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METHOD FOR REDUCING LONGITUDINAL SPHERICAL ABERRATION OF INTRAOCULAR LENSES

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It has been established that of all types of aberrations following the implantation of intraocular lenses, the most significant is spherical, inherent in the spherical optics in various aspects. This paper proposes a method for reducing the longitudinal spherical aberration of intraocular lenses by applying an additional optical layer onto their surface. To reduce spherical aberration, the thickness of a layer of polytetrafluoroethylene (Teflon) was simulated in the programming environment Zemax 13 (USA). Calculations that were performed included refractive indices of the environment and the material of the optics. It was established that in order to reduce the value of the longitudinal spherical aberration of an intraocular lens made of hydrophobic acrylic, the thickness of aTeflon layer should be about 100 nm.

The results of spraying indicate an improvement in the optical characteristics of the lens by reducing longitudinal spherical aberration. When examining different areas of lenses with spraying, it was established that there is no spherical aberration in the lens area. In the 4 mm zone, the spherical aberration indicator decreased by 4 times compared to the original lens. In the region with a diameter of 6 mm, spherical aberration decreased by 0.2. Applying a layer of Teflon reduced Fresnel reflection by 4 times, which improves the sensitivity and contrast of vision. The hydrophobic properties of Teflon provide the anti-adhesive state of the lens, which is a counteraction to the development of secondary cataracts. The SolidWorks 19 software (France) was used to design a model of the lens "NVision Optics" whose aberrations were eliminated as much as possible

Keywords: crystal, spherical aberration, intraocular lens, polytetrafluoroethylene, vacuum spraying, Zemax, SolidWorks

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1. Introduction

One of the leading causes of blindness, poor vision, and visual disability is the development of cataracts [1–3]. The method of eliminating cataracts is surgery, followed by replacing the native crystal with an artificial one. This operation is performed using various types of intraocular lenses (IOL). In the treatment of cataracts, a common method is a phacoemulsification with the implantation of flexible IOL [4, 5].

There are many types of IOL in the world market, which differ in shape, size, material from which they are made, ways of fixation in the eye, etc. [6] All of them, regardless of parameters, create not only non-desirable photic effects but also cause aberrations, the main of which is spherical.

The high value of the magnitude of spherical aberration is inherent in spherical IOL. The appearance of optical deviations depends on the roughness of the lens surface, the size of the refractive force of the material, the shape, the thickness of the lens edge, and the place of implantation of IOL in the eye. Standard spherical IOLs have a positive spherical aberration, which increases the overall CA of the cornea. As a consequence, the resulting quality of vision is no higher than that of an elderly person without cataracts [7].

After implantation of monofocal IOL, the development of light phenomena is 9 %, after implantation of multifocal IOL – 41 % [8].

The frequency of higher-order aberration emergence, that is spherical, which is the sum of optical abnormalities and reaches a level that creates life discomfort, is 15 %. With an increase in the refractive power of IOL, the frequency of aberrations increases [9].

Aspherical IOLs, which have a smaller CA size, and some negative ones, have become widespread. It is known that the visual quality of aspherical IOL can deteriorate to a greater extent than the quality of spherical IOL, if their inclination is more than 10°, and decentralization is more than 0.8 mm [10].

It is a relevant task to conduct research aimed at further improvement and development of methods for reducing the magnitude of spherical aberration and undesirable photic effects.

2. Literature review and problem statement

Paper [11] reports the results of comparative studies into the methods for reducing intraocular lens aberrations. One of the methods under consideration was gradient optics. Theoretical calculations have shown that a gradient approach to reducing aberrations can be applied to lenses. A given approach was not implemented due to the lack of necessary materials that could meet both optical and medical conditions. Some IOL models change the refractive indicatorso that it changes from the periphery to the center of the lens, providing a multifocal optical structure.

It is common in the fight against spherical aberration to use aspherical lenses. Aspherical lenses leave the spherical aberration of the cornea to create an increased depth of focus. At the same time, aspherical lenses demonstrate worse contrast transmission and do not counteract the occurrence of aberrations of higher orders [12]. Second-order aberrationmodes in almost all models of aspherical IOL are predominant [13].

Some lenses, such as AcrySof IQ ReSTOR SV25T0 (Alcon Laboratories, Fort Worth, TX, USA), have an apodised diffraction surface [14]. The central and external refractive parts of the lens are designed for vision in the distance. The front surface is designed with negative spherical aberration – 0.20 μm (the value of the Zernike coefficient is 4.0 for the pupil of 6 mm) to compensate for positive spherical corneal aberrations [15]. The disadvantage of that approach is a distorted light transmission [16], and a mirrored glare in the form of rings, which creates discomfort [17]. Proprietary achromatic diffraction echelon construction is also used, which corrects chromatic corneal aberration to reduce spherical aberrations [18].

Paper [19] reports an analytical formula in closed form for designing free-form lenses without spherical aberration and astigmatism. The disadvantage of that approach is the incompleteness of information, namely, the information is commercial in nature. The above method does not describe the possibility of using the proposed approach to IOL. Complexity, high price, and the need for high-precision devices are other obstacles to implementation.

Based on the above, we can assert that it is advisable to conduct a study aimed at reducing the influence of spherical aberration of intraocular lenses, and, as a result, obtaining a clear image.

3. The aim and objectives of the study

The purpose of this study is to reduce the longitudinal spherical aberration of intraocular lenses. This would make it possible to obtain the necessary optical coating on the lens surface, which could reduce the numerical value of spherical aberration and negative photic effects.

To accomplish the aim, the following tasks have been set:

– to calculate the required refractive indicator for the intraocular lens coating;

– to conduct optical modeling involving the indicators obtained;

– to apply an optical coating onto the lens and perform its morphological analysis;

– to investigate the intraocular lens for the magnitude of the longitudinal spherical aberration;

– based on the results, to design a new model of the intraocular lens.

4. The study materials and methods

We calculatedthe optical indicators and devised methods to improve them using the formula of gradient optics, which includes refractive indexes of the environment and IOL material. To spray polytetrafluoroethylene (PTFE), the vacuum spraying unit UVN-74 (Ukraine) was used. The atomic-power microscope NanoScope IIIa Dimension 3000TM (USA) was applied to study the thickness of the sprayed PTFE layer and the morphology of its surface on the lens. To measure the longitudinal spherical aberration of IOL, we employed Linnik's method of visual focusing on the optical bench OSK-2. SolidWorks software package (France) was used to design a new IOL model. The object of our study was IOL, the actual technical solution described in the patent application U 2021 04749 [20].

5. Results of studying the resulting intraocular lens with a low longitudinal spherical aberration

5. 1. Calculation of the required refractive index for the coating of the intraocular lens

When light passes through the human eye, up to 4 % of light is lost on each optical surface. If we consider the eye as an optical system of four elements (cornea, front chamber, crystal, vitreous body), then about 84 % of the light flux can pass through the system. At the same time, there is a reflection phenomenon (Fresnel reflection), for the weakening of which thin-layer (interference) films are used, termed the gradient of optics [21, 22].

Taking into consideration the fact that the human eye crystal also uses the principle of gradient optics to focus light, it is possible to create IOL in a similar approach. We calculated the refractive index of the material required for axial application on IOL made of hydrophobic acrylic. The applied layer should have a refractive index according to the formula:

$$n_{01} = \sqrt{n_{en} n_l}, \tag{1}$$

where n_{en} is the environment's refractive indices; n_l is the lens refractive index.

Given that the hydrophobic acrylic IOL has a refractive index of 1.55 [8], and the refractive index of aqueous humor is 1.33, we substitute in (3) to obtain:

$$n_{01} = \sqrt{1.33 \cdot 1.55} = \sqrt{2.0615};$$

$$n_{01} = 1.435.$$

Close to the specified parameter is the PTFE (Teflon) refractive index, namely 1.42 [23].

It is expected that the IOL to be created would have not only a corrected spherical aberration but also a lower predisposition to the occurrence of photic phenomena. Using formula (2), we calculated the Fresnel reflection coefficient for the following lens:

$$R_0 = \frac{(n-1)^2}{(n+1)^2}, \tag{2}$$

where n is the refractive index of the environment;

$$R_0 = \frac{(1.435-1.33)^2}{(1.435+1.33)^2} = 0.0014.$$

For the case without a PTFE layer:

$$R_0 = \frac{(1.55-1.33)^2}{(1.55+1.33)^2} = 0.0058,$$

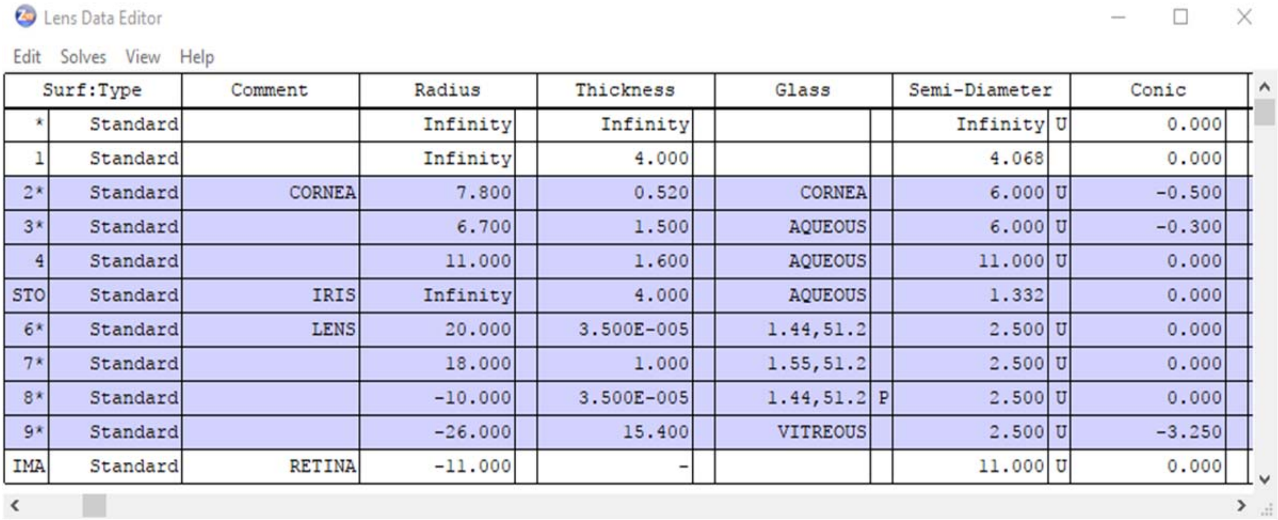
that is, the reflection decreases by more than 4 times.

Information about the quality of the image built by the optical system can be acquired in two ways – directly and indirectly.

5. 2. Optical modeling involving the obtained indicators

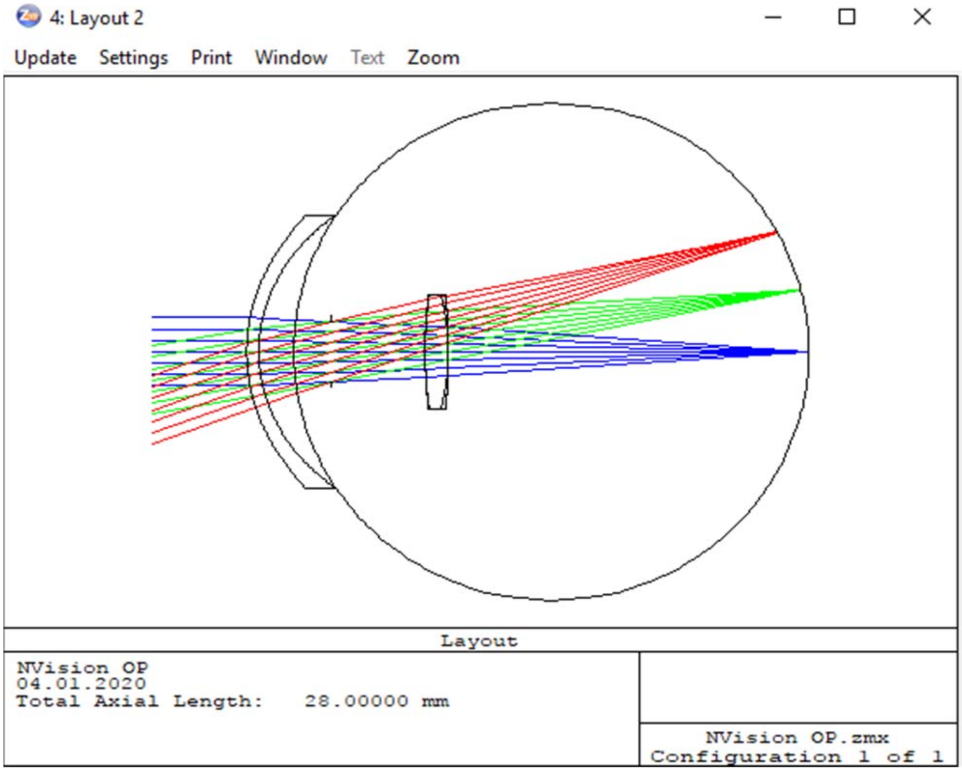
The programming environment Zemax 13 was used to simulate IOL using the obtained calculation results: an acrylic lens with a thickness of l=1 mm, with a refractive index of 1.55, covered with a layer of Teflon with a refractive index of 1.42. The lens is located in the human eye at a distance from the iris h=4 mm, the diameter of the inlet pupil d=3 mm, the sagittal eye axis is 28 mm (Fig. 1). Let us consider the 2D projection of the optical system (Fig. 2).

The resulting point scatter diagram (RMS) on the retina of a beam with a wavelength of 0.555 µm is shown in Fig. 3.



Surf:Type		Comment	Radius	Thickness	Glass	Semi-Diameter	Conic
*	Standard		Infinity	Infinity		Infinity U	0.000
1	Standard		Infinity	4.000		4.068	0.000
2*	Standard	CORNEA	7.800	0.520	CORNEA	6.000 U	-0.500
3*	Standard		6.700	1.500	AQUEOUS	6.000 U	-0.300
4	Standard		11.000	1.600	AQUEOUS	11.000 U	0.000
STO	Standard	IRIS	Infinity	4.000	AQUEOUS	1.332	0.000
6*	Standard	LENS	20.000	3.500E-005	1.44,51.2	2.500 U	0.000
7*	Standard		18.000	1.000	1.55,51.2	2.500 U	0.000
8*	Standard		-10.000	3.500E-005	1.44,51.2 P	2.500 U	0.000
9*	Standard		-26.000	15.400	VITREOUS	2.500 U	-3.250
IMA	Standard	RETINA	-11.000	-		11.000 U	0.000

Fig. 1. Simulation parameters of the eye with an intraocular lens: Cornea with a radius of 7.8 mm; refractive index, 1.376; Aqueous — (wet front chamber of the eye) refractive index is 1.336; Iris — (iris), a diaphragm with a hole of 3 mm; Lens — (intraocular lens) with a refractive index of 1.55, covered with a layer of Teflon with a refractive index of 1.42, located at a distance of 4 mm from the iris; Aqueous — a (vitreous body) with a refractive index of 1.336



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NVision OP
04.01.2020
Total Axial Length:    28.00000 mm
NVision OP.zmx
Configuration 1 of 1
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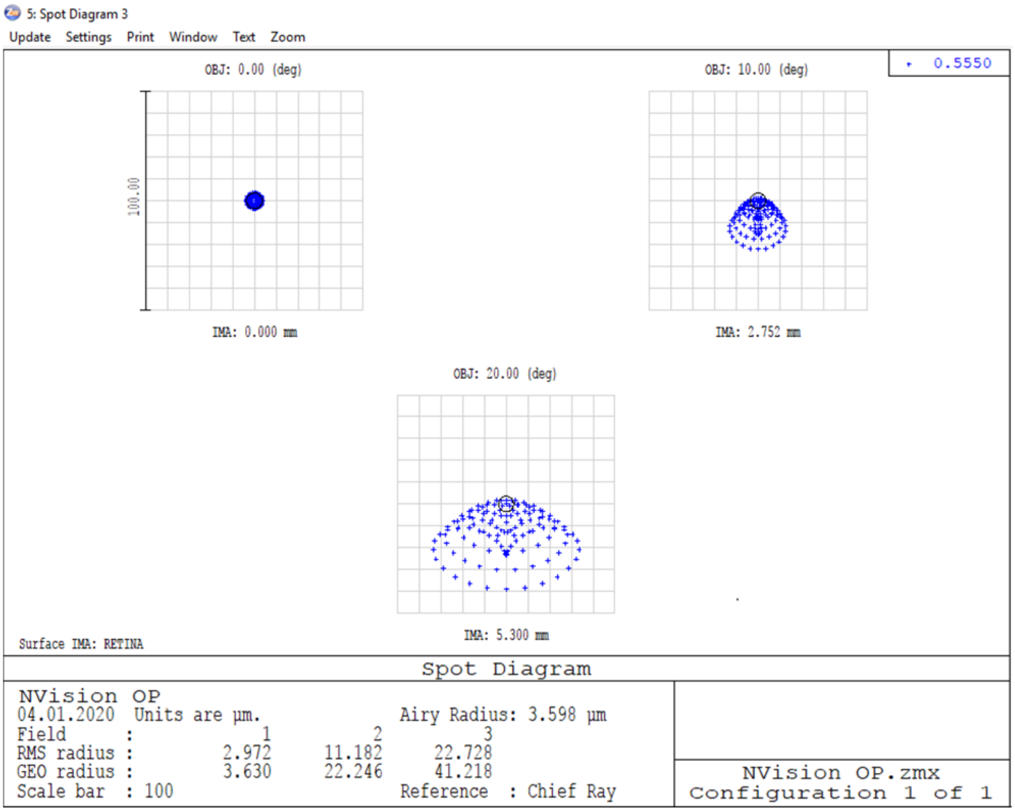
Fig. 2. 2D projection of the optical system with the specified parameters



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                              Spot Diagram
NVision OP
04.01.2020  Units are µm.                Airy Radius: 3.598 µm
Field      :          1         2           3
RMS radius :      2.972    11.182      22.728
GEO radius :      3.630    22.246      41.218
Scale bar  : 100                         Reference  : Chief Ray

                                             NVision OP.zmx
                                          Configuration 1 of 1
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Fig. 3. Point scatter diagram (RMS) of the proposed intraocular lens, where RMS radius=2.972 µm; GEO radius=3.630 µm; Airy radius=3.598

The root mean square (RMS) deviation is the root mean square value of the radial size of the scattering spot. The GEO spot size is the radius of a circle centered at the anchor point, within the boundaries of which all rays fall.

The image RMS deviation acquired by the proposed lens is 2.972 µm. The RMS of beamsis completely within the boundaries of the Airy Radius disc, which is 3.598 µm. Therefore, it follows that such an optical system is diffractionally limited, 2.972<3.598, and does not require further, similar, optical optimizations because they are not possible due to the wave nature of light [26].

To apply a thin PTFE film, we used the method of PTFE evaporation with the activation of products released to the gas phase. Underlying the method of obtaining a PTFE film is the process of polymer degradation with the cleavage of macromolecules [27].

For the evaporation of polymers and the formation of a polymer film on the substrate, we applied the method of heating with an unfocused electric current, which, if necessary, also enabled the electron activation of the evaporated polymer [28]. According to [29], PTFE is completely biocompatible with human living tissue and is allowed for medical use.

Moreover, due to its hydrophobicity to all substances, it is a barrier to the development of bacteria and the growth of A-CAC and E-CAC cells that provoke various types of complications and secondary cataracts on IOL.

5. 3. Application of optical coating on the lens with follow-up analysis of morphology

To spray a PTFE film on IOL, we applied the installation of vacuum spraying UVN-74 (Fig. 4) at the Institute of Semiconductor Physics named after V. E. Lashkarev, NAS of Ukraine. The installation was used with a rotating disc loaded into it, which contained three silicon samples and an IOL.

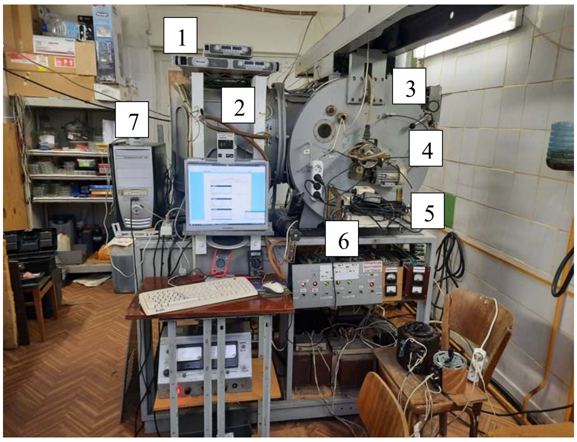


Fig. 4. Installation for vacuum spraying "UVN-74" [30]:
1 – HV generator Dressler Cesar 403; 2 – Vacuum meter Pfeiffer vacuum; 3 – HF generator control system;
4 – Substrate rotation drive; 5 – StellarNet spectrophotometer;
6 – Vacuum system control; 7 – Computer Manager

To improve the accuracy of measurements of the thickness of the applied film, an optical system was used, which included a four-channel system thickness meter Sigma Instruments SQM-242 (USA). It was equipped with the spectrophotometer StellarNet (USA), HF generator Dressler Cesar 403 (USA), vacuum meter Pfeiffer vacuum (Germany), a light source, fiber optic light conductors, and vacuum inputs of radiation into the chamber.

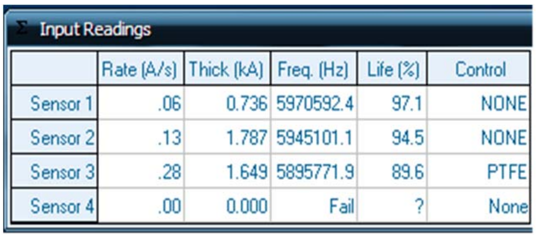
To spray 100 nm of PTFE, the initial frequency of the quartz meter was 5,903,571 Hz, which was decreased in a step of 76 Hz, thereby allowing control over the PTFE film growth.

Fig. 5 shows the initial parameters when spraying PTFE using the equipment; Fig. 6 – final.

Input Readings

	Rate (A/s)	Thick (kA)	Freq. (Hz)	Life (%)	Control
Sensor 1	.01	0.000	5971780.2	97.2	NONE
Sensor 2	-.01	0.000	5947963.3	94.8	NONE
Sensor 3	-.13	0.000	5903570.4	90.4	PTFE
Sensor 4	.00	0.000	Fail	?	None

Fig. 5. Initial parameters of UVN-74 when spraying 100 nm of polytetrafluoroethylene: voltage of electronic activation – 0.8 kV; the current of electronic activation is 10 mA; temperature, 26 °C; pressure, $-6.3\cdot10^{-5}$ mm Hg



Input Readings

	Rate (A/s)	Thick (kA)	Freq. (Hz)	Life (%)	Control
Sensor 1	.06	0.736	5970592.4	97.1	NONE
Sensor 2	.13	1.787	5945101.1	94.5	NONE
Sensor 3	.28	1.649	5895771.9	89.6	PTFE
Sensor 4	.00	0.000	Fail	?	None

Fig. 6. Final parameters of UVN-74 when spraying 100 nmof polytetrafluoroethylene: voltage of electronic activation – 0.8 kV; electric activation current – 10 mA; temperature, 368 °C; pressure, $6.8\cdot10^{-5}$ mm Hg

To study the morphology of the spray sample, the probe atomic force microscope NanoScope IIIa Dimension 3000^{TM} was used (Fig. 7).

Atomic force microscopy has established the thickness of the PTFE film applied onto the IOL, namely 102.66 nm (Fig. 8).

According to the obtained oscillation frequency of UVN quartz meter of 5,895,772 Hz, which is equal to 100 nm of polytetrafluoroethylene, the probe atomic force microscope confirmed the thickness of the applied layer of 102.66 nm. The value is in line with the permissible error of 2.6<5 %.

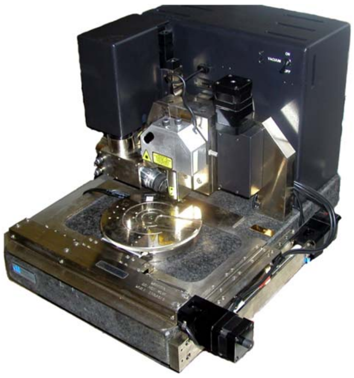
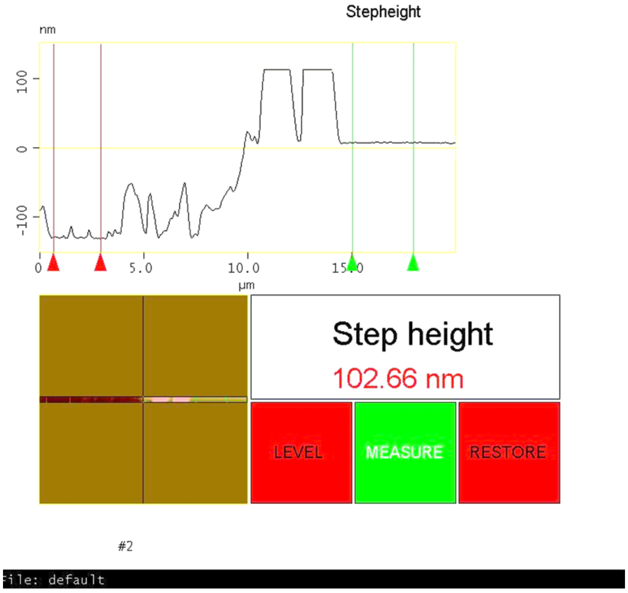


Fig. 7. Probe atomic force microscope NanoScope IIIa Dimension 3000^{TM} [31]



Step height
102.66 nm

Fig. 8. Values acquired from the cantilever of the atomic force microscope

5. 4. Investigating the intraocular lens for the value of longitudinal spherical aberration

We studied and compared the value of the longitudinal spherical aberration of intraocular lenses with and without PTFE spraying at the optical bench OSK-2 (Fig. 9) by Linnik's method of visual focusing.

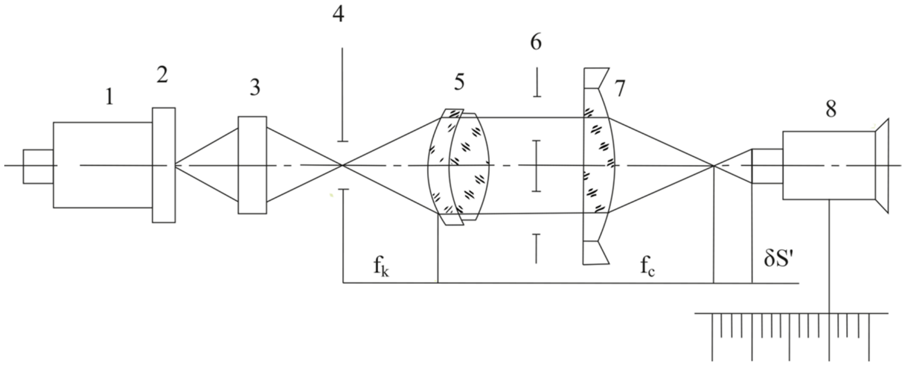


Fig. 9. Optical scheme of the installation for measuring longitudinal spherical aberration: 1 – light source (mercury lamp); 2 – light filter; 3 – cylindrical condenser; 4 – sliding gap or diaphragm; 5 – collimator lens, 6 – replaceable screens with even holes, serving to highlight narrow beams of rays, 7 – the investigated optical system in a holder, 8 – reference microscope

To measure longitudinal spherical aberration, Linnik's method of visual focusing is used. It is estimated by the magnitude of longitudinal refocusing, from Fig. 10, *b* to Fig. 10, *a*, of the reference microscope in the sliding gap or diaphragm 4 image.

Longitudinal spherical aberration is characterized by a difference:

$$\delta S' = \left|\delta S'_h - \delta S'_0\right|, \qquad (3)$$

where $\delta S'_0$ is the countdown on the scale of longitudinal movement of the microscope, focused on the image of the sliding gap in the paraxial rays of Fig. 10, *a*, $\delta S'_h$ – similar countdowns for refocusing from Fig. 10, *b* to Fig. 10, *a* in the rays falling on the input pupil of the optical system at height *h*.

To obtain the highest sharpness of the diffraction pattern, the width of the sliding gap or the diameter of the diaphragm must satisfy the following condition:

$$b \le \frac{\lambda \cdot f_k}{2 \cdot d}, \qquad (4)$$

where $d=(0.01 \div 0.02) f_c$, f_c is the focal length of the system under study, f_k is the focal length of the collimator lens, λ is the wavelength of light.

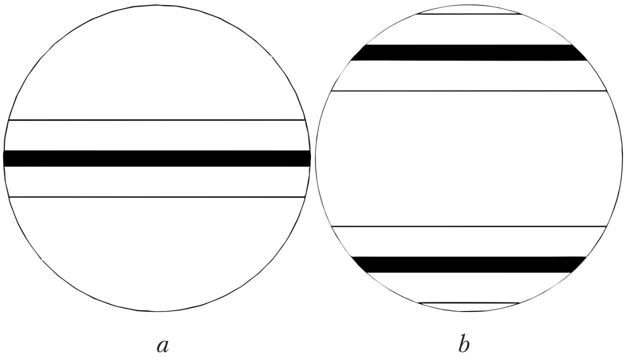


Fig. 10. Diffraction patterns observed in a microscope: *a* — visually focused image of the sliding gap; *b* — visually defocused image of the sliding gap

The microscope magnification was selected subject to that the diffraction band is visible through a microscope at an angle of at least 0.5°; it was calculated from the formula:

$$\Gamma \ge \frac{k \cdot d}{\lambda \cdot f_c}, \qquad (5)$$

where $k \approx 3$ mm is the empirical coefficient.

We analyzed the value of the longitudinal spherical aberration of IOL with and without PTFE spraying (Fig. 11).

When studying the intraocular lens with a PTFE spray of 100 nm through an aperture with a diameter of 2 mm, no longitudinal spherical aberration was detected. When examining zones with a diameter of 4 and 6 mm, it was found that the indicator of spherical aberration was significantly less than the corresponding indicator of the IOL without spraying. The result of the passage of light through a zone with a diameter of 4 mm is a decrease in the length of the spherical aberration zone by 4 times compared to the IOL without spraying. When investigating a zone with a diameter of 6 mm, a decrease in the spherical aberration by 0.2 mm was detected.

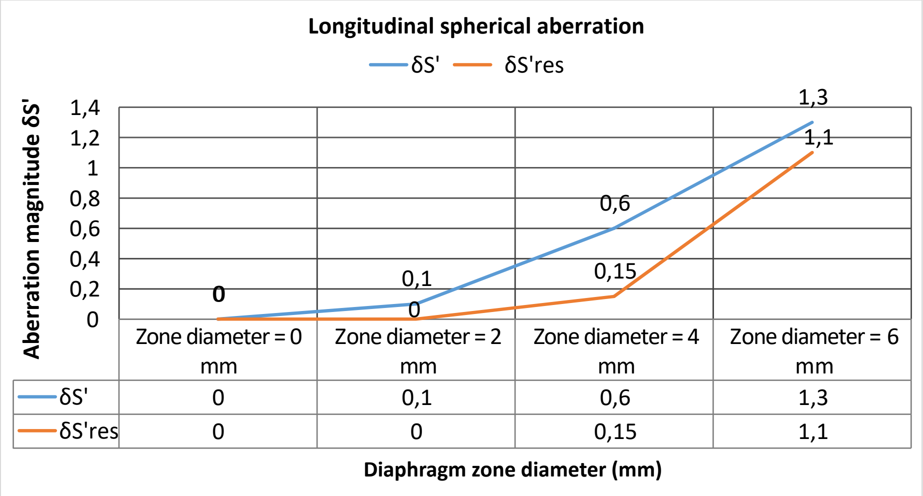


Fig. 11. The longitudinal spherical aberration of lenses with and without polytetrafluoroethylene spraying

5. 5. Designing a new model of the intraocular lens

Based on the results of our study, a model of the combined IOL "NVision Optics" is proposed; it was designed in the SolidWorks 19 programming environment (Fig. 12).

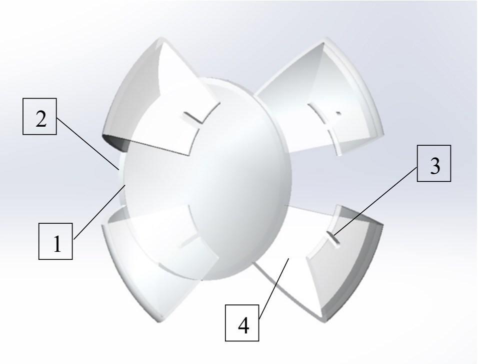


Fig. 12. Intraocular lens "NVision Optics" [20]: 1 — sharp edge; 2 — side; 3 — marker cutouts; 4 — leaf-shaped haptics

The volume-substituting multifocal intraocular lens "NVision Optics" has a shape and size similar to the natural crystal, which provides the possibility of volume-change implantation through a minimal incision into the capsule bag of the removed crystal to be securely, physiologically placed. Due to the volume-substituting design, IOL prevents the trembling of the iris (iridodonesis), contributes to the uniform tension of the capsule bag and the distribution of load on all segments of zinn ligaments. It reduces the likelihood of liquefaction of the vitreous body, and, as a result, retinal detachment, is multifocal, and preserves the physiological depth of the front chamber. The sharp edge of lens 1 and side 2 perform a barrier function, counteracting the development of secondary cataracts. Sheet-shaped haptics 4 are attached to the optics, which, due to their design, create a volume-substituting effect and play a mechanical role in the process of natural accommodation. The same haptic elements contain marker cutouts 3, which wouldallow the surgeon to perform the necessary manipulations in the intraoperative period. Implantation and, if necessary, explantation is proposed to perform with the help of a specially designed injector, pat. UA 149961 U [32].

6. Discussion of results achieved by the resulting intraocular lens with a low longitudinal spherical aberration

The most common optical distortion of intraocular lenses in the practice of cataract surgery is the appearance of unwanted monochromatic aberrations. To combat such effects, various methods are used. It is known that the cornea of the human eye carries a positive spherical aberration. To compensate for this, intraocular lenses with negative spherical aberration are offered [18]. However, the manufacture of paraboloid and hyperboloid optics is more time-consuming and expensive compared to spherical optics. At the same time, aspherical lenses have aberrational modes of higher orders and impaired contrast reproducibility. Some authors offer apodised diffraction optics [14, 15]. The disadvantage of that approach is the distorted light transfer and Fresnel reflection in the form of rings. Paper [33] proposes a double intraocular lens optimized for both chromatic and monochromatic correction of aberrations in pseudofacical eyes. Almost complete aberration correction was achieved with a double intraocular lens. The modulation function and the Stroller coefficient were better for the double lens compared to the aspherical lens.The disadvantage of a doublet lens is the presence of a surface with a very small curvature radius. Moreover, in the manufacture of the lens, the permissible decentralization between the surfaces of the lens and the permissible angle of the field would decrease. Thus, the efficiency of manufacturing is significantly reduced.

Our method makes it possible to reduce the spherical aberration of spherical intraocular lenses by applying an additional optical layer of polytetrafluoroethylene. According to the results of calculations using formula (3), it is possible to theoretically estimate the reduction of optical phenomena in a series with the laws of antireflection optics. The results from formula (4) indicate a decrease in the Fresnel reflection by 4 times. The simulation in the Zemax 13 environment (Fig. 4) has made it possible to achieve the diffraction limit of the optical system, compared to the Airy disk of 2.972<3.598. The simulationproduces an ideal variant but it is not fully confirmed in practice. According to (Fig. 12), one can see that the lens with the spraying of polytetrafluoroethylene has a smaller amount of spherical aberration than the lens without spraying. No longitudinal spherical aberration in the central region of the lens with a diameter of 2 mmwas detected.The highest value (1.1) was registered in the study of the zone, which reached the optical edge of the IOL; this indicator was less by 0.2 mm than that obtained in the study of IOL without spraying. The magnitude of the aberration of the lens with spraying is close to the aberration of paraboloid lenses [15, 18], which indicates the feasibility of using a given method.

The limitation of our method is that the application of polytetrafluoroethylene with a layer of 100 nm is advisable for lenses whose refractive index is in the range of 1.46 to 1.55. In this case, an experimental selection of the deposition parameters of Teflon should be carried out.

The caveat of the current study is the fact that polytetrafluoroethylene is non-resistant to mechanical damage, and, therefore, not suitable for use on IOL haptics. Eliminating this disadvantage could be the addition of other bioneutral materials to the Teflon compound.

Further work may involve the combination of polytetrafluoroethylene with other polymers. It is promising to form polytetrachlorethylene, which would make it possible to vary the value of the refractive index. As a result, polytetrachlorethylene couldallow it to be used to cover IOL with different refractive indices. Whenapplying a coating, it may be difficult to comply with the required conditions of application.

7. Conclusions

1. The formulas of antireflection optics were used to calculate and select the material with the required optical refractive index. To reduce longitudinal spherical aberration and dysphotopsia, a hydrophobic acrylic IOL must have an additional optical layer on its surface with a refractive index of about 1.42. The numerical parameter of the optical indicator matches polytetrafluoroethylene with a layer thickness of 100 nm. Moreover, the material satisfies the requirements for medical use.

2. The Zemax software package was applied tosimulate the intraocular lens with the calculated parameters. The simulation involved a layer of Teflon, 100 nm thick, applied onto a hydrophobic acrylic lens with anindex of 1.55. The RMS deviation in the lens image is 2.972 μm, which is smaller than the size of the Airy disc of 3.598 μm, and less than the diameter of the unit of the light-sensitive receptor of the eye of 4 μm. This intraocular lens is diffractionally limited, so further optical enhancements of optical indicators make no sense due to the wave nature of light.

3. To spray PTFE, we used an installation for vacuum spraying by the method of Teflon evaporation enabling the activation of products released to the gas phase. “UVN-74” makes it possible to apply a PTFE layer of the desired thickness, namely 100 nm. The thickness was controlled at the rate of frequency of quartz meter, which decreased stepwise by 76 Hz. We studiedthe film morphology at theatomic force microscope NanoScope IIIa Dimension 3000^{TM}; it produced a value of 102.66 nm, which is within the permissible deviations of 2.6 %.

4. We measured the value of longitudinal spherical aberration at the optical bench OSK-2 by Linnik’s method of visual focusing. Spraying a PTFE film with a thickness of about 100 nm has the consequence of a probable decrease in the longitudinal spherical aberrations of hydrophobic acrylic IOL while reducing the Fresnel reflection by 4 times. No spherical aberration in the lens area with a diameter of 2 mm was detected. At the edge of the lens, the aberration value took the highest value of 1.1. This figure was lower by 0.2 than that obtained in the IOL study without spraying. Comparing our data with the results reported by other authors, one can conclude that the use of an additional optical layer of Teflon on IOL makes it possible to improve the optical characteristics of the lens.

5. The current results make it possible to create a new IOL model whose structure wasdesigned in the SolidWorks programming environment. Givenitsvolume-substituting structure, the IOL prevents the trembling of the iris, promotes uniform tension of the capsule bag and the distribution of load on all segments of zinn ligaments. It reduces the likelihood of liquefaction of the vitreous body, and, as a result, retinal detachment; it is multifocal and preserves the physiological depth of the front chamber.Applying PTFE onto the optical surface of IOL improves optical performance and reduces the likelihood of developing secondary cataracts due to the hydrophobic properties of Teflon. It counteracts the proliferation of E-CAC and A-CAC cells.

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