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Professional paper

The Latest Generation of Intraocular Lenses, the Problem of the Eye Refraction after Cataract Surgery

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A B S T R A C T

Nowadays cataract surgery is refractive surgery as well. Intraocular lens implantation is gold standard, but there is plenty types of intraocular lenses, monofocal, multifocal, accommodating, and toric. Problem is to pick up correct one according life style, profession, health status and age. The aim is review current possibilities in cataract, refractive surgery and aphakia management.

***Key words**: cataract surgery, eye refraction, intraocular lenses, aphakia*

Introduction

IOL technology has evolved dramatically in recent years. Originally there was a replacement spherical lens with only one optical function – compensating aphakia but the function of modern IOL has changed and current designs improve quality of vision – aberration correcting IOL, filter inadequate wavelengths of light and compensate for pseudophakic presbyopia- multifocal or accommodating IOL[15]. This is concept of premium IOLs.

Review of IOLs

Monofocal IOL

This is the most commonly used implant with the IOL power chosen for seeing distant. For near vision, the patient requires reading glasses. The advantage of this IOL is excellent clarity for distant vision.

Monofocal IOL has a fixed-range single focal point. It has a fixed focusing power which is set for distant vision. Recent refinements in the optical quality of these lenses have allowed an even higher quality of vision than previously achievable. The materials of IOL are hydrophilic acrylate, hydrophobic acrylate, silicon and their combination. The most important is design of IOL – square edge, which prevents capsular opacification. Some of them have excellent optical clarity which minimizes problems of internal reflections associated with any IOL implanted in the eye with its anti-glare technology. As such, this IOL would be suitable for patients who suffer from glare during the day. Premium IOLs can be divided into aspheric, toric, presbyopia correcting IOLs and their combination. A good IOL design allows the surgeon to adapt vision to the patient's lifestyle.

Monofocal Aspheric IOL

Offer the best in optical innovation: a high-quality image and enhanced contrast perception during all daily activities, whatever the lighting conditions may be. Aspheric intraocular lenses Aspheric lenses allow you to achieve a visual performance that is close to that of a young person's eye

Toric IOL

Advancements in IOL design have led to the development of toric spherical and aspherical IOLs and multifocal toric IOLfor the treating pre-existing corneal astigmatism during refractive cataract surgery. With accurate preoperative planning and patient selection, a toric IOL can be a precise and effective option for treating astigmatism. Furthermore, the introduction of toric IOLs into practice can be an easy way to enter the premium IOL

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market[1]. The most important is good axis stability. Toric IOLs' powers range from –1.50D to –3.00D, giving them an effective power of up to –2.00D at the corneal plane. Higher amounts of astigmatism can be managed with limbal relaxing incisions. Accurate corneal cylinder measurements are required, either through keratometry or IOL Master measurement. Patients whose astigmatism is less than 1.25D can have it corrected with the placement of the incisions. Patients who might not be as successful with a toric IOL are those who have an unstable capsular bag or demonstrate pseudo exfoliation and/or weak zonules. In these patients, the lens may rotate once implanted, altering the patient's vision.

Multifocal IOL

This IOL is designed to solve the problem of focusing for near after cataract extraction so that the patient does not need reading glasses. The main problem with this IOL is that there is an average reduction in contrast sensitivity between 30–50% depending on how much light is weighted for near and how much for distance. There is also the problem of glare and haloes due to the multiple concentric focusing powers within the IOL[8,9]. However, the intermediate vision remains slightly out of focus.

Multifocal IOL has specialized optical properties that can divide light to bring it into focus at more than one point at the same time. This IOL is designed with concentric rings which can focus light rays from both distance and near simultaneously. The optics of modern multifocal IOLs is either rotationally symmetric or rotationally asymmetric. Some multifocal IOLs modify the index of refraction, from the peripheral to the central part of the lens, so that the lens optical power changes depending on pupil size[3,4]. Other presbyopia correcting IOL work by introducing asphericity or removing chromatic aberration from the lens optics to improve near and intermediate vision. For multifocal IOL to work efficiently, astigmatism must be completely eliminated. In most cases, multifocal IOLs induce a loss of contrast sensitivity and are therefore contraindicated in eyes with aberrated corneas or in patients with limited contrast sensitivity such as those with maculopathy, retinal dystrophy, glaucoma, or advance senility[12].

Perfect multifocal IOL must exhibits following optical and design principles[2]:

1. Focus dominant for far vision
2. Adequate disparity between near and far foci
3. Aspheric design
4. Available toric model
5. Pupil independent mechanism
6. Good optical performance on the optical bench in vivo
7. Good capsular stability
8. Low rate of posterior capsular opacification
9. Implantable through micro incision
10. Demonstration of good visual outcomes for far and adequate outcomes for intermediate and near vision that can be adapted to the lifestyle of the patient.

How we can achieve patient satisfaction with premium IOLs?

- Deliver well near vision. Patients must be able to read newspapers and books, at least in good light.
- We must know patient's need for intermediate vision.
- We must clarify to the patient that optical side effects are common
- We must explain to the patient that neural adaptation is a process
- Astigmatism must be corrected in multifocal IOL if the patient has more than 0,5D of astigmatism
- In some cases we must perform IOL exchange
- We must learn how to identify ideal candidates, mostly best one is hyperopic (2D or more) or hyperopic astigmatism. The second best is high myopic patient (–6D or more)

Patients should know that their visual quality will become more dependent on light conditions, that they will need a period of adaptation, and that eventually they might not achieve complete spectacle independence, but more likely partial spectacle independence. On average, distance visions of 20/25 and near vision of J2 are achieved by 80% of multifocal IOL patients.

The principle side effects of diffractive lenses are glare and halo, secondary to the two light foci within the eye. And, these lenses cause a reduction in contrast sensitivity as a result of the separation in light energy into the two bundles[11]. When comparing the contrast sensitivity of these IOLs to a monofocal control, there are measurable differences in contrast sensitivity between the two groups at higher spatial frequencies under both photopic and mesopic conditions. With diffractive optics, 41% of light energy is dispersed to the near image, and 41% of light energy is dispersed to the distance image. This leaves 18% of non- functional light[5]. Keep in mind that the human eye is not accustomed to processing multiple images, so it may take time for it to adapt to a diffractive lens. This process can take anywhere from weeks to a year. The incidence of dysphotopsias, however, differed drastically when patients were directly asked about it (20 to 77%) or asked to self-report it in the event that they manifested (0.2 to 1.5%)[6]. It has been found that younger patients, patients without maculopathy and patients with better convergence are more likely to neuroadaptation[8,9].

Triphocal IOL

These IOLs provides high patient satisfaction to presbyopic patients with increased safety[7]. It provides an excellent optical performance at all distances in all light conditions. Nowadays there is only one IOL in the market: AT LISA multifocal IOL[13,14].

The Benefit – LISA

Light distributed asymmetrically between distant (65%) and near focus (35%) for improved intermediate vision and greatly reduced halos and glare

Independency from pupil size due to high performance diffractive-refractive microstructure covering the complete 6.0 mm optical diameter

SMP technology for a lens surface without any sharp angles for ideal optical imaging quality with reduced light scattering

Aberration correcting optimized aspheric optic for better contrast sensitivity, depth of field and sharper vision

New IOL with trifocal optic enables spectacles independence and good vision at all distances, including intermediate space. IOL has +3,5D addition for near vision and +1,75D for intermediate vision and far focus for distance vision. Loss of light is reduced to 14% and there is no drop in visual acuity at any distance. Intermediate vision is good and sharp vision at distance and near is maintained. Design of IOL is aspheric with blue blocking filter. AT LISA tri 839MP is aspheric micro incision IOL. Principles of construction are light distribution asymmetrically, independency from pupil size, SMP technology for ideal optical imaging quality with reduced light scattering and aberration-correcting optimized aspheric optic for better contrast sensitivity, depth of field and sharper vision. Light distribution is 50% for far, 20% for intermediate and 30% for near. Other advantages are improved intermediate vision with 1,66D intermediate addition. The lens has refractive-diffractive profile increasing light transmittance to approximately 85,5%. Fewer rings on the optical surface IOL reduces the risk for visual disturbances and improved night vision. High resolution in all lighting condition, there are maximum pupil independence up to 4.5 mm

Accommodating IOL

The accommodating IOLs have several unique features. The haptic on the lens acts as a »hinge« to allow the lens to move slightly forward and flex secondary to vitreous pressure during accommodation. The optic of the lens moves forward with the contraction of the ciliary muscle through an increase in vitreous cavity pressure. Also, the lens »arches« centrally, which increases negative spherical aberrations and coma. Additionally, the central asphericity of the IOL increases depth of focus, providing improved near vision. In order to achieve a »flexing« of the lens, it must sit completely posterior within the capsular bag. If it sits differently, the distance prescription may be impacted, and also, the lens may not move forward enough to achieve good near vision[10].

Patients' Selections

These options can be confusing to patients, but it is important that they are aware of the lenses available. Steven Dell, M.D., has developed a survey to help patients understand that none of the lenses can provide »everything«.

This tool, or something like it, can help patients understand if their day-to-day lives require more distance, intermediate or near vision. The survey also helps you understand which patients are more or less likely to neuroadapt to multifocal IOLs. Such tools can help direct the conversation with cataract surgery patients about premium IOLs.

Several factors determine the IOL that best suits each patient. These include the patient's age, occupation, hobbies, daily activities, pupil size and retinal health. Pupil size is also important to consider. Patients with very small pupils (less than 3.5 mm) may not benefit from the full effect of the diffractive optics, and those patients with large pupils (greater than 7mm) may have increased glare and halo when implanted with diffractive lenses. Because these patients are paying a premium for these lenses, their demands for high-quality vision can be greater than those of the »average« cataract patient. The tear layer can also affect vision. Evaluating the tear layer should be part of the normal preoperative evaluation. When necessary, treating ocular surface disease before surgery improves the quality of vision after surgery. That treatment can include artificial tears, cyclosporine, hot compresses, fish oil pills and punctual occlusion. A patient's motivation to be free of glasses is also an important factor to evaluate. Some patients are very happy with glasses and are almost fearful to be without them. While spectacle dependence is minimized with all premium IOLs, complete independence cannot be expected with any of them, and none of the lenses accommodate as easily as a 25-year-old's eye. It is crucial to counsel patients as to the strengths and limitations of the different options. In general, patients who prefer close vision over intermediate vision will be happier with a diffractive lens. Those who are concerned about glare and are willing to use reading glasses as needed, will be happier with accommodating IOL. Of course, each patient needs to be treated individually. It is key to ask each patient the same list of questions: glare, acceptability of glasses for near work, etc. You will find there is only a small subset of answers.

Supplementary IOL

IOLs are design for refractive surprises after cataract surgery. There are many types, spheric, aspheric, multifocal, and toric and design for implantation in sulcus.

Photo chromatic IOL

Special intraocular lenses »Aurium« react quickly on light, its color change in 10 second in yellow and back to clear in 30 seconds.

Light Adjustable IOL

The unique molecular composition of the Light Adjustable Lens (LAL, Calhoun Vision) enables customized power and wavefront adjustment after implantation. It is good for straightforward correction of sphere and cylinder, to correct residual refractive errors following corneal refractive surgery, for customized near add and adjustable monovision. IOL can be adjusted postoperatively to correct for higher-order aberrations and common post-surgical refractive errors – a boon in this age of demanding patients with high expectations. This IOL has the potential to provide customized correction for each individual eye.

How It Works

Silicone IOLs have spaces on a molecular level within the IOL. In the LAL, these spaces are filled with light--sensitive, free-floating macromolecules, If the right wavelength of light hits one of the macromolecules, it will attach to the silicone, and what's left will redistribute itself and reshape the IOL. Specifically, the free-moving photosensitive macromolecules are fixed in place through polymerization when the surgeon shines UV light in the near range (365 nm) on the lens. When some of the macromolecules are polymerized, the remaining macromolecules redistribute through the lens, changing its shape and refractive power. The UV light is delivered with a digital light delivery device, made by Carl Zeiss Meditec. This allows a precise pattern on the lens that can be controlled. As a result, the LAL can be customized to treat spherical, cylindrical and other higher-order aberrations as well as to create refractive multifocality and diffractive bifocality. If the IOL is decentred a little from the optical axis, then the effect drops dramatically. But with the LAL, you can actually correct on the axis.«

Phakic IOL

Was effective in the correction of moderate to high myopia and provided excellent visual performance with no modification of physiologic ocular wavefront error. Adequate distance from the cornea and crystalline lens was maintained with no significant change during follow-up and under different environmental conditions. There are anterior chamber IOLs and posterior contact IOLs.

Violet and blue light blocking IOL

Optical radiation includes ultraviolet (UV) radiation (200–400 nm) and visible light (400–700 nm). Violet (400–440 nm) and blue (440–500 nm) light comprise the shorter wavelength part of the visible spectrum.[2,3] The cornea prevents UV radiation shorter than 300 nm from reaching the retina. The crystalline lens blocks most UV between 300 nm and 400 nm. Light transmission by the crystalline lens decreases with ageing, particularly at shorter wavelengths. The first poly(methylmethacrylate) intraocular lenses (IOLs) transmitted UV in addition to visible light. UV does not provide useful vision but it can harm the retina in acute intense exposures. Most IOLs incorporated UV blocking chromophores by year 1986.

Interest in blocking visible light as well as UV is motivated by the unproved hypothesis that phototoxicity from environmental light exposure can cause or accelerate age related macular degeneration (AMD)[16]. This phototoxicity – AMD hypothesis is popular in part because lipofuscin accumulates with ageing in the retinal pigment epithelium (RPE), perhaps increasing the retinal phototoxicity risks of older adults. But none the less, six of the eight major epidemiological studies found no correlation between AMD and lifelong light exposure, caused by its absence, difficulty in accurately estimating a subject's cumulative light exposure retrospectively, variability in genetic susceptibility, or other potentially obfuscating factors such as differences in the age at which subjects experience bright environmental light exposure.

Light can damage the retina by photomechanical, photothermal, or photochemical mechanisms.We know the two classic types of acute retinal photochemical injuries (»photic retinopathies« or »retinal phototoxicities«). The first type of phototoxicity is blue-green (»Noell-type,« »class 1,« or »white light«) photic retinopathy. Its action spectrum is similar to aphakic scotopic sensitivity because rhodopsin mediates both processes. Thus, blue--green phototoxicity hazardousness actually decreases in the blue and violet part of the spectrum below rhodopsin's peak sensitivity around 500 nm. Furthermore, any spectral filter that reduces blue-green phototoxicity causes an equivalent percentage decrease in scotopic sensitivity.

The second type of phototoxicity is UV-blue (»Ham--type,« »class 2,« or »blue light hazard«) photic retinopathy. Its severity increases with decreasing wavelength, similar to that of lipofuscin which is one of its primary mediators. The macular xanthophyll protection declines rapidly in the violet part of the spectrum, where porphyrin and cytochrome oxidase phototoxicity peak. The weakly phototoxic pyridinium bisretinoid A2E component of lipofuscin also has peak phototoxicity around 430 nm in the violet part of the spectrum. Separating acute photic retinopathy into the two preceding categories is useful heuristically, but it may oversimplify phototoxic interactions currently used to study retinal degeneration and cell biology. Acute UV-blue and lipofuscin phototoxicity rise rapidly in the violet part of the spectrum, where porphyrin and cytochrome oxidase phototoxicities peak and macular xanthophyll protection declines.

There are three types of retinal photopigments: cone photoreceptor photopigments that provide photopic (bright light) and mesopic (intermediate light) vision, rhodopsin in rod photoreceptors responsible for mesopic and scotopic (dim light) vision, and melanopsin in blue light sensitive retinal ganglion cells that modulate circadian photoentrainment, pupillary function, and possibly conscious vision. IOLs that block UV and visible light potentially reduce the risk of acute UV-blue phototoxicity. They also decrease the light reaching S-cones, light sensitive retinal ganglions, and rod photoreceptors, which have peak spectral sensitivities around 426 nm (violet), 480 nm (blue), and 500 nm (blue-green), respectively. Melanopsin containing light sensitive retinal ganglion cells control circadian photoentrainment through melatonin suppression. Melatonin suppression has peak sensitivity in human subjects of roughly 460 nm (blue), approximately 20 nm shorter than the peak sensitivity measured experimentally for the photopigment melanopsin. The action spectra for acute experimental blue-green and UV-blue phototoxicities are well characterised, but if there is chronic light damage in humans, its action spectrum is unknown. If the phototoxicity-AMD hypothesis is valid and chronic retinal damage arising from lifelong repetitive acute phototoxic injury does have a significant role in AMD, then action spectra for the two classic types of photic retinopathy can be used to estimate the relative protection afforded by different IOL spectral filters. UV-blue phototoxicity is characterised by the international standard aphakic retinal hazard function based on Ham's studies of light damage in young primates. Blue-green phototoxicity may be specified by the aphakic scotopic sensitivity function governed by rhodopsin light absorption. Retinal photoprotection, scotopic sensitivity, and circadian photoentrainment relative to a conventional UV only blocking IOL were computed for: hypothetical UV + violet blocking high pass filters that have different cut-off wavelengths, UV + violet and UV + violet + blue blocking IOLs, and crystalline lenses of different ages, using spectral data for acute UV-blue retinal phototoxicity, aphakic scotopic luminous efficiency, melanopsin sensitivity, and melatonin suppression, transmittance spectra measured for each IOL, and published data on the spectral transmittance of crystalline lenses and sunglasses. The terms »violet blocking« and »blue blocking« will be used for IOLs that attenuate UV + violet and UV + violet + blue light, respectively. Action spectra for most retinal photosensitisers increase in the violet part of the spectrum. Melanopsin, melatonin suppression, and rhodopsin sensitivities are all maximal in the blue part of the spectrum. Scotopic sensitivity and circadian photoentrainment decline with ageing. UV blocking IOLs provide older adults with the best possible rhodopsin and melanopsin sensitivity. Blue and violet blocking IOLs provide less photoprotection than middle aged crystalline lenses, which do not prevent age related macular degeneration (AMD). Thus, pseudophakes should wear sunglasses in bright environments if the unproved phototoxicity-AMD hypothesis is valid.

Conclusion

Author summarized current possibilities in intraocular lens implantation after lens surgery. The most important is individual approach to our clients and arts to listen all their demands.

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POSLJEDNJA GENERACIJA INTRAOKULARNIH LEĆA I PROBLEM U REFRAKCIJI OKA NAKON OPERACIJE KATARAKTE

S A Ž E T A K

U današnje vrijem kirurgija katarakte ujedno je i refraktivna kirurgija. Autor navodi razne tipove intraokularnih leća u korekciji monofokalno, multifokalno i torik. Prodlem je odabrati adekvatan tip leće obzirom na profesiju i starost pacijenta.