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Presbyopia Correction During Cataract Surgery with Multifocal Intraocular Lenses

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Abstract

Introduction: The first generations of multifocal intraocular lenses (MFIOLs) were designed to provide patients good distance and near vision, but intermediate was not satisfactory. Trifocal, a bifocal of low-add and quadrifocal MFIOLs were invented, offering possibility to correct vision for distance, near, and intermediate tasks. The novel IOL, extended range of vision (EROV), is covering mostly intermediate and distance vision, with lower level of photic phenomena.

Patients and methods: We have evaluated visual results in 4408 eyes implanted with different MFIOLs in 12 years period (2004–2016). Postoperative uncorrected visual acuity for far, intermediate, and near was evaluated. Postoperative satisfaction and complication rate and management of complications are presented.

Results: In the first generation MFIOLs, almost 70% of eyes gained uncorrected distance visual acuity of 1.0. Uncorrected near visual acuity was J1–J2 in 95% of eyes with diffractive IOLs. Modern MFIOL designs enabled improvement of vision at intermediate distance, without compromising vision at far and near.

Conclusion: With the first generations of MFIOLs, good distance and near uncorrected vision was achieved. With novel MFIOLs a very good uncorrected vision was achieved at far, intermediate and near, while with EROV lens, near vision was less satisfactory, but patients had less photic phenomena.

Keywords: multifocal, presbyopia, cataract surgery, refractive lens exchange, bifocal diffractive lens, intraocular lenses, refractive lens, trifocal lens, quadrifocal lens, extended range of vision lens

1. Introduction

The main cause for cataract or opacification of the lens is age, although it can also be a congenital disease or a consequence of ocular and systemic diseases (uveitis and diabetes), systemic

medication (steroids), trauma, and inherited abnormalities (Marfan syndrome, Lowe syndrome). According to WHO data, it accounts for 48% of world blindness, and surgical removal of cataract is the only available treatment for a patient with developed cataract. The prevalence of cataract surgery increases with age, from 16% in the 65–69 age group up to 71% in more than 85 years age group [1]. Removal of cataract by phacoemulsification of the lens, followed by intraocular lens implantation, is in fact one of the most common surgical procedures. According to estimates, 20 million cataract surgeries are performed annually worldwide, but despite this impressive statistic, the number of patients visually handicapped by cataract still globally increases every year. Modern cataract surgery had tremendous development during the past 10–15 years. Improved surgical technique and modern materials have enlarged indication profile for cataract surgery. This also created higher postoperative expectations from patients. Although it is often expected that patient will not need spectacle correction after cataract surgery (at least for far vision), more than 50% of operated eyes need spectacles after surgery to achieve optimal vision. This is due to the fact that with the standard monofocal intraocular lenses (IOL), first of which had been implanted in 1950 by Sir Harold Ridley, only a spherical component of the refractive error can be corrected, without taking care of the astigmatism. In order to determine accurate IOL power for each patient's eye, it is essential to determine keratometric values and axial length readings. Based on such readings, a calculation of the spherical power of the monofocal IOL is made with specially designed formulas adapted for each refractive error. Monofocal IOLs are readily available in different optical powers in every operating theater and thus can be implanted during a standard cataract case, correcting patient's spherical error and providing good distance vision. However, full visual recovery in patients with corneal astigmatism and presbyopia will be limited by the fact that both corneal astigmatism and presbyopia were not corrected with the implantation of standard monofocal lens. Every patient with such IOL will lose its ability to focus near objects and will need spectacle correction of approximately +2.5 diopters for near vision. With the increasing patient's expectations regarding their vision after the surgery, newer generations of intraocular lenses had to be provided.

First, IOLs successfully dealing with presbyopia, named multifocal lenses (MFIOLs) or “premium lenses,” were launched on the market in the early 1980s and were represented with diffractive and refractive design [2]. They were the first step toward full vision correction after cataract surgery. Bifocal diffractive IOL with +4.00D near addition is designed along the principles of diffractive optics and was available in a silicone or hydrophobic acrylic model. This lens consists of a three-piece or single-piece, square-edged 6.0 mm optic with a prolate anterior surface producing -0.27 spherical aberration. The posterior surface of the optic features a diffractive zone. The near addition is +4.00D translating to +3.00D at the spectacle plane. In the theory, the optical design redistributes incident light, 50% for near and 50% distance, independent of pupil size. Bifocal diffractive IOL with +3.00D near addition is aspheric one-piece hydrophobic IOL with central apodized diffractive structure and peripheral refractive zone. The near addition of +3.00D refers to +2.4D at spectacle plane. These lenses, due to their diffractive design, were able to provide patients with good near vision even without the use of spectacles, thus correcting presbyopia [3]. Refractive IOLs available at that time were multizonal IOLs with different areas for distant and near vision. They are a

three-piece refractive acrylic lens with five concentric zones. Three zones, including the central one, are for far vision, and two zones are for near vision. An aspheric transition provides a balanced intermediate vision. The near add-power is +3.50D, translating to +2.50D at the spectacle plane. A unique edge design provides a 360° barrier aimed to offset the incidence of posterior capsular opacification (PCO) and minimizes edge glare. They gave good distant and intermediate visual acuity but poorer near vision with a significant problem with halos in night driving.

Disadvantages of MFIOLs caused by lens design were halo and glare (especially at night) in some patients, loss of contrast sensitivity, and the fact that patients needed some time for their brain to adapt to MFIOLs [4]. Moreover, the first multifocal IOLs were unable to correct vision at intermediate distance, which is mostly important for younger presbyopes who often use computers or other tasks at the distance of 60 cm to 1 m. Later on, newer, modern designs of MFIOLs were invented, trifocal, bifocal, and “low-add” lenses with different add-powers, extended range of vision, and quadrifocal IOLs, successfully correcting vision for all visual needs at distance, intermediate, and near [5–7]. Trifocal IOL is an aspheric, diffractive intraocular lens. The optical zone of trifocal lens had +3.33D near addition and a +1.66D intermediate addition (although different add-powers are also available). It has asymmetrical light distribution of 50, 20, and 30% for far, intermediate, and near foci, respectively. The IOL is fabricated from a hydrophilic acrylic material with a 25% water content and hydrophobic surface. This is a single-piece IOL with 6.0 mm optic diameter. Central 4.34 mm zone includes trifocal optic, and peripheral 1.66 mm zone has bifocal optic. It has a four-haptic design with an angulation of 0° and a 360° square edge to prevent posterior capsule opacification. Quadrifocal IOL is a non-apodized diffractive trifocal IOL with an intermediary 4.5 mm diffractive zone that distributes light to three focal points independent on pupil size. The IOL is a single-piece lens fabricated from a hydrophobic and ultraviolet- and blue light-filtering acrylate/methacrylate copolymer material. This novel diffractive structure has optimized light utilization, transmitting 88% of light at the simulated 3.0 mm pupil size to the retina. The light is split into two, with one half allocated to the distance focus and the other half split evenly between the near and intermediate focuses. The lens design is intended to improve the intermediate vision tasks and increase patient satisfaction, with a third focal point at an optimal intermediate distance of 60 cm, tending to provide more continuous vision. Bifocal diffractive “low-add” IOLs are provided with different add-powers (e.g., +2.75D, +3.25D, +4.00D add), and they have a full diffractive profile on the posterior surface of the optic. The relief height of the diffractive rings is equal in all three models; they have equal light distribution to distance and near regardless of pupil size or add-power. The focal point distance is controlled by the number and spacing of the diffractive rings, and patients have same contrast sensitivity and low-light visual acuity for all add-powers. Extended range of vision IOL delivers a continuous, full-range vision with reduced incidence of halos and glare. It merges two complementary technologies: echelette design which introduces a novel pattern of light diffraction that elongates the focus of the eye, resulting in an extended range of vision, and achromatic technology for the correction of longitudinal chromatic aberration which causes contrast enhancement. It is a diffractive, single-piece, aspheric IOL.

Although MFIOLs were able to fully correct vision in high percentage of patients, especially when modern lens designs are used, they were not applicable in eyes with the astigmatism, since such eyes have an individual need for correction of cylindrical power and axis which is different in each eye. In general population, 35% of eyes have the astigmatism of ≥ 1.25 diopter (D), 61% having with the rule astigmatism, 25% against the rule astigmatism, and 14% oblique astigmatism. Both the cataract itself and the astigmatism reduce patient's vision and thus the quality of life. The anterior corneal surface shifts from with-the-rule to against-the-rule astigmatism with aging, whereas posterior corneal astigmatism remains as against the rule in most cases. Total corneal astigmatism is calculated from anterior and posterior corneal curvature measurements [8]. The quantity and axis of the astigmatic refractive error are different in each patient's eye and can be corrected by spectacles with cylindrical power. If the eye scheduled for cataract surgery has a significant astigmatism, postoperative vision will be impaired by this refractive error, and patient will need spectacles to obtain adequate distance and near vision. For patients with significant astigmatism, solution was found with the invention of toric IOLs, which were designed for two functions: to restore visual acuity deteriorated by cataract and to correct corneal astigmatism [9–13]. Toric IOLs must be produced individually since each eye with the corneal astigmatism has a unique combination of spherical and astigmatic correction (regarding both the amount and the axis of astigmatism). Moreover, in a proper calculation of toric intraocular lens power, one should evaluate total corneal astigmatism as a better predictor than keratometric astigmatism [8, 14]. Since the prevalence of against-the-rule astigmatism significantly increases with age, such astigmatism should be treated more aggressively during cataract surgery [15]. The most recent advancement in IOL technology is a combination of multifocal and toric design, resulting in multifocal toric design of the lens which provides a complete visual recovery for patients with astigmatism and presbyopia [9, 16, 17].

Based on the positive visual outcome with the implantation of newer generation of lenses in a cataract surgery, modern IOLs have become treatment of choice for many patients with presbyopia and astigmatism even when their natural lens is still clear and has no cataract [18–20]. Namely, refractive errors such as hyperopia and myopia combined with presbyopia, and also plano-presbyopia, cannot be fully treated with refractive surgery on the cornea. Laser corneal ablation is highly effective in correction of refractive errors and may be the best option for younger population [21]. However, for patients aged 45 or more, only distance vision can be corrected by laser ablation, but the problem of presbyopia remains. With the surgery on the lens, called refractive lens exchange, and implantation of MFIOL full vision can be restored: distance, intermediate, and near vision. If MF toric IOL design is used, also the preexisting astigmatism can be fully corrected [9, 16, 17].

In this chapter, we have analyzed postoperative visual results in our patients operated for cataract and refractive lens exchange with implantation of different types of MFIOLs, used in our setting throughout the last 12 years.

2. Patients and methods

A total of 4408 eyes were implanted with different presbyopia-correcting intraocular lenses in our hospital throughout a period of 12 years (2004–2016). Exclusion criteria for MFIOL

implantation were corneal disease, retinal or optic nerve disease, or severe dry eye syndrome. Preoperative assessment included precise biometry and IOL calculation (IOL Master 500, Zeiss, Germany), corneal topography (Pentacam, Oculus, USA), aberrometry (Wavefront Aberrometer, USA), pupillometry, endothelial cell analysis (Noncontact Specular Microscope, Topcon, USA), optical coherence tomography (OCT, Zeiss, Germany), ultrasound, and careful examination of the retinal status. Patient's selection and preoperative counseling were made by experienced cataract surgeons.

The first group of eyes included 2546 eyes implanted with bifocal diffractive MFIOLs (ReSTOR 4+, ReSTOR 3+, Tecnis, Acrylisa) and refractive design (ReZoom) MFIOLs, with a follow-up of 5 years. Most of the patients were implanted with same lens design in both eyes, while in 440 eyes, a technique so-called "mix and match" was used to enhance intermediate vision. In "mix and match" approach, a refractive IOL (ReZoom) was implanted in dominant eye and diffractive IOL (Tecnis or ReSTOR) in non-dominant eye. The second group of eyes included 1862 eyes implanted with MFIOLs of the following designs: (a) trifocal (Zeiss AT LISA tri), (b) quadrifocal (AcrySof IQ PanOptix), (c) combination of "low-add" bifocals with different add-powers (Tecnis ZKBOO +2.75D in dominant and Tecnis ZLBOO +3.25D add in non-dominant eye), and (d) extended range of vision (Symphony ZXR00) (see **Table 1**). Follow-up was at least 6 months (range 6–144 months). All eyes were operated under topical anesthesia, as a conventional phacoemulsification procedure on two phaco machines (Whitestar Signature, Abbott Medical Optics and Infinity Vision System, Alcon, USA). Special attention was made during the following surgical steps: small incision preferably on the steep axis, continuous curvilinear manual capsulorhexis with 5 mm diameter, careful polishing of the posterior and anterior capsule, and viscoelastic removal behind the IOL. Same MFIOL was implanted in both eyes simultaneously, except in case of "low-add" lenses where "low-add" with addition of +2.75 was implanted in dominant and "low-add" of +3.25 add in a non-dominant eye. Postoperative uncorrected visual acuity (UCVA) for far, intermediate, and near vision was evaluated for different types of MFIOL. For MF toric IOL implantation, the axis of astigmatism was marked on a patient's eye during preoperative preparation, in a seated position on a slit lamp, and toric IOL was aligned with this mark during the surgery. The amount of corrected astigmatism was evaluated. Postoperative satisfaction rate, complication rate, and management of complications are presented for all MFIOLs.

Type of multifocal IOL	Number of eyes
Diffractive +4.00 bifocal	1160
Diffractive +3.00 bifocal	826
Refractive	560
Trifocal	649
Low-add	550
Extended range of vision	663
Quadrifocal	30

Table 1. Number of eyes implanted with different types of multifocal intraocular lenses throughout a 12-year period.

3. Results

The number of eyes implanted with different types of multifocal intraocular lenses throughout a 12-year period in our hospital is represented in **Table 1**. In the first 5 years of MFIOL use, mainly lenses of diffractive bifocal and refractive design were implanted, while later on newer generations of MFIOL like trifocal, “low-add” combination, extended range of vision, and quadrifocal lenses were used.

Visual outcome after implantation of first-generation MFIOLs of diffractive and refractive design is represented in **Figure 1**. Close to 70% of eyes gained uncorrected distance visual acuity (UDVA) of 1.0, while <10% of eyes had UDVA of less than 0.8. Uncorrected near visual acuity (UNVA) was J1–J2 in 95% of eyes with diffractive IOLs and in 84% of eyes with refractive lens design. Overall, close to 90% of eyes was spectacle independent. “Mix and match” technique did not change visual outcome for distance vision and had slightly negative impact on near vision; however, it did increase percentage of spectacle-free time since it improved intermediate vision.

With the first generation of lenses, the optical design could not provide good vision at intermediate distance. Therefore, we have started to implant the first lenses designed to improve intermediate vision—lenses of trifocal design and compared the outcome of these lenses with bifocal ones (**Figure 2**). With trifocal design very good UDVA and UNVA were preserved, and there was a significant improvement in uncorrected intermediate vision (UIVA), with mean visual acuity of 0.8 for intermediate tasks. With even newer design of trifocal lens—so-called quadrifocal IOL—more continuous vision at intermediate distance was obtained due to superior visual outcome at 60 cm (arm length). Novel technology of extended range of vision (EROV) lenses became available, and a combination of two different add-on powers in “low-add” bifocal lenses aimed to improve intermediate vision of our patients. Visual outcome of UDVA, UIVA, and UNVA in patients implanted with four modern lens designs compared to older lens designs are represented in **Figure 3**. As shown, modern MFIOL designs enabled a significant improvement of vision at distance of 60–100 cm (intermediate) as compared to diffractive and refractive MFIOLs, without compromising very good visual results at far and near. Satisfaction rate after MFIOL implantation according to preoperative refractive error is presented in **Table 2**. In patients with the astigmatism of >1D, multifocal toric lenses were implanted to correct the astigmatic part of the refractive error. The axis of toric MFIOL implantation was always marked in a sitting position, to avoid misplacement of the lens due to cyclotorsion while the patient is lying down. After toric MFIOL implantation, the mean preoperative astigmatism of 2.25 D was reduced to a mean of 0.32 D (**Figure 4**). The appearance of a bilaterally implanted trifocal toric IOLs, in a primary position (left) and with a dilated pupil (right), correcting patient’s vision in both eyes to 100% distance, intermediate, and near vision without any spectacles, is shown in **Figure 5**.

Complications related to MFIOL design like halo and glare were determined among our patients: 15% of patients with refractive lenses reported halos and glare during night driving. Due to

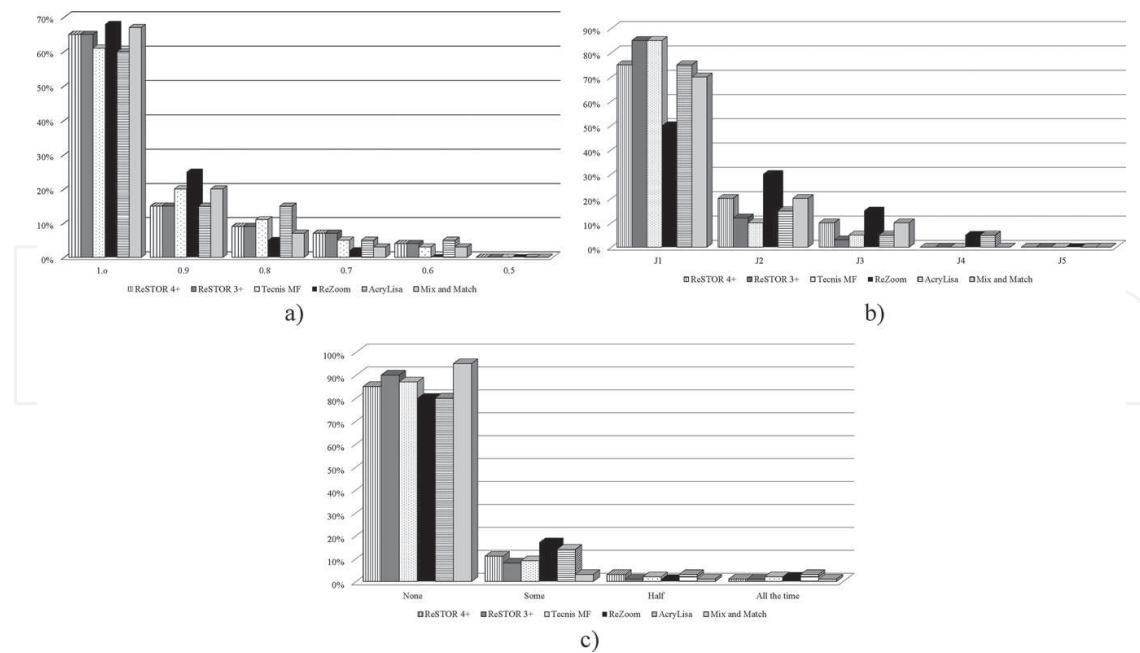


Figure 1. Percentage of eyes achieving (a) uncorrected distance visual acuity of >0.5, (b) uncorrected near visual acuity of >J5, and (c) a portion of time wearing glasses in eyes implanted with different types of multifocal intraocular lenses, in a 5-year follow-up.

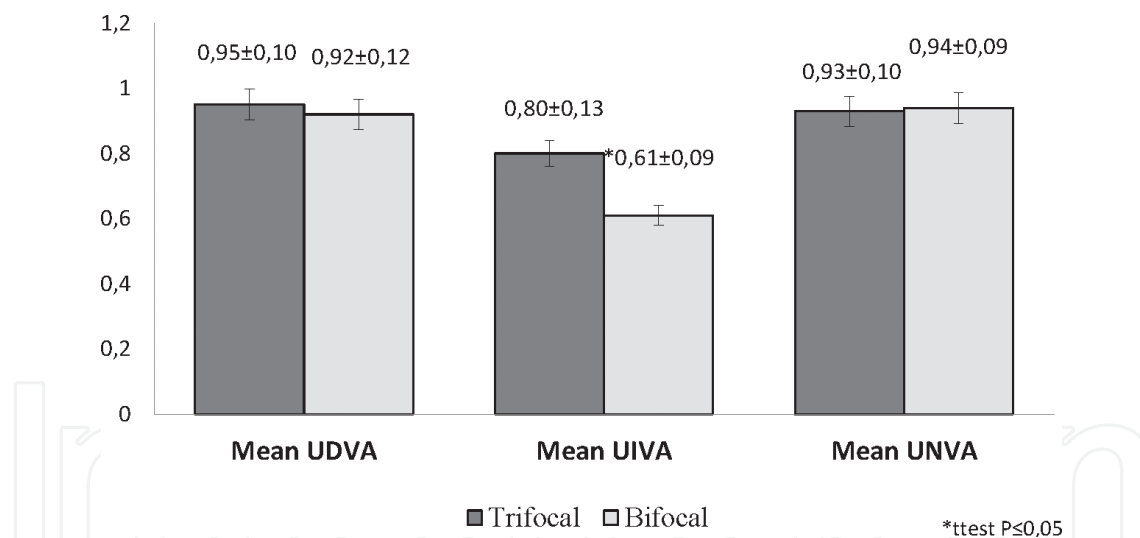


Figure 2. Comparison of mean uncorrected distance visual acuity (UDVA), uncorrected intermediate visual acuity (UIVA), and uncorrected near visual acuity (UNVA) between eyes implanted with trifocal and bifocal multifocal intraocular lenses (expressed in decimal values).

severe halo and glare, we had to explant 12 out of 560 (2.1%) refractive IOLs and replace them with bifocal diffractive IOLs. In modern lens designs, the percentage of halo and glare ranged from 4 to 9%, being lowest in EROV IOL (Table 3). Postoperative residual refractive errors were solved with laser refractive surgery. Laser surgery was needed in 6.1% of patients with diffractive bifocal IOLs, while in another groups, enhancement rate was between 1 and 3% (Table 3).

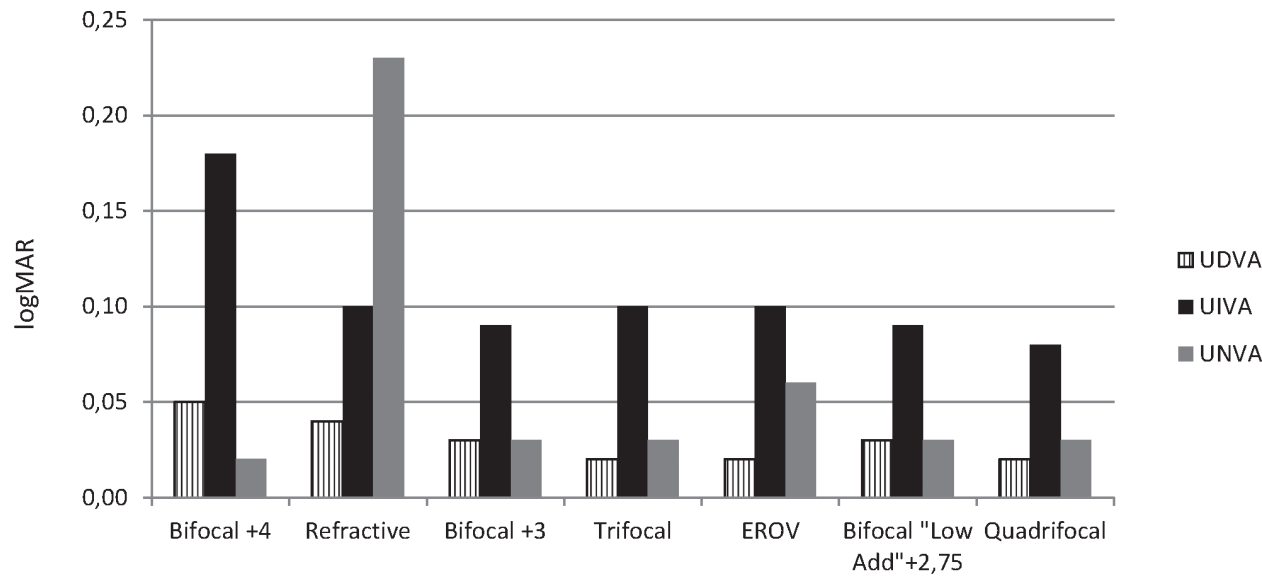


Figure 3. Comparison of uncorrected distance visual acuity (UDVA), uncorrected intermediate visual acuity (UIVA), and uncorrected near visual acuity (UNVA) between eyes implanted with diffractive (bifocal +4 and bifocal +3), refractive, trifocal, extended range of vision (EROV), "low-add," and quadrifocal multifocal intraocular lenses.

Patient refraction	Satisfaction after surgery; average mark [1-10]
High hyperopia	9.6
Low hyperopia	9.1
Plano-presbyopia	8.7
High myopia	8.2
Low myopia	8.1

Table 2. Satisfaction rate after bilateral multifocal intraocular lens implantation, according to preoperative refractive error.

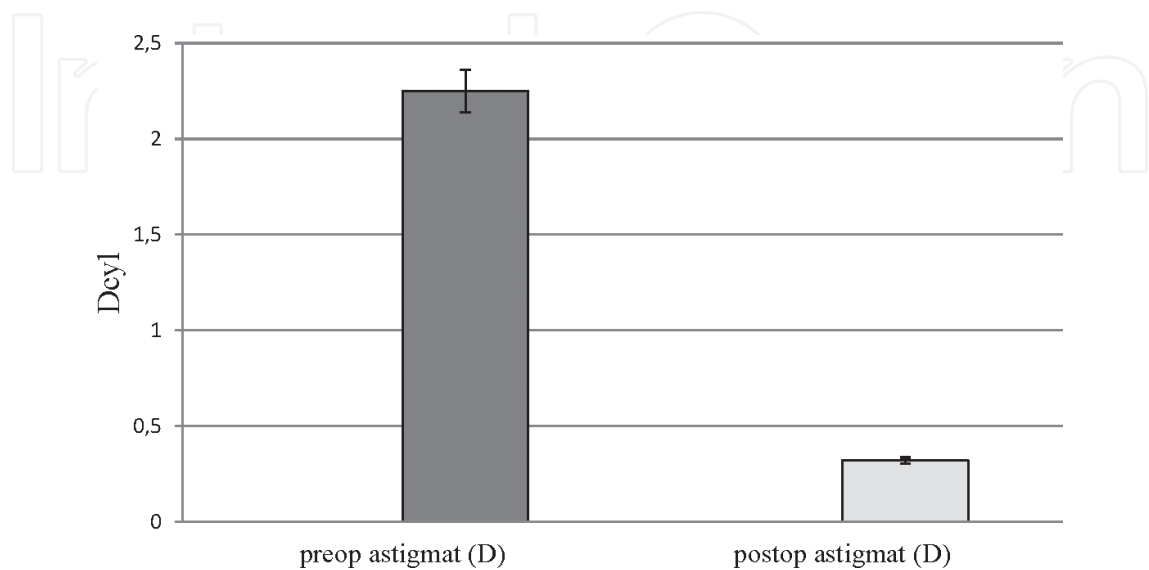


Figure 4. Change in the amount of astigmatism in eyes implanted with toric multifocal intraocular lens.

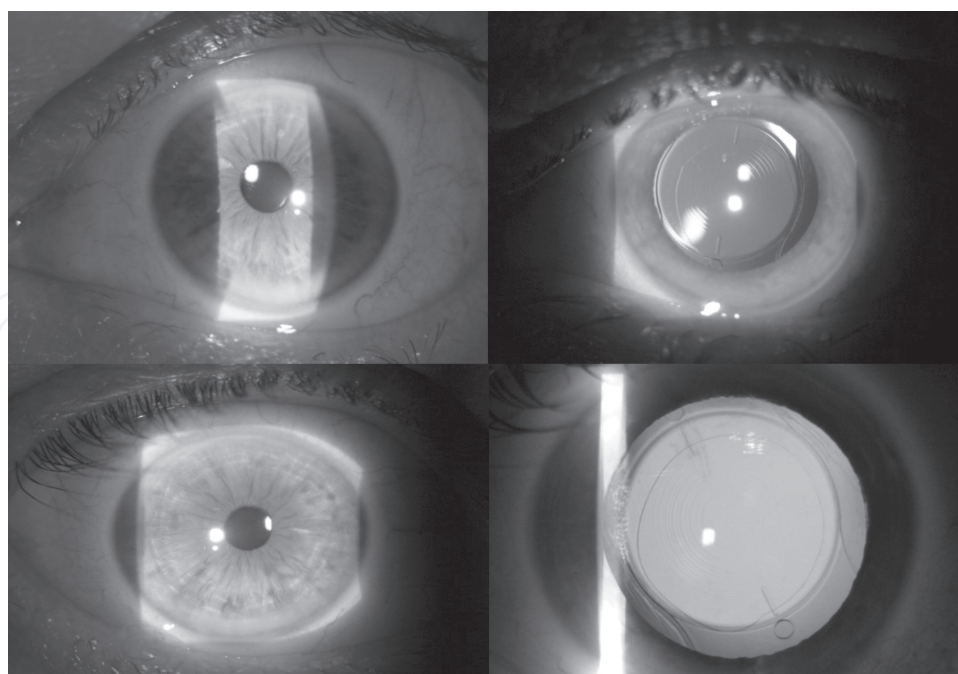


Figure 5. Patient aged 56, after bilaterally implanted trifocal toric IOLs, in a primary position (left) and with a dilated pupil (right). Visual acuity in both eyes is 100% for distance, intermediate (80 cm), and near, without any spectacles.

Lens design/complication rate (%)	Halo and glare	Laser enhancement for residual refractive error	Need for spectacle wear
Bifocal diffractive (Tecnis)	7.7	6.1	5.5
Bifocal diffractive (ReSTOR)	7.2	1.3	4
Refractive (ReZoom)	15	2.6	25.2
Trifocal	9	1.6	1.2
Extended range of vision	4	1.76	4.42
“Low-add” bifocal	8.6	2	1.3
Quadrifocal	5	0	1

Table 3. Complication rate after implantation of different types of multifocal intraocular lenses.

Almost one-third of patients reported symptoms of dry eye. Those patients were treated with artificial tears and punctal plugs when necessary. The need for spectacles was highest in refractive IOL group (25%), mostly for near reading. In bifocal diffractive group, 4–5% of patients had to wear glasses, mostly for computer or tasks at 60–100 cm. In EROV IOL group, 4.22% of patients needed glasses mainly for near vision. The best spectacle independence is achieved in patients with quadrifocal (although the number of implanted lenses is greatly smaller compared to other groups, so the data will most probably change with bigger numbers), trifocal, and bifocal diffractive IOL with “low-add” combination (**Table 3**). Posterior capsular opacification rate was very hard to compare because of a different follow-up (range 3–6%), but trifocal lens did have higher PCO rate compared to others, possibly due to hydrophilic material.

4. Discussion

Nowadays, cataract surgery is becoming a more and more refractive surgery at the same time. Patient's expectations are growing; but thanks to development of new technologies, surgery techniques, and intraocular lens designs, ophthalmologist can fulfill those demands. The aim of modern cataract surgery is to achieve good unaided vision at all distances together with high quality of vision in a safe manner and with a fast recovery. Presbyopia-correcting intraocular lenses are currently the most efficient and permanent treatment for presbyopia. First, IOLs successfully dealing with presbyopia, named multifocal intraocular lenses (MFIOLs), were launched on the market in the early 1980s. They were designed to have several foci in order to provide full vision correction after cataract surgery. These lenses, due to their design, were able to provide patients with good distance and near vision even without the use of spectacles [22]. However, due to their design, MFIOLs have also some disadvantages caused by the presence of several foci. Halo and glare (especially at night) are produced by defocused image and scattered light. Higher near additions at IOL optics increase halo and glare. Moreover, patients need some time for their brain to adapt to MFIOL (so-called neuroadaptation). Very often with neuroadaptation, symptoms of halo and glare tend to decrease. Another characteristic of MFIOL is loss of contrast sensitivity caused by separation of the light entering to the eye in two or three foci. Patients record this as slightly washed out or grayish image, especially in low-light conditions. MFIOLs are also very dependent on eventual residual refractive error, dryness of the eye, IOL centration, posterior capsule opacification, pupil size, and presence of vitreal opacities.

In eye hospital "Svjetlost," MFIOLs are in use since 2004, and currently around one-third of all implanted lenses are MFIOLs. For the first 5 years, we have used MFIOLs available at that time: bifocal diffractive lenses with +4.00D addition (later on also with +3.00D addition) and refractive IOLs. Bifocal diffractive IOLs enabled very good uncorrected far vision and near vision at 30–40 cm, with very good satisfaction rate among patients who did not perform many tasks at intermediate distance (60–100 cm). Refractive IOLs performed somewhat better at intermediate distance range, but near vision was significantly worse as compared to diffractive design. Visual outcome after implantation of the first diffractive and refractive lenses recorded among our patients was similar to other published data [23, 24]. However, lack of good intermediate vision was unacceptable for younger presbyopes performing many tasks at a distance of 60–100 cm. In an attempt to enhance intermediate vision, a technique called "mix and match" was invented aiming to ensure uncorrected vision at all distances. Refractive IOL was implanted in dominant eye (for far and intermediate) vision and diffractive IOL in non-dominant eye (for far and near). It worked well in majority of patients; however, in our hands around 25% of patients were complaining at different images in two eyes (because we used two different technologies) and/or photic phenomena. Some authors have reported very high satisfaction rate with "mix and match" approach, despite the fact that in a presented group of their patients also high percentage of halo and glare was reported [25]. These data show that despite some objective photic phenomena many patients still remain happy with the surgical outcome since they have gained spectacle independence. However, from physician's point of view, we were not satisfied

enough with the outcome of “mix and match” method, so we stopped using this technique and switched to newer generations of lens designs emerging on the market: trifocal, combination of “low-add” bifocals with different add-powers, and extended range of vision (EROV) technology [25–27].

In our hands, all types of new-generation or “premium” MFIOLs (trifocal, quadrifocal, “low-add” combination, and EROV) provided similar and very good UDVA. The main improvement of modern lens designs is the quality of uncorrected intermediate vision, which is very satisfying with all lenses. Trifocal lenses provided excellent far, intermediate, and near vision, which seems to be more “continuous” with quadrifocal design mainly for tasks at 60 cm distance. The EROV provided excellent distance and intermediate vision, performing slightly worse at near if emmetropia was aimed in both eyes. Thus, to improve near vision with EROV lens, we are now implanting many patients with a planned myopic shift of -0.5% in a non-dominant eye (“mini-monovision”), and in this manner, better near vision was achieved. The advantage of EROV IOL is that it maintains a very similar level of visual quality as monofocal IOL, less visual disturbances compared to bi- and trifocals, and we have successfully implanted this lens also in amblyopic patients and those with the previous refractive surgery on the cornea. To conclude, both EROV and trifocal IOLs are good options for patients with intermediate distance requirements, while in patients having numerous near-vision tasks, EROV IOL should be aimed slightly myopic in a non-dominant eye, or trifocal/quadrifocal technology may be used. Comparing to other lens designs, PCO occurrence was higher in trifocal lens, but subsequent YAG capsulotomy did not affect long-term visual outcome. Implantation of two “low-add” lenses with different near add-powers provided good near, intermediate, and distance vision, comparable to the outcome with EROV and trifocal/quadrifocal IOLs.

In our patients with the astigmatism $>1D$, multifocal toric IOLs were implanted. These lenses are capable of correcting both presbyopia and astigmatism. Invention of multifocal toric IOLs was based on very good results in astigmatic correction with monofocal toric IOLs, which showed to be safe and effective in correcting astigmatism and improving vision even in cataract patients with very high astigmatism such as topographically stable keratoconus, pellucid marginal degeneration, and post-penetrating keratoplasty astigmatism [28–30]. The systematic literature review shows that spectacle independence for patients treated with four brands of monofocal toric IOLs increased from 15 to 85% of those who never wore spectacles [1]. There are several specific requirements for the IOLs aimed to treat the astigmatism; the lens has to be easy to manipulate in the capsular bag in order to achieve good alignment and needs good long-term positional stability, as low as possible induction of capsular shrinkage and posterior capsule opacification. Namely, toric IOL which has to be produced for each individual case is marked on its surface for proper alignment in the capsular bag. Axis of astigmatism has to be determined and marked in a seating position due to cyclotorsional movements of the eye while the patient is lying down for the surgery. Proper alignment of toric IOL during surgery is crucial since misalignment of only 10° leads to a loss of one-third of the astigmatic correction. Moreover, even a small decentration of IOL of less than 1 mm will induce aberrations and poorer visual result [31]. Shrinkage of the capsular bag may also lead to decentration of the lens and thus have negative impact on its proper alignment. Misaligned toric intraocular

lens has to be repositioned into its proper position by surgical revision. If surgical correction is needed, the intervention should be performed as soon as possible after the primary surgery to avoid manipulation in the capsular bag with abundant fibrosis. Although it is recommended to re-center the lens in the first months after primary surgery, it has been reported that lens can be safely repositioned even 15 months after its implantation [32]. According to our results, with properly calculated and implanted toric MFIOL, both spherical and cylindrical errors can be successfully corrected.

In recent years, special medical equipment and centering systems were invented to minimize potential sources of errors during each step of the surgery (e.g., Verion Image Guided System or Zeiss Callisto). Both systems may improve precision, and size of the incisions enables perfect shape and size of the capsulorhexis and more precise alignment of the toric IOL or multifocal IOL along the optical axis. Such a computer-assisted cataract surgery will make premium IOL surgery even more precise, but it will take some time till all the cataract surgery units embrace this technology. All the results presented in this chapter are obtained without the use of advanced computerized systems. Therefore, the outcome and performance of different MFIOL designs implanted in our hospital in the last 12 years are in fact more objective to compare, since the methodology of surgery did not change significantly throughout this period. Once we add sophisticated computer-controlled systems into standard equipment used during cataract surgery with MFIOL implantation, the results should improve further.

Finally, very important or maybe the most important issue when we discuss about MFIOL use is the issue which cannot be presented by pure scientific data—preoperative counseling. Spectrum of lens design available nowadays on the market is quite large, and only careful discussion over patient lifestyle, everyday activities, job, and expectations may provide to write answer on which lens design to use. Patients who are looking for guaranties, “perfect” vision, or 100% spectacle independence are not good candidates for MFIOLs. The first step toward good results is that the surgeon working with MFIOL understand that there is no perfect lens for every patient, and then to transfer in a proper way this information to a patient. Looking at the preoperative refractive errors, hyperopic patients are the best candidates for such surgery. It is very wise to under-promise how it is going to be with implanted MFIOLs and then hopefully over-deliver. With such a proper preoperative counseling, and subsequent choice of the MFIOL best suited to individual patient needs, all currently available MFIOLs will provide a high level of both spectacle independence and patient satisfaction.

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