

Review

The Feasibility of Implanting Multifocal Intraocular Lenses in Patients with Glaucoma.

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Citation: Petrov A. The feasibility of implanting multifocal intraocular lenses in patients with glaucoma.

Otorhinolaryngology, Head and Neck Pathology (ORLHNP). 2024; 3 (2): 4-8.

<https://doi.org/10.59315/ORLHNP.2024-3-2.4-8>

Academic Editor: Valentin Popadyuk

Received: 15.06.2024

Revised: 22.06.2024

Accepted: 30.06.2024

Published: 1.07.2024

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Abstract: The article provides a literary review of the latest data and recent studies on the effect of multifocal intraocular lens implantation on ocular functions and quality of life in patients with glaucoma. One of the most common problems of modern ophthalmological practice is the presence of combined ocular pathology in patients. The presence of cataracts and glaucoma in a patient increases the risk of developing blindness. The presence of cataracts can contribute to the progression of glaucoma due to the increased size of the lens, which, acting on the iris, displaces it, thereby making the angle of the anterior chamber already from the initial anatomical parameters of a particular eye. This change leads to an increase in intraocular pressure and the progression of glaucoma. Cataract surgery with IOL implantation provides a good opportunity to improve the quality of vision in patients with POAG. To date, there are several types of IOLs on the market, the implantation of which is considered individually for each patient to achieve maximum results. One is the most popular IOL that patients choose is multifocal IOL. Multifocal IOLs provide optimal vision in the distance, at medium and close distances, after implantation of this type of IOL, eyeglass correction is not required. However, multifocal IOLs have several disadvantages: have an increased light scattering effect, it is not uncommon after implantation to experience a decrease in the quality of vision, which leads to problems, especially in dim lighting, patients often complain about the presence of photopsia. Due to the prevalence of combined cataracts and glaucoma, as well as the increased popularity of multifocal IOLs, the question arises whether it is advisable to implant these types of intraocular lenses in patients with glaucoma. The urgency of the problem is the small number of studies in this area.

Keywords: keywords.

Introduction

One of the most common problems of modern ophthalmological practice is the presence of combined ocular pathology in patients. For example, the risk of combined glaucoma and cataract in patients increases with age. The presence of cataracts and glaucoma in a patient increases the risk of developing blindness. According to various data, the prevalence of this combined pathology varies from 17.0 to 38.6%. [1,2].

According to multiple estimates, approximately 57.5 million people worldwide suffer from primary open-angle glaucoma (POAG), and the total prevalence of the disease is 2.2%. In Europe, approximately 7.8 million people suffer from POAG, with a prevalence of 2.51%. It is expected that by 2040, approximately 111.8 million people worldwide will be diagnosed with primary open-angle glaucoma [2].

In the Russian Federation, the total prevalence of POAG in 2019 was 1.3 million people. An increase in the prevalence and incidence of POAG in the Russian Federation is expected in the next 15 years [3].

It is worth because eye structures such as the drainage system, ciliary body, lens, zonular ligaments are involved in the formation of the anterior and posterior chambers of the eye. Based on this, these structures form a morphofunctional integrated system, the destabilization of which can lead to such changes as impaired hydrodynamics, microhemodynamics, and dystrophic changes of the most discussed conditions is the effect of an enlarged lens size. The presence of cataracts can contribute to the progression of glaucoma due to the increased size of the lens, which, acting on the iris, displaces it, thereby making the angle of the anterior chamber already from the initial anatomical parameters of a particular eye. This change leads to an increase in intraocular pressure and the progression of glaucoma. Currently, there is evidence that cataract surgery can lead to a decrease in intraocular pressure (IOP) [4].

It is also worth emphasizing the indirect effect of glaucoma on the development of cataracts. Glaucoma itself does not cause cataracts, although there are certain situations where cataracts progress as a result of surgical treatment of glaucoma. For example, glaucoma surgeries such as trabeculectomy or implantation of drainage devices are known to accelerate the process of cataract formation to some extent [4].

Cataract surgery provides a good opportunity to improve the quality of vision in patients with POAG. Great achievements in the development of modern intraocular lenses (IOL) and improvements in the technique of cataract surgery can ensure independence from wearing glasses in individual patients and maximize the quality of vision.

Cataract surgery is the most frequently performed ophthalmic surgery, in 2020 the number of people requiring cataract surgery worldwide increased to 30.1 million, which is 50% more than in 2000. According to 2020 data, 460-480 thousand cataract surgeries are performed annually in Russia [5, 6].

In the presence of combined cataracts and glaucoma, there is a dilemma of what should be operated on first and how to resolve this situation. There are three surgical approaches to solving this problem:

- 1) cataract extraction with IOL implantation.
- 2) two-stage surgical treatment.
- 3) combined simultaneous intervention with IOL implantation [7].

The choice of tactics for the treatment of combined pathology depends on a number of factors, such as: the stage of glaucoma, stabilization of the glaucoma process, the level of intraocular pressure, hypotensive regime, the degree of maturity of the cataract, the size of the lens.

As noted above, cataract surgery is the most sought-after surgical treatment in ophthalmic practice. In case of combined cataract and glaucoma, cataract extraction alone is recommended, according to a few authors, in the presence of initial, immature or mature cataracts, compensated IOP levels when using a minimal hypotensive regimen by the patient, as well as stabilization of the glaucoma process according to perimetry data [8,9].

Two-stage treatment of a patient with a combined pathology is recommended in cases where the degree of maturity of the cataract corresponds to an initial or immature one with concomitant unstable glaucoma and uncompensated IOP at maximum hypotensive mode. At the same time, it is advisable to perform anti-glaucoma intervention at the first stage, and then, no earlier than 6 months later (after the formation of outflow pathways), approach the second stage of treatment - cataract extraction [10, 11].

In recent years, performing combined surgery for combined cataract and glaucoma has been gaining popularity. This method of surgical treatment solves two problems simultaneously: in the postoperative period, visual acuity increases, and IOP levels are compensated [12].

It has been proven that the degree of IOP reduction in patients after combined surgery is greater than in patients after cataract extraction [13].

Types of IOL

To date, there are several types of IOLs on the market, the implantation of which is considered individually for each patient to achieve maximum results:

- Monofocal IOLs provide optimal visual acuity (far or near) at a certain distance, depending on the calculation. After implantation of this type of IOL, the patient requires a point correction depending on the initial calculation parameters [14].
- Toric monofocal IOLs provide optimal visual acuity in patients with astigmatism without subsequent cylindrical eyeglass correction. However, after implantation of this type of IOL, the patient will need spherical correction for short or long distances, depending on the parameters of the initial calculation [12].
- Multifocal IOLs provide optimal vision in the distance, at medium and close distances, after implantation of this type of IOL, eyeglass correction is not required. However, multifocal IOLs have several disadvantages:
 - have an increased light scattering effect. This feature leads to a decrease in contrast sensitivity.
 - it is not uncommon after implantation to experience a decrease in the quality of vision, which leads to problems, especially in dim lighting,
 - patients often complain about the presence of photopsia [5].
- Multifocal Toric IOLs make it possible not only to correct astigmatism, but also to provide acceptable visual acuity at different distances [12].
- IOL with increased depth of focus is a completely new category of intraocular lenses for correction of presbyopia, designed to expand the range of vision, smooth transition of focal length from medium to near distance, while, unlike multifocal lenses, photopsia occur less frequently [15].

- **Accommodative IOLs** This type of IOL can provide optimal visual acuity at various distances using similar accommodative mechanisms as the native lens. The work of this type of IOL is based on a change in its anterior-posterior position under the action of the ciliary muscle [16].

Contrast sensitivity

As noted above, the main advantage of multifocal IOLs is that this type of intraocular lens is able to provide vision at several distances without resorting to eyeglass correction. However, as has already been proven based on numerous studies, multifocal IOLs reduce contrast sensitivity. As it was found, after passing through a multifocal IOL, less than 50% of the light rays are directed to one of several main focus.

Therefore, it is logical to assume that image focusing occurs with a certain loss of contrast sensitivity. The human visual system (photoreceptors, visual pathway, and tract, as well as the occipital cortex of the brain) is able to minimize the manifestations of blurred images and improve image focusing [17].

Vingolo E.M. et al. In 2007, the visual acuity and contrast sensitivity of patients without concomitant ocular pathology who were implanted with a multifocal IOL were compared with patients without concomitant ocular pathology who were implanted with a monofocal IOL. According to the results of the study, multifocal IOL provided lower contrast sensitivity than monofocal IOL [4, 18].

In 2013, Nancy Aychoua et al. published the results of a study where compared the quality of contrast sensitivity in patients with phakic and artificial eyes. In the study, the patients were divided into 3 groups. The first group included 16 patients with implanted multifocal IOLs, the second group consisted of 18 patients with a native lens as a control group, the third group included 12 patients with implanted monofocal IOLs. The average age of the patients in the three groups was 64 years without concomitant ocular pathology. Contrast sensitivity was assessed using the Humphrey Field Analyzer perimeter (Carl Zeiss Meditec Inc.) in the 30-2 program. The results of the study showed that MD, on average, was 2.40 dB lower in the group of patients with multifocal IOLs compared with the control group and 0.32 dB lower compared with the group of patients with monofocal IOLs ($p=0.52$) [19].

Historically, for patients who are recommended cataract surgery and who have POAG as a concomitant ocular pathology, a systematic approach to the choice of IOL is necessary.

Due to the prevalence of combined cataracts and glaucoma, as well as the increased popularity of multifocal IOLs, the question arises whether it is advisable to implant these types of intraocular lenses in patients with glaucoma. The urgency of the problem is the small number of studies in this area.

Glaucoma and contrast sensitivity

It is known that in glaucoma, the patient suffers from contrast sensitivity, the severity of which directly correlates with the degree of structural and functional damage to the nerve fibers of the ZN and SNVS.

Iancu R. Et al. come to conclusion that patients in the early stages of glaucoma often notice a decrease in vision than could be expected. This feature is most likely associated with the presence of concomitant ophthalmological pathology, as well as a decrease in photosensitivity due to the presence of glaucoma. In addition, patients with glaucoma notice a decrease in the ability to see optimally in low-light conditions, as well as the ability to detect low-contrast objects [20].

Clinical features after multifocal IOL implantation in healthy patients and patients with glaucoma

Healthy people may not even notice a decrease in contrast sensitivity after implantation of multifocal IOLs. However, the combination of IOLs (in particular multifocal IOL) in the eye with an already progressive loss of contrast sensitivity due to glaucoma causes much more concern [21].

The difficulties in choosing multifocal IOL in patients with glaucoma are based on a decrease in contrast sensitivity after implantation of this type of IOL, especially in the advanced and advanced stages of glaucoma, as well as these fields of vision. However, there is evidence from scientific research that in the initial stage of glaucoma with compensated IOP and the patient's desire, multifocal IOL implantation can be carried out. Optimization of the control of such patients should be carried out with careful monitoring of the IOP level, the state of the IOP and the visual fields, since the progression of glaucoma optic neuropathy in patients with implanted multifocal IOLs can lead to an even greater loss of contrast sensitivity [22, 23].

A large percentage of patients with combined glaucoma and cataract expect high visual acuity and refusal to wear glasses after cataract surgery. Thus, the main question arises – Is it advisable to implant multifocal IOLs in these patients [22]

It is worth noting that some patients with glaucoma often have a narrow pupil size. This feature should be considered when choosing multifocal IOLs. The fact is that in the refractive-diffractive design of this type of intraocular lens, the distribution of light varies depending on the size of the pupil, so in large pupils most of the light is directed at a distance, and in small ones the light splits. This phenomenon can lead to additional photopsia and defocusing at different distances in patients with glaucoma [24, 25].

According to literature sources, pseudoexfoliation syndrome is the basis for the occurrence of POAG in some patients. The presence of this syndrome is associated with an increased risk of instability of the zinc ligaments. Considering that multifocal IOLs require perfect alignment, as well as stability of the capsule bag and zinc ligaments. Thus, it is advisable to avoid implantation of myoles in this group of patients. The weakness of the zonular apparatus can lead to the descentration of multifocal IOLs, thereby not satisfying the final and expected results from implantation of this type of IOL [24,25].

Currently, there is insufficient scientific data from large-scale studies on the feasibility of implantation of multifocal IOLs in patients with glaucoma, which makes this research vector relevant.

The study conducted by Carmen Sánchez-Sánchez et al involved 38 patients aged 57 to 88 years, who were divided into 4 groups: the first group included 11 patients without concomitant ocular pathology (control group), the second included 9 patients with preperimetric glaucoma, the third group included 9 patients with advanced and far-advanced stage of glaucoma, 9 patients with a dry form of AMD were included in the fourth group. The authors concluded that the implantation of multifocal IOLs in patients with glaucoma (in particular, in patients with advanced and advanced stage of glaucoma) is impractical, because these patients had lower spatial contrast sensitivity than in the group of patients without concomitant ocular pathology, the group of patients with preperimetric glaucoma and the group of patients with dry form AMD. In addition, it was shown that the group of patients with implanted multifocal IOL and glaucoma experienced more difficulties when driving at night and complained of more frequent glare than patients from the group of patients without concomitant ocular pathology and the group of patients with preperimetric glaucoma. Patients with glaucoma and dry AMD after implantation of a multifocal IOL required eyeglass correction for nearness more often than in the other two groups [5].

Kameth GG et al. In 2000, a large-scale study was conducted, which included 133 patients with cataracts and concomitant ocular pathology, including 33 patients with various stages of glaucoma. The average age of the patients was 73.2±3.2. Multifocal IOL was implanted in 11 patients with glaucoma, in turn, monofocal IOL was implanted in 12 patients with glaucoma. The authors concluded that the only difference in the results of patients with monofocal and multifocal IOLs was an improvement in visual acuity without near correction in patients with multifocal IOL implants [26].

Conclusion

The implantation of multifocal IOLs in patients with cataracts and concomitant glaucoma is controversial. The rate of progression optic nerve damage because of glaucoma, the anatomical feature of the eye in these patients, and the ability to reduce the contrast sensitivity of multifocal IOLs make it difficult to decide on the implantation of this type of intraocular lenses.

The lack of large, randomized trials of the use of multifocal IOLs in patients with glaucoma makes it difficult to generalize clear indications for the use of these types of IOLs.

To date, the main decision-making for the implantation of multifocal IOLs is based on an individual approach, the postoperative result of which may not meet the expectations of both the surgeon and the patient himself.

Based on all the above, the goal of subsequent research in this area is a clear determination in determining the indications and contraindications for the implantation of multifocal IOLs.

The goal is to meet the patient's expectations without adversely affecting the progression of glaucoma.

Application of artificial intelligence:

The article is written without the use of artificial intelligence technologies.

Author Contributions: Conceptualization, I.K., V.P. and I.R.; methodology, G.M. and Iv.K.; software, G.M.; validation, M.K., E.S., I.K. and G.M.; formal analysis, V.A.; investigation, I.K. and G.M.; resources, X.X.; data curation, K.L.; writing—original draft preparation, K.I. and G.M.; writing—review and editing, V.P., I.R. and E.S.; visualization, V.P.; supervision, K.L.; project administration, I.K. All authors have read and agreed to the published version of the manuscript.”

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest: The authors declare no conflict of interest.

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