas permeable scleral lenses are not suitable for all patients: restrictions on rigid gas permeable scleral lenses occur under certain workplace conditions (for example, high air temperature in production workshops). In some cases the limiting factor is the cost of these lenses, etc. The method of implantation of the MyoRing into a corneal graft that has appeared in recent years is a fairly promising direction and can be an alternative method of correcting PA, including its irregular shape, in patients who cannot wear rigid gas permeable scleral lenses [5]. After implantation of the MyoRing into the corneal graft, a so-called conditionally «additional limb» is created in it, located symmetrically with respect to the patient's visual axis, relative to which the corneal graft is evenly flattened and its sphericity and regularity increase [6]. In connection with the above, as well as with limited information in the literature on the results of implantation of the MyoRing into a corneal graft, a comparative analysis of the effect of rigid gas permeable scleral lenses and the MyoRing implantation method on clinical and functional parameters in patients with irregular postkeratoplastic astigmatism is quite relevant.

THE AIM OF THE STUDY

To conduct a comparative analysis of the effect of rigid gas permeable scleral lenses and the MyoRing implantation method on clinical and functional parameters in patients with irregular postkeratoplastic astigmatism.

MATERIAL AND METHODS

We examined 60 patients (60 eyes) aged 25 to 42 years (the average age was 33 ± 6.1 years), 37 men and 23 women. All patients had a history of PK for stage IV keratoconus 4–10 years ago. All corneal grafts were transparent. The diameter of the corneal graft was 8.0 mm in 48 eyes and 8.5 mm in 12 eyes. According to keratotopography, an irregular form of PA was noted in all patients. All patients, depending on the method of correction of postkeratoplastic ametropia, were divided into two groups.

Group I included 30 patients (30 eyes); we selected rigid gas permeable scleral lenses OKVision (Canadian company OKV-RGP Onefit Med) for them. This type of rigid gas permeable scleral lenses was made of Contamac Optimum Extra with an oxygen permeability of 100 units. The diameter of the rigid gas permeable scleral lenses was 15.6 mm, the thickness in the center was 0.22 mm. Optical coherence tomography (OCT) of the cornea was used to assess the centralization of the rigid gas permeable scleral lens, the position of its edge in different quadrants, as well as the thickness of the central, peripheral and limbal clearances.

Group II consisted of 30 patients (30 eyes) who underwent implantation of the MyoRing (Dioptex, Austria) into a penetrating corneal graft using a femtosecond laser (FSL) FemtoVisum 1 MHz (Troitsk, Russia). Surgery was performed in two stages. At stage I, an intrastromal pocket was formed within the corneal graft with a diameter of 8.0 mm at a depth of 80 % of the minimum thickness of the corneal graft using FSL. The length of the entrance tunnel incision was 1.0 mm, the width was 4.5 mm. At stage II, a MyoRing (diameter – 5.0 mm, thickness – 0.5 mm, height – 200-320 μm) was implanted into the formed intrastromal pocket through an entrance tunnel incision using special tweezers. The selection of the parameters of the whole ring was calculated based on the values of the spherical and cylindrical components of refraction [7]. The ring was centered taking into account the location of the patient's visual axis.

All patients underwent ophthalmological examination before and during rigid gas permeable scleral lens fitting, as well as before and after implantation of the MyoRing into the corneal graft. The examination included autorefractokeratometry, visometry, biomicroscopy, computer keratotopography on the TMS-4 device (Tomey, Japan), aberrometry on the Pentacam device (Oculus Optikgerate GmbH, Germany), calculation of endothelial cell density (ECD) on the Confoscan-4 device (Nidek, Japan), OCT of the corneal graft on the Casia-2 device (Tomey, Japan). Corneal aberrations in both groups were analyzed in the 3.0 mm optical zone in order to create conditions close to photopic conditions without the edge of the intrastromal ring entering the patient's field of view, as well as in the 6.0 mm zone – to create conditions close to mesopic conditions and the edge of the intrastromal ring entering the patient's field of view. The observation period was 1 year.

All studies and manipulations were conducted in compliance with the principles of the World Medical Association Declaration of Helsinki on Ethical Principles for Medical Research Involving Human Subjects.

Statistical data processing was performed in the IBM SPSS Statistics 20 software (IBM Corp., USA). The Shapiro – Wilk test was used to check the normality of the distributions of the studied parameters. The statistical significance of the differences in the studied parameters was assessed by the parametric t-test for dependent variables in connection with the normal distribution of the values of the studied parameters. When comparing the average values of the studied parameters in both groups, the t-test for independent samples was used. The average visual acuity value was recalculated logarithmically. The values of the studied parameters are presented in the form M ± SD, where M is the arithmetic mean, SD is the standard deviation. In both groups, the values of the studied parameters before the selection of the rigid gas permeable scleral lenses and implantation of the MyoRing were comparable ($p > 0.05$). During the statistical analysis, the studied parameters in both groups were compared on the next day, after 6 and 12 months, compared with the data before the selection of rigid gas permeable scleral lenses in group I and with preoperative values in group II. The values of the studied parameters were also compared between the groups after 12 months of follow-up after the stabilization of clinical and functional parameters in group II. The differences in the studied parameters were considered statistically significant at $p < 0.05$.

RESULTS

On the next day after the selection of the rigid gas permeable scleral lenses, all patients of group I noted a significant increase in visual acuity. The average value of uncorrected visual acuity (UCVA) increased 10.1 times, and corrected visual acuity (CVA) – 4.3 times (Table 1).

The spherical component of refraction (SCR) decreased by 6.10 ± 1.27 D, the cylindrical component of refraction

TABLE 1

CLINICAL AND FUNCTIONAL PARAMETERS BEFORE AND AT DIFFERENT TERMS AFTER WEARING RIGID GAS PERMEABLE SCLERAL LENSES (GROUP I; N = 30) AND INTRASTROMAL MYORING IMPLANTATION INTO THE PENETRATING CORNEAL GRAFT USING A FEMTOSECOND LASER (GROUP II; *n* = 30), M ± SD

Groups	Parameters	Before the selection of the rigid gas permeable scleral lenses (surgery)	The next day		In 6 months		In 12 months	
		M ± SD	M ± SD	*p*	M ± SD	*p*	M ± SD	*p*
Group I Rigid gas permeable scleral lenses (*n* = 30)	UCVA	0.08 ± 0.05	0.81 ± 0.12	0.0047	0.81 ± 0.12	0.0047	0.81 ± 0.12	0.0047
	CVA	0.19 ± 0.11	0.81 ± 0.14	0.0058	0.81 ± 0.14	0.0058	0.81 ± 0.14	0.0058
	$K_{av.}$, D	48.7 ± 3.9	42.6 ± 2.9	0.0066	42.6 ± 2.9	0.0066	42.6 ± 2.9	0.0066
	SRI	1.3 ± 0.3	0.4 ± 0.1	0.0096	0.4 ± 0.1	0.0096	0.4 ± 0.1	0.0096
	SAI	2.2 ± 0.9	0.5 ± 0.1	0.0083	0.5 ± 0.1	0.0083	0.5 ± 0.1	0.0083
	SCR, D	−6.25 ± 2.35	−0.15 ± 0.08	0.0061	−0.15 ± 0.08	0.0061	−0.15 ± 0.08	0.0061
	CCR, D	−5.15 ± 1.54	−0.5 ± 0.22	0.0055	−0.5 ± 0.22	0.0055	−0.5 ± 0.22	0.0055
	ECD, cells/mm^2	2106 ± 320	2112 ± 325	0.1232	2076 ± 311	0.0156	2047 ± 295	0.0146
Group II MyoRing implantation using FSL (*n* = 30)	UCVA	0.09 ± 0.05	0.26 ± 0.04	0.0352	0.44 ± 0.04	0.0152	0.53 ± 0.04	0.0152
	CVA	0.16 ± 0.10	0.48 ± 0.06	0.0362	0.59 ± 0.06	0.0163	0.71 ± 0.07	0.0145
	$K_{av.}$, D	49.26 ± 4.11	40.96 ± 2.21	0.0169	41.93 ± 3.11	0.0135	42.96 ± 3.44	0.0152
	SRI	1.49 ± 0.43	1.33 ± 0.28	0.0288	1.29 ± 0.22	0.0233	1.22 ± 0.21	0.0235
	SAI	2.69 ± 1.10	1.79 ± 0.54	0.0278	1.71 ± 0.51	0.0246	1.62 ± 0.48	0.0226
	SCR, D	−7.05 ± 2.51	1.25 ± 0.45	0.0354	0.28 ± 0.28	0.0216	−0.75 ± 0.35	0.0215
	CCR, D	−5.85 ± 1.71	−2.85 ± 1.12	0.0235	−2.36 ± 1.01	0.0274	−1.75 ± 0.85	0.0269
	ECD, cells/mm^2	2054 ± 231	2050 ± 226	0.3111	2021 ± 215	0.0215	1992 ± 203	0.0269

Note. $K_{av.}$ – the Average value of Keratometry; SRI – Surface Regularity Index; SAI – Surface Asymmetry Index; SCR – Spherical Component of Refraction; CCR – Cylindrical Component of Refraction

(CCR) – by 4.65 ± 1.32 D. According to keratotopography data the average value of keratometry ($K_{av.}$) in rigid gas permeable scleral lenses decreased by 3.6 ± 1.0 D, surface regularity index (SRI) – by 0.9 ± 0.2, surface asymmetry index (SAI) – by 1.7 ± 0.8, the spherical component of refraction – by 6.10 ± 2.27 D, the cylindrical component of refraction – by 4.65 ± 1.32 D. The data obtained remained stable throughout the entire observation period and are consistent with the literature data [7-9]. After a year of wearing of rigid gas permeable scleral lenses, the coefficient of effectiveness (Cef) was 4.3 ± 0.8, the coefficient of safety (Cs) was 4.3 ± 0.9.

When analyzing corneal aberrations measured in patients the next day after selection rigid gas permeable scleral lenses on the Pentacam device, there was a decrease in photopic conditions (in the 3 mm optical zone) of the root mean square (RMS) deviation of the wavefront of total aberrations (RMS Total) by 3.6 times, RMS of higher order aberrations (RMS HOA) – by 3.4 times, RMS of spherical aberrations (RMS SA) – by 2 times, RMS Coma – by 2.8 times, RMS Trefoil – by 4.2 times compared with the data before the selection of the rigid gas permeable scleral lenses (Table 2).

In the 6 mm optical zone, RMS Total decreased by 2.4 times, RMS HOA – by 2.5 times, RMS SA – by 1.6 times, RMS Coma – by 4.3 times, RMS Trefoil – by 4.3 times (Table 3).

The obtained results remained stable during 12 months of observation and correlated with the literature data. In 2019 V.I. Tikhonova et al. conducted a clinical study on changes in corneal aberrations after the selection of rigid gas permeable scleral lenses in 8 eyes (8 patients) after PK according to the OPD-Scan II device (Nidek, Japan). The authors noted a decrease in rigid gas permeable scleral lenses of corneal higher orders aberrations in 3 mm (RMS HOA decreased by 3.8 times, RMS Trefoil – by 2.7 times, RMS SA – by 2.9 times) and 5 mm optical zones (RMS HOA decreased by 3.0 times, RMS Trefoil – by 3.4 times, RMS SA – by 3.1 times) [8]. In 2021 A. Penbe et al., against the background of wearing rigid gas permeable scleral lenses in 35 patients (38 eyes) after PK, noted a significant decrease in higher orders aberrations, especially coma, spherical aberrations, astigmatism, which is consistent with the results of this study [9].

Corneal graft minimum thickness (CGMT) at the center, measured using OCT Casia-2 before wearing the rigid gas permeable scleral lenses, averaged 532.3 ± 33.4 μm. After 12 months in all patients, after wearing a rigid gas per-

TABLE 2

CORNEAL ABERRATIONS IN PHOTOPIC CONDITIONS (IN 3.0 MM OPTICAL ZONE) ACCORDING TO PENTACAM DATA BEFORE AND AT DIFFERENT TERMS AFTER WEARING RIGID GAS PERMEABLE SCLERAL LENSES (GROUP I; *n* = 30) AND INTRASTROMAL MYORING IMPLANTATION INTO THE PENETRATING CORNEAL GRAFT USING A FEMTOSECOND LASER (GROUP II; *n* = 30), M ± SD

Groups	Type of aberration, RMS	3.0 mm optical area						
		Before the selection of the rigid gas permeable scleral lenses (surgery)	The next day		In 6 months		In 12 months	
		M ± SD	M ± SD	*p*	M ± SD	*p*	M ± SD	*p*
Group I Rigid gas permeable scleral lenses (*n* = 30)	Total, μm	1.96 ± 0.65	0.55 ± 0.22	0.0053	0.55 ± 0.22	0.0053	0.55 ± 0.22	0.0053
	HOA, μm	3.11 ± 1.22	0.91 ± 0.32	0.0058	0.91 ± 0.32	0.0058	0.91 ± 0.32	0.0058
	SA, μm	–0.040 ± 0.030	–0.020 ± 0.005	0.0088	–0.020 ± 0.005	0.0088	–0.020 ± 0.005	0.0088
	Coma, μm	0.11 ± 0.05	0.04 ± 0.02	0.0189	0.04 ± 0.02	0.0189	0.04 ± 0.02	0.0189
	Trefoil, μm	0.21 ± 0.13	0.05 ± 0.02	0.0352	0.05 ± 0.02	0.0352	0.05 ± 0.02	0.0352
Group II MyoRing implantation using FSL (*n* = 30)	Total, μm	2.26 ± 0.73	1.42 ± 0.22	0.0123	1.34 ± 0.22	0.0144	1.15 ± 0.22	0.0164
	HOA, μm	3.17 ± 1.33	2.24 ± 0.29	0.0254	2.11 ± 0.26	0.0246	1.91 ± 0.22	0.0296
	SA, μm	–0.07 ± 0.05	–0.06 ± 0.03	0.0368	–0.05 ± 0.02	0.0346	–0.04 ± 0.02	0.0396
	Coma, μm	0.16 ± 0.05	0.12 ± 0.04	0.0189	0.11 ± 0.03	0.0189	0.09 ± 0.03	0.0189
	Trefoil, μm	0.25 ± 0.12	0.16 ± 0.05	0.0362	0.14 ± 0.05	0.0363	0.12 ± 0.04	0.0396

TABLE 3

CORNEAL ABERRATIONS IN PHOTOPIC CONDITIONS (IN 6.0 MM OPTICAL ZONE) ACCORDING TO PENTACAM DATA BEFORE AND AT DIFFERENT TERMS AFTER WEARING RIGID GAS PERMEABLE SCLERAL LENSES (GROUP I; *n* = 30) AND INTRASTROMAL MYORING IMPLANTATION INTO THE PENETRATING CORNEAL GRAFT USING A FEMTOSECOND LASER (GROUP II; *n* = 30), M ± SD

Groups	Type of aberration, RMS	3.0 mm optical area						
		Before the selection of the rigid gas permeable scleral lenses (surgery)	The next day		In 6 months		In 12 months	
		M ± SD	M ± SD	*p*	M ± SD	*p*	M ± SD	*p*
Group I Rigid gas permeable scleral lenses (*n* = 30)	Total, µm	3.16 ± 1.23	1.33 ± 0.45	0.0063	1.33 ± 0.45	0.0063	1.33 ± 0.45	0.0063
	HOA, µm	4.12 ± 1.31	1.66 ± 0.39	0.0095	1.66 ± 0.39	0.0095	1.66 ± 0.39	0.0095
	SA, µm	0.41 ± 0.18	0.25 ± 0.04	0.0046	0.25 ± 0.04	0.0046	0.25 ± 0.04	0.0046
	Coma, µm	0.99 ± 0.51	0.23 ± 0.04	0.0236	0.23 ± 0.04	0.0236	0.23 ± 0.04	0.0236
	Trefoil, µm	0.95 ± 0.43	0.22 ± 0.03	0.0214	0.22 ± 0.03	0.0214	0.22 ± 0.03	0.0214
Group II MyoRing implantation using FSL (*n* = 30)	Total, µm	3.3 ± 1.23	2.03 ± 0.72	0.0163	1.93 ± 0.69	0.0165	1.8 ± 0.65	0.0142
	HOA, µm	4.82 ± 1.55	2.83 ± 0.86	0.0136	2.64 ± 0.79	0.0145	2.44 ± 0.62	0.0185
	SA, µm	0.33 ± 0.19	0.45 ± 0.21	0.0156	0.49 ± 0.22	0.0167	0.55 ± 0.24	0.0187
	Coma, µm	0.94 ± 0.42	0.95 ± 0.44	0.0288	0.99 ± 0.46	0.0294	1.03 ± 0.49	0.0268
	Trefoil, µm	0.99 ± 0.44	1.02 ± 0.45	0.0356	1.09 ± 0.48	0.0368	1.13 ± 0.49	0.0389

meable scleral lens for 8 hours it was removed and CGMT was measured at the center and was 543.5 ± 36.2 µm. Thus, the increase in CGMT in the center did not exceed 2.1 %, which indicated the absence of clinically significant corneal transplant edema. According to the literature, an increase in the minimum thickness of the cornea in the center of less than 4.0 % after removal of the rigid gas permeable scleral lens, as in this clinical study, corresponds to the physiological norm, since it does not exceed the increase in corneal thickness in physiological edema after sleep [10, 11]. In 2016 J. Vincent et al. in 15 patients (in 15 eyes), after removal of the rigid gas permeable scleral lenses, obtained an increase in the minimum thickness of the cornea in the center, not exceeding 2 % of the minimum thickness of the cornea before wearing the rigid gas permeable scleral lenses [12].

After 12 months of follow-up, according to Confoscan-4, there was a decrease in ECD by 2.8 %, which did not exceed the physiological loss.

In group II, after intrastromal implantation of the MyoRing into the corneal graft, intra- and postoperative complications were not observed in any of the patients. During biomicroscopy, a transparent penetrating corneal graft was visualized on the 1st day after surgery in all patients; the MyoRing was centered relative to the visual axis (Fig. 1).

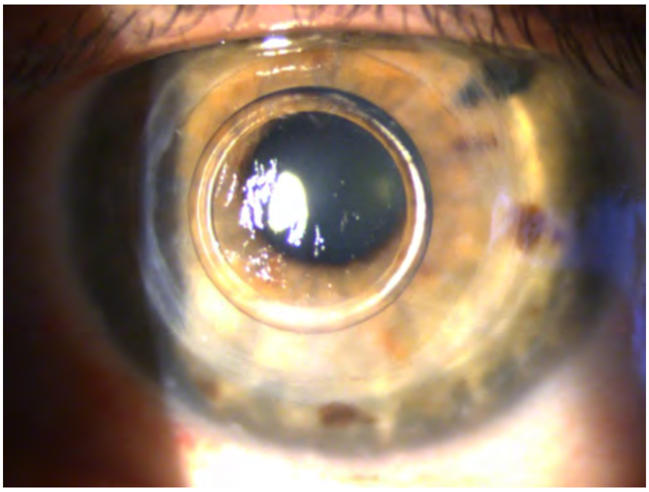

FIG. 1.
Biomicroscopy of a corneal graft on the first day after MyoRing implantation using femtosecond laser

On the first day after the surgery, a high refractive result was noted. UCVA increased by 0.17 ± 0.02, CVA – by 0.32 ± 0.04. SCR decreased by 8.3 ± 2, D, CCR – by 3.0 ± 0.5 D. 6 months after the surgery, UCVA increased by 0.18 ± 0.04, CVA – by 0.11 ± 0.04, SCR increased by 0.97 ± 0.17 D, CCR decreased by 0.49 ± 0.11 D. 12 months after the surgery, UCVA increased by 0.09 ± 0.04, CVA – by 0.12 ± 0.05, SCR increased by another 0.47 ± 0.07 D, CCR decreased by 0.61 ± 0.16 D. 1 year after the surgery, the Cef was 3.3 ± 0.6, Cs – 4.4 ± 0.6.

When analyzing the keratotopographic parameters obtained on the first day after surgery, there was a decrease in the values of $K_{av.}$ by 8.3 ± 1.9 D, SRI – by 0.16 ± 0.05, SAI – by 0.9 ± 0.2. 6 months after the surgery, the $K_{av.}$ increased by 0.97 ± 0.31 D, SRI decreased by 0.04 ± 0.02, SAI – by 0.08 ± 0.03. 12 months after the surgery, the $K_{av.}$ increased by 1.03 ± 0.33 D, SRI decreased by 0.07 ± 0.02, SAI – by 0.09 ± 0.03.

After 12 months of follow-up, patients in both groups showed a statistically significant difference in the values of UCVA, CVA, SRI, SAI, CCR ($p < 0.05$); there was no difference in $K_{av.}$ and SCR ($p > 0.05$). In group I, there was a greater increase in UCVA by an average of 3 lines, CVA – by 2 lines, a decrease in SRI by 3.3 times, SAI – by 1.7 times, CCR – by 0.55 ± 0.12 D compared with group II.

When analyzing corneal aberrations measured in patients the day after surgery under photopic conditions, RMS Total decreased 1.6 times, RMS HOA – 1.4 times, RMS SA – 1.2 times, RMS Coma – 1.3 times, RMS Trefoil – 1.6 times. 6 months after the operation, RMS Total decreased by 0.08 ± 0.04 μm, RMS HOA – by 0.13 ± 0.04 μm, RMS SA – by 0.01 ± 0.01 μm, RMS Coma – by 0.01 ± 0.01 μm, RMS Trefoil – by 0.02 ± 0.01 μm. 12 months after the operation, RMS Total decreased by 0.19 ± 0.04 μm, RMS HOA – by 0.2 ± 0.04 μm, RMS SA – by 0.01 ± 0.01 μm, RMS Coma – by 0.02 ± 0.01 μm, RMS Trefoil – by 0.02 ± 0.01 μm.

After 12 months of follow-up, patients in both groups showed a statistically significant difference in corneal aberrations in photopic conditions according to RMS Total, RMS HOA, RMS Trefoil ($p < 0.05$); difference in RMS SA, RMS Coms was absent ($p > 0.05$). In group I, compared with group II, there was a greater decrease in RMS Total by an average of 0.30 ± 0.08 μm, RMS HOA – by 1.01 ± 0.24 μm, RMS Trefoil – 0.03 ± 0.02 μm.

In the 6 mm optical zone, RMS Total decreased by 1.37 ± 0.41 μm, RMS HOA – by 2.18 ± 0.59 μm, RMS SA – by 1.6 times, RMS Coma – 4.3 times, RMS Trefoil – 1.6 times. The results obtained remained stable during 12 months of follow-up.

After 12 months of study under mesopic conditions, a statistically significant difference was revealed in all studied corneal aberrations in both groups. In group I, compared with group II, there was a greater decrease in RMS Total by an average of 0.33 ± 0.09 μm, RMS HOA by 0.08 ± 0.03 μm, RMS SA by 0.39 ± 0.11 μm, RMS Coma – by 0.27 ± 0.05 μm, RMS Trefoil – by 0.4 ± 0.1 μm.

The correct position of the MyoRing was confirmed by the corneal OCT data (Fig. 2).

The next day after surgery, the average value of CGMT in the center according to the OCT of the cornea increased by 19 ± 4 μm, which is associated with edema of the corneal graft due to irrigation of the intrastromal pocket. The CGMT at the center reached preoperative values in group II patients within a month after surgery and did not change further.

The loss of ECD one year after implantation of the MyoRing into a penetrating corneal graft using FSL was 3.0 %, which did not exceed the physiological loss. There was no statistically significant difference in the decrease in ECD between the two groups after 12 months of follow-up ($p < 0.05$).

Thus, a greater increase in visual acuity (UCVA and CVA) in the rigid gas permeable scleral lenses compared with intrastromal implantation of the MyoRing into the corneal graft is confirmed by a more pronounced decrease in CCR, SRI and SAI, total corneal aberrations and highest order corneal aberrations.

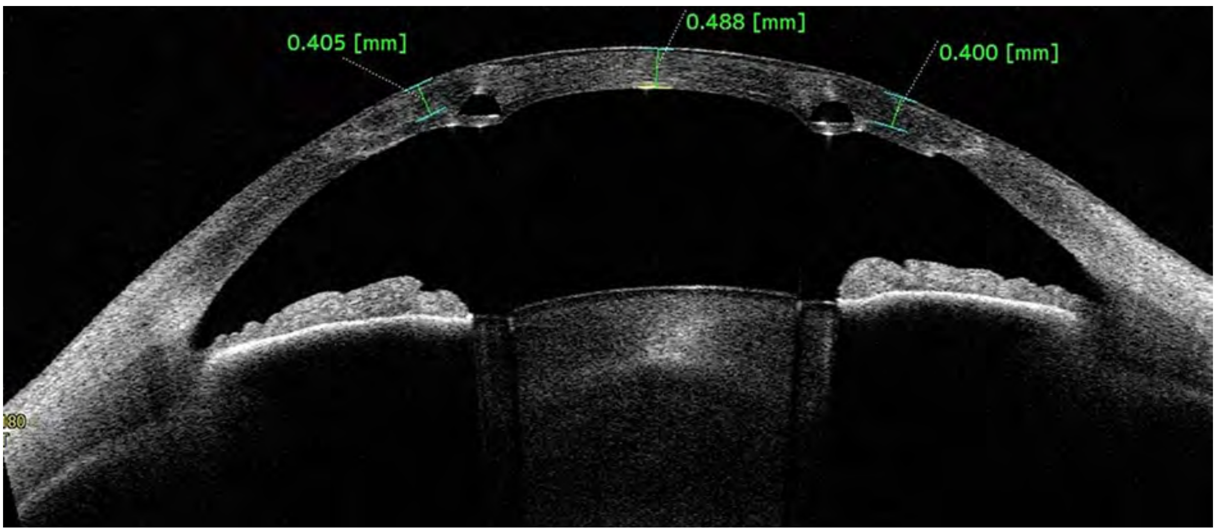

FIG. 2.

Optical coherence tomography of the corneal graft after MyoRing implantation into the penetrating corneal graft using femtosecond laser: the profile of the MyoRing is visualized being located at a depth of 80 % of the minimum thickness of the penetrating corneal graft

CONCLUSION

A comparative analysis of the effect of rigid gas-permeable scleral lenses and the MyoRing implantation method on clinical and functional parameters in patients with irregular postkeratoplastic astigmatism with a follow–up period of 12 months showed: a greater increase in UCVA – by an average of 3 lines, CVA – by 2 lines, a greater decrease in SRI – by 3.3 times, SAI – by 1.7 times, CCR – by 0.55 ± 0.12 D, corneal aberrations in photopic conditions (RMS Total – by 0.30 ± 0.08 μm, RMS HOA – by 1.01 ± 0.24 μm) and mesopic conditions (RMS Total – by 0.33 ± 0.09 μm, RMS HOA – by 0.08 ± 0.03 μm) in patients wearing rigid gas permeable scleral lenses compared to patients implanted with MyoRing in the corneal graft.

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Conflict of interest
The authors of this article declare the absence of a conflict of interest.

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