

Optical features of the anterior segment of the eye and lens

Ivan N. Koshits¹, Olga V Svetlova², Peter P. Bakshinsky³ and Maksat B. Egemberdiev⁴

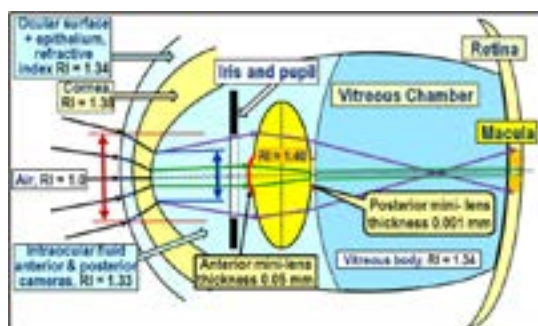
¹Petercom-Network Management System/Consulting Grope Close Corporation, Russia

²North-Western State Medical University named after I.I. Mechnikov, Russia

³The Vidnoe district Central Clinical Hospital in Moscow region, Russia

⁴Chuy Region United Hospital, Chief of the Department of Ophthalmology, Bishkek, Kyrgyzstan

1. Optics of the anterior segment of the eye: We are used to idea that light rays entering the eye are refracted by the cornea. However, this is not the entirely true. Incoming light rays first pass through the first barrier: the tear film with the epithelium, where the refractive index (RI) = + 43.6 D on the border with air. And only then the rays pass through the second barrier "tear film – cornea" with RI = + 5.3 D. There is no air layer between the epithelium and the cornea, which makes it possible to create a kind of biological optical system: "tear film + epithelium + cornea". Such optical design of anterior segment of the eye produces a kind of "optical compression", it "collects" a wide picture of the visual space in the eye in a narrow "optical tunnel", as in a telescope. This optical compression is necessary in order to provide the possibility of passing the light bundle even through a narrow pupil (Pic. 1).

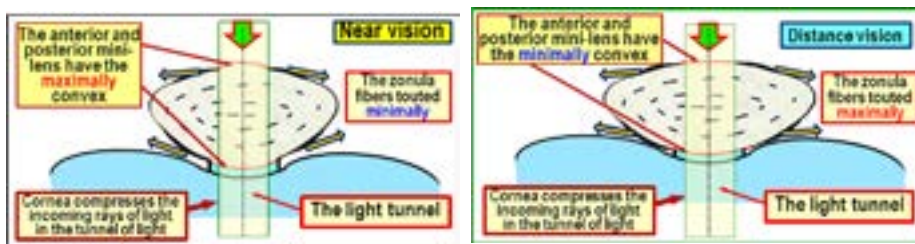


Pic. 1. Features of passing light rays through the anterior optical system of the eye "tear film + epithelium + cornea + aqueous humor" with a wide pupil.

The thickness of the cornea in the center is almost 2 times less than in the periphery, which is typical for the scattering lens. Therefore, for example, the white light rays coming out of the cornea at the border of the "cornea – intraocular fluid" will be slightly divergent (see Fig. 1) and further subject to dispersion, decomposing into a spectrum, this means that inside the eye there will always be rays of all colors of the spectrum and only in the center of the cornea wavelengths of light will all be in one bundle – the white light. Furthermore, the anterior optical system (AOS) of the eye, consisting of the "eye surface" and the cornea, borders with a less dense optical medium – intraocular fluid. AOS works as a biological lens, providing at first compression in the "light tunnel", and then - a weak scattering of passing light rays.

Therefore, white light rays will always be subject to dispersion on the posterior surface of the cornea, and will go to the anterior surface of the lens as slightly divergent and expanding color bands, including three base bands: blue, green and red (BGR-band), which can be detected by macular cones. The effect of thickness and topography of the tear film with corneal epithelium on the overall refractive power of the eye is quite noticeable. Therefore, in dry eye syndrome, patients often complain about the lack of image sharpness, since the thinning of the lacrimal surface significantly reduces its refractive power.

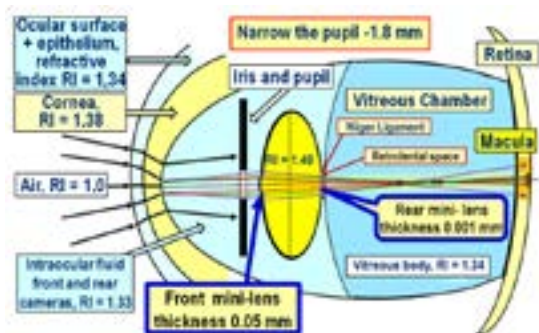
2. Optical structures of the lens: The mystery of the focusing mechanism of light rays that pass close to the optical axis of the eye exactly into the macula for many years had no solution. Traditionally, it was believed that the lens capsule cannot strongly refract light in its central region due to the small curvature radius. As it turned out, this is not a complete picture. In the center of the anterior and posterior surfaces of the lens capsule there are two thin mini-lenses: the front mini-lens and the rear, which change their optical powers depending on the pressure inside the lenses capsule, depending on the tone of the ciliary muscle (Pic. 1). These mini lenses provide maximum refraction when looking at the objects at the minimum distance. Pic. 2 shows the change in the geometry of the front and rear mini-lens in the extreme phases of accommodation. When looking at closely located objects the pressure in the capsule of the lens is as big as its refractive power (the circumference) of these mini-lenses. When looking into the distance, the pressure inside the lens bag same as the refractive power of the mini lenses are at its minimum. This is because when you look objects placed at near distance the capsule of the lens is the least stretched by the ciliary zonules and therefore the most powerfully compresses structure inside the lens.



Pic. 2. The front and rear mini lenses have the greatest curvature at the time of accommodation focusing on objects at near sight and the least curvature when looking into the distance.

Pic. 3 Shows a diagram of the flow of light through a narrow pupil when looking at the objects at close distance. The light bundle compressed into a "light tunnel" passes through the front and rear mini lenses of the lens and is refracted in them so that the macula can perceive this image as three basic color bands [1-4].

Conclusion: The anterior optical segment of the eye is a composite biological lens, which includes the following refractive structures: tear film, corneal epithelium and the cornea itself. The main task of the eyes optic system is to effectively compress into a "light tunnel" with a diameter of 1.8 -2.5 mm coming into the eye light flux for it to pass even through the narrow pupil. The



Pic. 3. The work of the optical system of the eye at near vision with a narrow pupil.

cornea is a weakly scattering lens, so the light rays are spread out in the spectrum at the border with the aqueous humor of the anterior chamber, then undergo a weak deviation from the outside on the posterior surface of the cornea. In the center of the optical axis in the lens capsule there are two mini-lenses – anterior and posterior, which change their curvature (refractive power) in different phases of accommodation due to changes in pressure inside the lens with different tone of the ciliary muscle.

References

1. Koshits I.N., Svetlova O.V., Guseva M.G., Pevko D.V., Egemberdiev M.B. Optical features of the passage of light through the refractive structures of the eye.- Ophthalmic journal, 2017.- 4(477): 60-73. [in Russian, in English].
2. Koshits I.N., Svetlova O.V. Adaptive myopia. Part 2. New views on the physiological mechanisms of the guidance of eyes to sharpen.- Ophthalmic journal, 2017.- 1 (474): 38-50. [in Russian, in English].
3. Koshits Ivan, Svetlova Olga, Gorban Anatoly. Physiological features of executive mechanisms of accommodation and development of the theory of Helmholtz accommodation. Metabolic adaptation theory myopia: monography. -2 Edition.- St. Petersburg: Northwestern State Medical University by name I.I. Mechnikov, 2016.– 264 p. [in Russian].
4. Koshits Ivan, Svetlova Olga, Guseva Marina. Physiological principles of rational optical correction. Practical recommendations. Normal physiology of the eye: monography.-St. Petersburg: Northwestern State Medical University by name I.I. Mechnikov, 2016. - 152 c. [in Russian].
5. Olga Svetlova, Ivan Koshits. Theory. Actuating mechanisms of accommodation and development of the theory of accommodation by Helmholtz.- Proceedings of 3rd Global Pediatric Ophthalmology Congress, 2018.- London, UK.- Journal of Clinical & Experimental Ophthalmology, March 2018.- Vol.9.- P. 66-70.

Biography

Ivan N. Koshits is mechanical engineer, biomechanics, a member of the St. Petersburg Sechenov Society of physiologists, biochemists, pharmacologists. Author of 70 scientific works in biomechanics, normal and pathological physiology of the eye and its elements, 2 monographs (2016). Organizer and co-head of the first scientific conferences in Russia on the Biomechanics of the eye in 1998 -2009. Author dispersion theory aiming eye on sharpness and formation mechanisms of binocular vision due to optical rings-sights in the macula. Co-author and developer of the theory of functions of fibrous sheath eyes, the theory of open angle glaucoma and metabolic theory of adaptation myopia. As well as the co-author of dynamic diagnostic methods to determine the in vivo new physiological and biomechanical characteristics of the eye. General Director of the company of Petercom - Network/Management System Consulting Grope Cl. Corp.

Notes: