Effects of Chromatic Aberration, Decentration And Corneal Astigmatism on Through Focus Performance of Premium Intraocular Lenses

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Background

As the eye ages, it loses the ability to accommodate. A strategy for overcoming the loss of accommodation is the replacement of the crystalline lens with an accommodating or multifocal premium intraocular lens (IOL).

The efficacy of premium IOLs depends on many factors, such as chromatic aberrations of the eye, IOL alignment and aberrations of the cornea, however there has been little investigation into the importance of these factors measured in an optical metrology system.

The goal of this study is to investigate the effect of chromatic aberration, IOL decentration, and corneal astigmatism on retinal image quality (RIQ) and depth-of-focus (DoF) of premium IOLs using an optical metrology system and model eye developed in our lab.

Methods

• Analyzed pupil diameter: 4mm
• Artificial cornea designed according to the Gulstrand-model. Corneal Power = 40D and spherical aberration = 0.085µm for a 4mm pupil (for a 6mm corneal surface, spherical aberration = 0.26µm)
• Inducing Chromatic Aberration: 1951 USAF resolution target was incoherently illuminated with white light and monochromatic light (green interference filter: λ = 546nm, M. = 10.5mm)
• Inducing Corneal Astigmatism: Ophthalmic trial lenses were placed before the artificial cornea to simulate corneal astigmatism (up to 1.0D) and varying object distance (2-0 to 5.0D)

Image Quality Metric: Cross-Correlation Coefficient (CCC)

Defining Depth-of-Focus

Raleigh-Criterion: Dioptric range for which image quality does not fall below 0.8 times the peak distance (ID) value of the control monofocal IOL.

Conclusions

• Chromatic aberration causes a relatively small reduction in image quality.
• Decentration of up to 700µm did not reduce image quality significantly.
• Uncorrected corneal astigmatism greater than 0.5D in pseudophakic patients can reduce the benefit of extended depth-of-focus of premium IOLs and needs to be compensated to maximize their efficacy.

Optical Metrology System Layout

Effect of Chromatic Aberration and IOL Decentration on Distant Image Quality

Effect of Corneal Astigmatism on Through-Focus Image Quality

• For up to 700µm of decentration, changes in image quality of white light images for all IOLs were insignificant.
• A ray-trace simulation of 700µm decentration of a monofocal IOL showed insignificant change in image quality.

• Premium IOLs do not exhibit an extended DoF as compared to monofocal IOLs in the presence of corneal astigmatism larger than 0.5D.

• Monofocal ASF and accommodating CAO & CHD have high RIQ at 0D of corneal astigmatism greater than 0.5D in pseudophakic patients can reduce the benefit of extended DoF of premium IOLs and needs to be compensated to maximize their efficacy.