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Retinal stray light originating from intraocular lenses and its effect on visual performance

van der Mooren, Marie Huibert

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Summary

Intraocular lenses are designed for vision correction following cataract removal. The intraocular lens typically replaces a cataractous natural lens that exhibits very high levels of light scattering. The amount of scattering is significantly reduced with an intraocular lens, though it is rarely quantified. Both the surface and the bulk of the intraocular lens may contribute to light scatter at some level, and in some cases affect patients' post-operative quality of vision. The clinical importance of retinal stray light induced by intraocular lenses is illustrated by two cases where single-piece multifocal acrylic intraocular lenses were explanted because of complications related to the presence of glistenings in the bulk of the intraocular lens optic. Both cases support the hypothesis that glistenings may result in clinically significant visual symptoms due to stray light.

The halo around a light source is a clinical manifestation of retinal stray light. The Rostock Glare Perimeter was developed in order to measure the size of the halo in the presence of a glare source. An expected significant mean positive correlation of halo radius with age was found. Smaller halo sizes in phakic subjects were found compared to pseudo-phakic subjects indicating that current intraocular lenses do not outperform a clear crystalline lens for the conditions tested. Among the pseudo-phakic subjects, the monofocal lens group had a smaller halo size than the multifocal lens group. The halo size measured in the binocular condition was significantly reduced when compared to the monocular condition.

To quantify and to improve our understanding of the visual consequences of stray light, the influence of induced retinal stray light was measured via halo size, low luminance detection threshold in the presence of a glare source and contrast sensitivity with and without a glare source. Various retinal stray light levels were simulated in five healthy subjects using different photographic filters. The level of stray light induced was measured both psychophysically with a commercially available instrument and in an optical bench, and the two outcomes were found to be similar. Low levels of induced retinal stray light that can be measured with the commercially available instrument but which do not affect visual acuity can cause significant increases in halo size, result in elevated luminance detection thresholds and cause reduced contrast sensitivity with and without a glare source present.

Two complementary in-vitro quantitative methods for measuring light scatter of isolated intraocular lenses were developed. The combined methods are capable of recording ten decades of light intensity variation from the focal image position out to all forward and backward scatter positions. The measured amount of light scatter could be compared to stray light levels of healthy crystalline lenses of various ages. Intraocular lenses from hydrophobic and hydrophilic acrylic materials with spherical, aspheric, and diffractive surface were tested. Irrespective of the material or design, monofocal intraocular lenses had stray light levels below or close to those of a 20-year-old human crystalline lens.

Diffractive multifocal intraocular lenses had stray light levels higher than those of monofocal intraocular lenses but less than those of a 70-year-old human crystalline lens. After an initial decrease for small angles, hydrophilic intraocular lenses showed an apparent increase in stray light level for larger angles. Two of the four acrylic intraocular lens types tested, showed significant levels of glistenings causing stray light levels higher than that of a healthy 20 year old human crystalline lens. Based on these findings, it can be concluded that the stray light levels of intraocular lenses are design and material dependent and may cause moderate to severe visual symptoms.