



Managing visual disturbances caused by IOLs.

IOLs: Maximising Outcomes



Dr. Simon Chen

A retrospective case series has provided evidence that many patients complaining of negative dysphotopsia following cataract surgery can be effectively treated by implantation of a secondary intraocular in front of the original intraocular lens.

Negative dysphotopsia is defined as “the perception of a shadow obscuring the temporal field of vision” and in the majority of cases resolve or diminish over time. In less than 1 per cent of pseudophakic patients, severe symptoms persist.



“Negative dysphotopsia is... a surprisingly common phenomenon experienced by many patients following routine, otherwise uncomplicated cataract surgery”

It has been suggested that negative dysphotopsia may occur due to the reflection of light rays between the IOL edges and anterior capsulorhexis. Current treatments are IOL exchange with the placement of a secondary IOL in the bag or ciliary sulcus, implantation of a supplementary IOL, reverse optic capture and YAG laser anterior capsulectomy.

Led by Dr. Natalia Y. Makhotkina from Maastricht University, a review of seven patients (nine eyes) with severe negative dysphotopsia treated with a Rayner Sulcoflex IOL determined that symptoms resolved completely in six eyes, partially in one eye and remained unchanged in



Sulcoflex side image

two eyes. The researchers wrote that implantation of a supplementary IOL resulted in decreased anterior segment dimensions which, in combination with a displacement of light rays by the rounded edges of the Sulcoflex IOL, may have contributed to the resolution of symptoms.

The researchers noted that one patient had the supplementary IOL removed. This patient experienced no complications.

Dr. Makhotkina et al concluded that supplementary implantation of the Sulcoflex IOL was safe and effective. “A Sulcoflex IOL reduces the dimensions of the anterior and posterior chambers, covers the anterior capsulorhexis, and may refract light rays by its surfaces and rounded edges. All these mechanisms may reduce the intensity of the photic images on the retina and contribute to the development of neuroadaptation.”

Comment

Negative dysphotopsia is the term used to describe a visual disturbance characterised by a curved dark shadow in the temporal visual field noticed by patients following cataract surgery. It is a surprisingly

common phenomenon experienced by many patients following routine, otherwise uncomplicated, cataract surgery, being reported in up to 15 per cent of patients.

Most patients don't actually complain about it but if you ask them to look for it, many will notice it. For the large majority of patients it is not a problem, however for a small minority, it can be very disturbing, with some of those patients reporting the experience as being similar to wearing a horse's blinkers. Importantly for the clinician, negative dysphotopsia may be a cause of patient dissatisfaction after cataract surgery despite excellent unaided visual acuity.

The precise cause is uncertain but theories proposed have implicated the interaction of obliquely incident light entering the pupil from the temporal side of the eye with oedematous temporal corneal incisions, squared-edged IOL optics, high refractive index IOL materials and the edge of the anterior capsule. The theory that has gained the most traction is one proposed by Dr. Jack Holladay and colleagues. Using a computer based ray tracing technique in a mathematic model eye, they developed a unifying theory that suggests the likelihood of negative dysphotopsia occurring is dependent on an interplay between numerous parameters including pupil size, profile of the IOL edge, refractive index of the IOL material, anterior chamber depth, the anterior-posterior position of the IOL, axial length, and the anterior extent of the retina in the nasal part of the globe.

Risk factors for negative dysphotopsia indicated by Dr. Holladay's model include a small pupil, increased distance between the IOL and the posterior surface of the iris, squared-edged acrylic IOLs, and a functional nasal retina that extends anterior to the shadow. The theory explains numerous clinical observations.

The initial management when a patient complains of negative dysphotopsia is conservative because the majority will report that the symptoms diminish or resolve completely by six months after cataract surgery, possibly due to neuroadaptation and/or opacification of the anterior capsule. For those patients who remain significantly bothered by negative dysphotopsia despite an adequate period of conservative management, numerous treatments have been described including IOL exchange with an IOL of different refractive index and edge profile, moving the IOL optic anterior to the anterior capsule (known as reverse optic capture) or YAG laser anterior capsulotomy. Although effective in selected cases, none of these options is universally successful.

This paper reports an interesting and potentially useful management option

to treat negative dysphotopsia by implanting a secondary IOL into the sulcus. This may work by addressing multiple risk factors that contribute to negative dysphotopsia i.e. by reducing the distance between the IOL and the posterior surface of the iris and placing a curved-edged IOL into the optical path of obliquely incident light.

This treatment is potentially attractive because a) it is technically relatively easy to perform (unlike an IOL exchange which requires a high degree of technical skill and carries a risk of damaging the posterior capsule and causing vitreous prolapse which in turn increases the risk of a retinal detachment, b) it appears to be effective in a majority of patients, and c) it can be easily reversed by removing the secondary IOL if the treatment is ineffective or causes complications.

Reference

Makhotkina, Natalia Y, Berendschot, Tos T J M, Beckers, Henry J M, Nuijts, Rudy M M A. Treatment of negative dysphotopsia with supplementary implantation of a sulcus-fixed intraocular lens. *Graefes's Archive for Clinical and Experimental Ophthalmology* (2015) 253:973-977.

REDUCING RISKS OF REFRACTIVE SURPRISES IN HIGH MYOPES

Using appropriate modern intraocular lens (IOL) calculation formulas to select IOL power may enable surgeons to achieve accurate refractive results after cataract surgery in highly myopic patients, according to a study published in the *Journal of Cataract and Refractive Surgery*.

Cataract surgery today aims to both treat the cataract and achieve improved refractive results, reducing a patient's dependence on spectacles or contact lenses, by implantation of an appropriately powered IOL.

Biometry before surgery, which measures the length of the eye along the visual axis, the curvature of the cornea and in some cases, a number of other dimensions of the eye, enables the surgeon to utilise IOL calculation formulas to estimate the power of IOL needed to achieve the desired refractive outcome.

Printout from a Lenstar calculation



In his paper, Dr. Adi Abulafia noted that accurate IOL power prediction for eyes with high or extreme myopia is challenging, with standard formulas for IOL power calculation often yielding errors in post operative refractive outcomes, particularly in eyes with an axial length greater than 26.0mm.

However, he noted, new-generation formulas and standard formulas using customised IOL constants together with adjustments to the measured axial length were able to achieve lower refractive prediction errors.

“in high myopes, widely used third generation IOL formulas such as the SRK T and Holladay 1 frequently lead to postoperative hyperopic surprises”

For the first time, Dr. Adi Abulafia and colleagues compared postoperative refractive outcomes in highly myopic eyes using standard IOL formulas (Holladay 1, SRK/T, Hoffer Q, and Haigis) and an axial length (AL) adjustment method as well as new-generation formulas (Barrett Universal II, Holladay 2, and Olsen).

Dr. Adi Abulafia found that the best refraction prediction results for axial lengths over 26.0mm and IOL powers of 6.0 D or higher were achieved with the SRK T, Haigis, Barrett Universal II, Holladay 2, and Olsen formulas.

He concluded, “our results suggest that the SRK T, Haigis, Barrett Universal II, Holladay 2, and Olsen formulas provide the most predictable outcomes with an IOL power of 6.0 D and higher for eyes with ALs greater than 26.0 mm.

“The Holladay 1 (with AL adjustment), Haigis (with AL adjustment), and Barrett Universal II formulas had the most accurate predicted refraction for an IOL power of less than 6.0 D. Predictable refractive results similar to those in eyes with average ALs can be achieved in highly myopic eyes when appropriate adjustment methods or improved formulas are implemented.”

Comment

When thinking about how to get the best possible result from cataract surgery, patients and referrers often focus on the technical skill of the surgeon and the technology used (e.g. femtosecond laser versus traditional manual phacoemulsification or monofocal versus multifocal IOLs). Whilst the surgical ability of the surgeon and using the most up to date surgical equipment are undoubtedly important, another less sexy but potentially more critical aspect of cataract surgery is the process of pre-operative ocular biometry and IOL power calculation.

Ocular biometry is the process of measuring the dimensions of the eye that are relevant to IOL power selection. Prior to the development of biometry, the power of the IOL to be implanted in an eye during cataract surgery was calculated based purely on a patient's refractive error (e.g. adding 19 dioptres (D) to the pre-op refractive error to determine the required IOL power). The current widespread use of optical biometry to measure axial length and corneal curvature with devices such as the Zeiss IOL Master and Haag-Streit Lenstar has enabled consistently accurate refractive results following cataract surgery.

The key elements needed for accurate IOL power calculations are precise measurement of the axial length and corneal curvature, the use of an appropriate IOL calculation formula, personalised lens constants and prediction of the post-operative position of the IOL called the effective lens position (ELP).

Large national datasets from Sweden show a post-operative prediction error from the target refraction of ± 0.5 D in 71 per cent of eyes and ± 1.0 D in 93 per cent of eyes following modern cataract surgery. However, the accuracy of prediction for eyes with very short or very long axial lengths is lower and remains a significant challenge. In these eyes, the ELP is more difficult to determine, which leads to inaccuracies in IOL power calculation even with accurate biometry.

A wide range of different IOL power calculation formulas have been developed and this is an evolving field. All modern IOL formulas have been shown to provide good results in eyes with average axial lengths (between 23 to 25mm) and average keratometry readings. However, in high myopes, widely used third generation IOL formulas such as the SRK T and Holladay 1 frequently lead to postoperative hyperopic surprises.

One explanation for this is that the greater volume of vitreous in high myopes is not

accounted for in the global refractive index (used to average out the index of refraction of the cornea, aqueous, lens and the vitreous) used to calculate the axial length, leading to a systematic over-estimation of the true axial length.

One method to address this problem is to apply a calculation known as the Wang-Koch adjustment to adjust the measured axial length in order to produce more accurate results. Another approach has been the development of fourth generation IOL formulas such as the Holladay 2, Olsen and Barrett Universal II.

The paper presented describes a retrospective study comparing the results of these different methods to calculate IOL power in myopic eyes with axial lengths over 26.0mm.

The authors found that after evaluating 106 eyes of 68 patients, overall, the Barrett Universal II formula was the only formula that met the benchmark criteria of having a prediction error of ± 0.5 D in at least 71 per cent of eyes and ± 1.0 D in 93 per cent of eyes.

The Barrett Universal II formula is a theoretical paraxial ray tracing thick lens formula which accounts for the varying principle planes among different-powered IOLs, making it particularly useful in extremely myopic eyes that require a low power plus or minus power IOL.

Some of the most modern and sophisticated IOL formulas require the use of specific biometry devices or proprietary commercial software, which have limited their widespread use. In contrast, the Barrett Universal II formula which performed the best overall in the reported paper, has been made freely available online by its developer, Australian ophthalmologist Dr. Graham Barrett from the Lions Eye Institute, Perth Western Australia. This commendable and generous act has benefitted surgeons and patients throughout the world by providing access to a state-of-the-art modern IOL formula which is simple to use and provides robust results that are comparable, and in many cases better, than those obtained with other modern IOL formulas.

The Barrett Universal II as well as Dr. Barrett's other IOL formulas for toric IOL calculation and post-refractive surgery IOLs are gaining in popularity and being increasingly used by cataract and refractive surgeons throughout the world.

The availability of multiple formulas provides surgeons with numerous options from which to choose, based on their patient's individual anatomical ocular features and measurements, leading to improved refractive results following cataract surgery.

Reference

Abulafia Adi, Barrett, Graham D, Rotenberg Michael, Kleinmann Guy, Levy Adi, Reitblat Olga, Koch Douglas D, Wang Li, Assia Ehud I. Intraocular lens power calculation for eyes with an axial length greater than 26.0 mm: Comparison of formulas and methods. *Journal of Cataract Refract Surgery* 2015; 41:548-556

CURRENT MULTIFOCAL IOLS AND HALOES

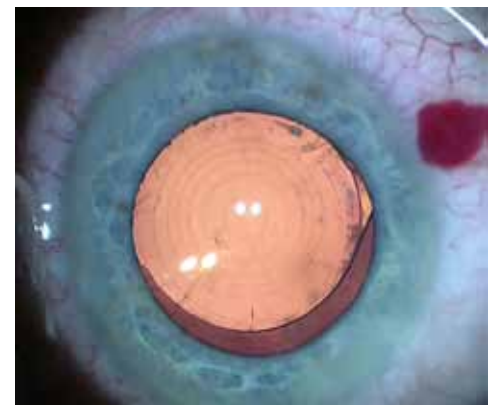
Differences in the design of diffractive multifocal intraocular lenses (mf-IOLs) will influence the optical quality experienced by patients, according to results from an optical bench study presented by Professor Fidel Vega and colleagues.

Clinical studies have demonstrated that patients implanted with bifocal diffractive mf-IOLs typically enjoy good distance and near visual acuities while experiencing compromised intermediate visual acuity. The recent introduction of trifocal diffractive IOLs aims to overcome this shortfall, providing patients with good unaided intermediate vision, which is important for an increasingly number of patients that regularly use computers.

Multifocal IOLs are widely known by clinicians to be associated with photic phenomena including glare and haloes, particularly in low light conditions. A small minority of patients implanted with mf-IOLs are troubled enough by



Multifocal IOL



Trifocal IOL

photic symptoms to request surgery to remove them.

Vega and colleagues used optical bench testing to evaluate and compare the optical quality and characteristics of haloes produced at different pupil sizes, of four current diffractive intraocular lenses.

Optical quality was assessed by measuring the modulation transfer function (MTF) and halo formation was assessed by image analysis. The mf-IOLs tested included three diffractive bifocal IOLs (Alcon ReSTOR +2.5 D, AMO Tecnis +2.75 D, and Zeiss AT LISA 809M) and a diffractive trifocal IOL (AT LISA tri 839MP).

Professor Vega's study found that the smallest haloes occurred for the distance focus of the ReSTOR +2.5D but this mf-IOL was also associated with the lowest near focus optical quality. The distance focus of the Tecnis +2.75D, AT LISA 809M, and AT LISA tri 839MP were of similar quality, but the near focus of the Tecnis +2.75D outperformed the near foci of the rest of the IOLs. The optical performance of all mf-IOLs gradually deteriorated as pupil size increased.

“While the trifocal mf-IOL may provide better intermediate vision... it also produced the largest halo in the distance focus for a 4.5-mm pupil”

Comment

Achieving spectacle independence following cataract surgery is a desirable goal for an increasing number of patients. This is particularly true of younger cataract surgery patients in the baby boomer generation who often opt to have cataract surgery at a younger age than previous generations as they are typically less tolerant of impaired vision that may hinder their lifestyle. Additionally, there are increasing numbers of post-refractive surgery patients who expect to maintain long-term spectacle independence.

Complete or partial spectacle independence after cataract surgery may

be achieved with a monovision approach or the use of multi-focal IOLs. Classic multi-focal IOLs are bifocal, providing good distance and near vision. Patients with bifocal multi-focal IOLs typically require glasses for intermediate visual tasks such as computer use.

Recently introduced trifocal multi-focal IOLs in Australia including the Zeiss AT-LISA tri 839MP, the Bausch and Lomb FineVision and the AcrySof IQ PanOptix aim to provide better intermediate vision whilst maintaining clear distance and near vision, potentially increasing the rate of complete spectacle independence. Early published and anecdotal reports indicate high levels of patient satisfaction with trifocal multi-focal IOLs and their manufacturers are hopeful this will increase the percentage of Australian patients that have multi-focal IOLs implanted at the time of cataract surgery, which currently sits at 6 per cent.

Barriers to widespread multi-focal IOLs use include the concerns of many ophthalmologists about photic symptoms (particularly haloes and glare), the potential need for corrective surgery such as corneal laser refractive surgery or IOL exchange in the event of residual post-operative refractive error or patient dissatisfaction, and concerns that reduced contrast sensitivity associated with multi-focal IOLs, compared to monofocal IOLs, may have a negative impact on vision if the patient later develops ocular disease such as age related macular degeneration, diabetic retinopathy or glaucoma.

By design, diffractive multi-focal IOLs project multiple images from multiple distances onto the retina simultaneously. This means that a focused image due to one of the foci will always be overlaid by one (in the case of bifocal multi-focal IOLs) or two (in the case of trifocal multi-focal IOLs) out-of-focus images formed by the other foci of the mf-IOL. This effect inevitably reduces image contrast in comparison to a monofocal IOL and contributes to potentially disturbing glare and haloes.

The study by Vegas provides useful insights into the photic symptoms associated with mf-IOLs and the factors that influence them. Four different mf-IOL models and a monofocal IOL were tested on an optical bench to assess the characteristics of haloes and the influence of pupil size, and the through-focus performance.

Optical bench testing of mf-IOLs provides important information that cannot be obtained in patients because it is objective and enables accurate assessment of the effect of factors such as pupil size and lens centration on image quality.

The study found that different mf-IOL designs caused clinically relevant differences in visual performance. The optical quality, size and intensity of haloes at different pupil sizes varied between mf-IOL models. Haloes were noted at all focal points with all mf-IOLs. For each mf-IOL apart from the Alcon ReSTOR +2.5D, the halo size increased as the pupil size increased from 3.0 to 4.5 mm. For both pupil sizes, the largest haloes were obtained with the bifocal and trifocal AT LISAs, which are also the mf-IOLs with highest add powers for the near focus (+3.75 and +3.33 D, respectively) indicating that the higher the near add, the larger the haloes (due to the greater intensity and size of the superimposed out of focus image). There was a general trend for image quality (measured by the modulation transfer function) to decrease as the pupil size increased.

As expected, the trifocal mf-IOL was the only IOL which demonstrated a true intermediate focus. While the trifocal mf-IOL may provide better intermediate vision without compromising near and distance vision, it also produced the largest halo in the distance focus for a 4.5mm pupil.

It should be noted that the results of optical bench testing may not directly correlate with what a patient would see due to the complexities of visual perception, processing and neuroadaptation that occur in the human visual system. This may explain why only a minority of patients complain of long-term symptomatic haloes and glare following mf-IOL implantation.

Despite the improvements in mf-IOL technology, all current options involve compromises. Careful patient selection and counseling to set realistic expectations is critical to achieving patient satisfaction with mf-IOLs. An understanding of the optical characteristics of the different mf-IOL models enables the choice of IOL to be tailored to the individual patient's requirements. [mi](#)

Reference

Vega Fidel, Alba-Bueno Francisco, Millan Maria S, Varon Consuelo, Gil Miguel A, and Buil Jose A. Halo and Through-Focus Performance of Four Diffractive Multifocal Intraocular Lenses. *Investigative Ophthalmology and Visual Science (ARVO Journal)* June 2015

Dr. Simon Chen is a retinal and cataract surgeon with extensive experience in vitreoretinal and cataract surgery. He is a conjoint senior lecturer at the University of New South Wales and an investigator for numerous international clinical trials of novel treatments for retinal disease.

Dr. Chen trained at the teaching hospitals of the Universities of Oxford and Cambridge, UK and completed advanced surgical fellowships at the Oxford Eye Hospital and Lions Eye Institute. Dr Chen practises at Vision Eye Institute in Bondi Junction, Drummoynne, Chatswood and Hurstville, NSW.