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Neuroadaptation to multifocal intraocular lenses: A new approach to solving the problem

Summary

The current trend towards the implantation of multifocal intraocular lenses is associated with the desire of patients to be independent of glasses and improve the quality of life. However, the brain in conditions of multifocal correction of aphakia works with several foci, which is unphysiological, energy-consuming and requires long-term neuroadaptation. With the depletion of brain resources in adulthood due to problematic neuroadaptation to multifocal intraocular lenses, the neuropsychic or somatic health of patients may deteriorate.

The eye-brain system is evolutionarily adapted to aberrations within 1.5 diopters. It is proposed to form direct simple myopic astigmatism up to 1.5 diopters during monofocal correction of aphakia (by laser correction of corneal refraction or implantation of a spherical cylindrical intraocular lens). The specified refraction, expanding the focal area of the pseudophakic eye, provides the greatest (in comparison with other types of refraction) amount of pseudo-accommodation and, accordingly, independence from glasses. The proposed approach is physiological for the brain and does not cause problems with neuroadaptation.

Keywords: neuroadaptation, multifocal intraocular lenses, pseudoaccommodation, aberrations up to 1.5 diopters, evolution

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Relevance

Cataract is the most common cause of blindness in the world. Millions of people undergo cataract surgery every year. The resulting aphakia is corrected by implantation of intraocular lenses (IOL) - monofocal or multifocal. Monofocal IOLs - compared to multifocal ones - are better tolerated, give higher corrected visual acuity, but require additional spectacle correction for certain distances.

The current trend towards the implantation of multifocal IOLs (MFIOLs) is associated with the desire of patients to be independent of glasses, that is, to improve the quality of life. MFIOLs have 2 or 3 foci. Trifocal IOLs provide a good level of pseudo-accommodation and independence from spectacle correction in far, near and intermediate vision. However, with MFIOL in the postoperative period, a decrease in contrast sensitivity, the development of dysphotopsia (lights, flashes, halos, glare around light sources) are possible, in some cases, long-term adaptation of the central nervous system is required.[1,2]

Neuroadaptation is a serious problem in MFIOL implantation. The impossibility of neuroadaptation causes glare, distortion, confusion and a feeling of poor vision, which requires the replacement of such lenses with a monofocal model.[3,4]

Objective

Propose a new approach to solving the problem of neuroadaptation to multifocal intraocular lenses.

Why is neuroadaptation to MFIOL usually long - up to 1 year?

Evolutionarily, the visual analyzer is adapted to process only one image, which is focused on the retina with the help of accommodation. With the separation of light caused by the optical design of the MFIOL, several foci occur, the brain simultaneously receives different images on the retina (clear and blurry), which need to be processed. This poses a more difficult than usual task for the brain. The brain must choose from several simultaneous images the one that is currently a priority. This requires excessive tension, maximum mobilization of the body's physiological reserves.

It is known that young patients tolerate neuroadaptation to MFIOL more easily than older ones. In adulthood, when brain resources are usually depleted, the brain, in order to work with several focuses, in some cases has to turn off some organs and systems. It is necessary to take into account the following: the visual analyzer is very energy-consuming - its work is served by 6 pairs of cranial nerves (half of the 12 available). MFIOLs further increase the volume of brain work (simultaneous processing of several images). When the general condition of the body is severe, the brain sometimes seeks to «make life easier» - to block the visual analyzer (in order to pay more attention to other vital organs and systems).[5] The principle of the block is a sharp decrease in central vision. With multifocal correction, macular edema, retinal detachment, epiretinal gliosis, glistening (clouding of the IOL due to fluid microvacuoles)[2] can be observed , leading to a drop in visual functions (that is, to a block). These processes are based on the inability of the brain to neuroadaptation due to reduced resources. The exhaustion of brain processes can also be realized in neuropsychic or somatic diseases. In other words, MFIOL under certain conditions can worsen the health of patients. To establish the truth of this statement, multicenter randomized studies of the health status of patients with multifocal and monofocal IOLs should be conducted.

Empirically, the correct approach to the selection of patients for MFIOL has already been found: scientists call for studying (along with the ophthalmological status) the physical and psycho-emotional status of patients before implanting such lenses.[6] Disturbing: encephalopathy, hysterical personality type, initially overstated requirements of the patient. Since physical and mental problems in the body are interrelated, it is necessary to examine patients before surgery in a comprehensive manner. Certain prospects in the study of brain reserves and the possibility of neuroadaptation to MFIOL are provided by functional magnetic resonance imaging, which scans changes in blood flow caused by neuronal activity of the brain.[7,8]

Perhaps this method will help discover new ways to improve patient satisfaction with multifocal correction.

But we believe that, in principle, MFIOLs are non-physiological (they force the brain to solve a problem that it has not encountered in the process of evolution). EDOF IOLs (Extended Depth of Focus IOLs) are more suitable for increasing pseudoaccommodation of the pseudophakic eye. Unlike MFIOLs which have 3 fixed foci, EDOF IOLs work by creating a single elongated focal point to increase the depth of focus. Therefore, in comparison with MFIOL, there is no blurring of the image in the intervals between focuses, less dysphotopsia, the image contrast does not drop sharply, and neuroadaptation passes faster.[9] However, the design of the EDOF IOL (diffractive, refractive) does not completely exclude the presence of the above negative phenomena. Are there other options for solving the issue of pseudoaccommodation of the pseudophakic eye that would not cause problems with neuroadaptation?

We propose to form direct simple myopic astigmatism up to 1.5 diopters (D) on the eye with a monofocal IOL.[10] This can be achieved by laser correction of corneal refraction after cataract surgery or intraoperatively: implantation of a spherical IOL. In the 90s of the last century, we formed the indicated astigmatism in pseudophakic eyes using keratotomy (corneal incisions). In combination with a narrow pupil (no more than 3 mm in diameter) and a intact retina, the mentioned refraction of the pseudophakic eye provides distance sharpness of 0.8; near - 0.5 (which gives independence from glasses in most cases).

Why is this approach preferred over existing ones?

The eye-brain system is adapted to aberrations within 1.5D in the course of evolution. The normal eye has optical imperfections (spherical and chromatic aberrations, physiological astigmatism) up to 1.5 D and they do not significantly affect the image quality. The surfaces of the lens are not spherical: the anterior surface has direct astigmatism up to 1.5D, the posterior surface has reverse astigmatism up to 1.5D.

The expansion of the space of clear vision without energy consumption of accommodation is achieved by increasing the focal area: direct corneal astigmatism of 1.0–1.5 D is inherent in most eyes.[11] Our studies have shown that direct simple myopic astigmatism up to 1.5 D maximizes (compared to other types of refraction) the focal area of the pseudophakic eye, which provides a volume of pseudoaccommodation sufficient for comfortable vision at different distances in patients with monofocal IOL.[10]

This refraction in the pseudophakic eye does not cause problems with neuroadaptation, since it is physiological for the brain. Modern technologies make it possible to achieve "target" refraction after refractive and cataract surgery in the vast majority of cases. Therefore, the proposed approach - the formation of direct simple myopic astigmatism up to 1.5 D in an eye with a monofocal IOL - can be considered promising. Due to the emerging depth of the focal area (and, accordingly, the amount of pseudo-accommodation), the patient is provided with independence from glasses. But it is not necessary to pay for this with long-term neuroadaptation (which can lead to neuropsychic or somatic diseases), since the brain is evolutionarily adapted to aberrations up to 1.5 D in one or between both eyes.[12]

Conclusion

i. The brain in conditions of multifocal correction of aphakia works with several foci, which is unphysiological, energy-consuming, and requires long-term neuroadaptation.

ii. With the depletion of brain resources in adulthood due to problematic neuroadaptation to multifocal intraocular lenses, the neuropsychic or somatic health of patients may deteriorate.

iii. The eye-brain system is evolutionarily adapted to aberrations within 1.5 diopters.

iv. It is proposed to form direct simple myopic astigmatism up to 1.5 diopters with monofocal correction of aphakia (by laser correction of corneal refraction or implantation of a spherocylindrical intraocular lens).

v. The specified refraction, expanding the focal area of the pseudophakic eye, provides the greatest (in comparison with other types of refraction) amount of pseudo-accommodation and, accordingly, independence from glasses.

vi. The proposed approach is physiological for the brain and does not cause problems with neuroadaptation.

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None.

Conflicts of interest

The authors declare no conflicts of interest.

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