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

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Chapter 2

Explanted multifocal intraocular lenses

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We report 2 cases in which single-piece multifocal acrylic intraocular lenses (IOLs) were explanted because of complications related to the presence of glistenings in the bulk of the IOL optic. In both cases, the patients complained about blurry or hazy vision. In vivo slitlamp examinations prior to IOL explantation confirmed the presence of severe glistenings in the IOL optic in 1 case and moderate glistenings in the second case. In the first case, the symptoms resolved and both corrected and uncorrected distance visual acuities improved by 4 lines following IOL exchange with a monofocal IOL. In the second case, the visual symptoms persisted with a hard contact lens. Symptoms resolved following an exchange with a monofocal IOL that was free of glistenings. These findings indicate that straylight caused by IOLs with glistenings may be clinically significant in cases in which multifocal IOLs are implanted and patients require optimized retinal sensitivity.

The single-piece hydrophobic acrylic Acrysof intraocular lens (IOL) (Alcon Laboratories, Inc.) is the most widely used IOL. Several recent studies based on large numbers of patients implanted with Acrysof IOLs (≈ 100 patients) conclude that moderate to severe or dense glistenings occur in 60% to 87% of patients with these IOLs.[1–5] The formation and the severity of glistenings have been correlated with longer followup times.[5–10] Two studies that evaluated the progression beyond 1 year found glistening formation to be stable.[2,11] Whether glistenings affect visual performance, and if so how, is frequently a question. We report 2 cases in which the presence of glistenings in the optics of single-piece multifocal Acrysof IOLs may have led to severe vision complaints requiring IOL explantation.

CASE REPORTS

Case 1

A 77-year-old man had bilateral cataract extraction in 2006 with implantation of multifocal IOLs (Acrysof Restor SN60AD3). Mild dry age-related macular degeneration (AMD) was subsequently diagnosed in both eyes. Prior to IOL explantation, the patient presented at Cape Coral Eye Center with severe complaints of glare at night, difficulty reading and driving, and blurry vision in both eyes. During slitlamp examination, peripheral posterior capsule opacification and dense glistenings were observed in both IOL optics (Figure 1). In the left eye, the uncorrected distance visual acuity (UDVA) was 20/100 and the corrected distance visual acuity (CDVA), 20/70. In January 2011, an IOL exchange with a 24.5 diopter (D) monofocal Tecnis Z9002 IOL (Abbott Medical Optics, Inc.) relieved the visual symptoms. The UDVA improved to 20/40 and the CDVA to 20/30. The IOLs in both eyes were explanted. The multifocal IOL in the left eye was explanted in 1 piece and stored in a saline solution at room temperature, enabling in vitro modulation transfer function (MTF), dioptric power, and straylight measurements on an optical bench; dark-field microscopy;

and confocal microscopy. Image J software (National Eye Institute, Bethesda, Maryland, USA) was used to analyze the size and density of the glistenings in vivo and in vitro on confocal images. Because glistenings gradually decrease when the explanted IOL is kept at room temperature, glistenings were induced in the laboratory to the in vivo level by raising the IOL temperature to that of the eye. The IOL was then cooled to room temperature and measured at the moment the glistening sizes and density were similar to the sizes and density in vivo at slitlamp examination just before explantation. All in vitro measurements were taken before and after the IOL was exposed to temperature changes. Figure 2 shows the dark-field image before and after induction of glistenings. The MTF measurements were low but appeared not to be affected by glistenings, and the measured dioptric power was 24.0 D. The straylight level of the explanted IOL was high and close to the level of a 70-year-old healthy crystalline lens (Figure 3).

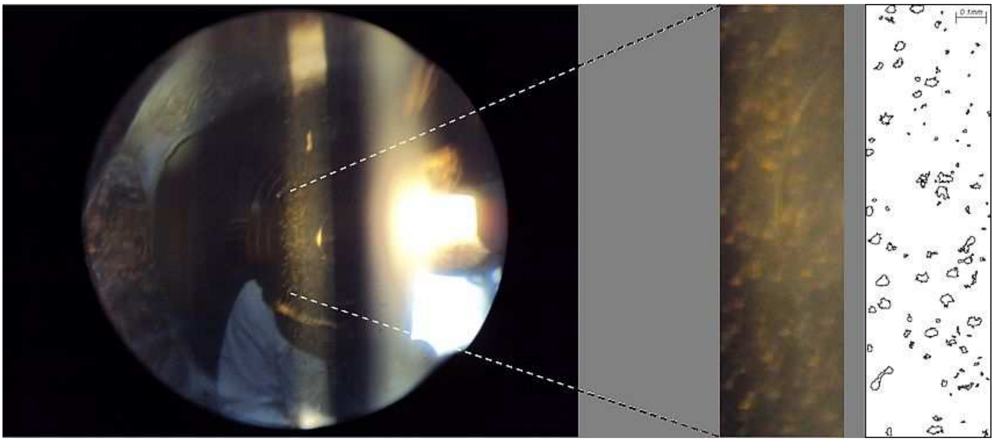

Figure 1. Case 1: A slitlamp image (left) and Image J results obtained from the center portion of the IOL (right).

Figure 2. Case 1: Dark-field image before (left) and after (middle) the temperature procedure and in vitro Image J results obtained from a confocal image after the temperature procedure (right).

The glistening level resulted in approximately 15% of light being scattered, and therefore this light was not imaged but rather appeared as veiling glare or haze on the retina. The

IOL in the right eye was exchanged with the monofocal Tecnis Z9002, and the CDVA and UDVA improved as in the left eye. No other ocular conditions were identified in either eye, and despite the remaining mild AMD in both eyes, the level of glistenings is considered the major cause of the vision complaints.

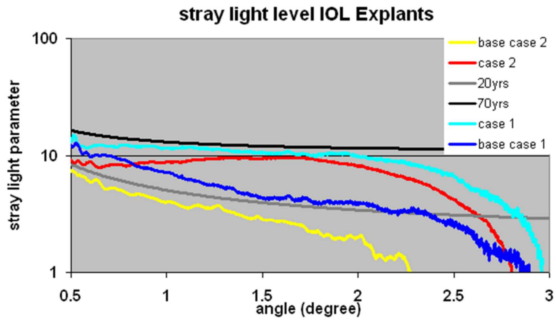

Figure 3. The gray and black solid lines represent the straylight levels for a healthy 20-year-old lens and a healthy 70-year-old crystalline lens, respectively, as a function of retinal eccentricity. The colored lines represent the levels of the explanted IOLs before(base) and after the temperature procedure.

Case 2

A 53-year-old man who previously had laser in situ keratomileusis (LASIK) had no visual complaints until a cataract developed. Cataract extraction was performed in 2009 with implantation of a 19.5 D multifocal Acrysof Restor SN60AD3 IOL in both eyes. Approximately 6 months postoperatively, the patient began complaining of halo and glare in the right eye but not in the left eye. Examination revealed significant glistenings in the IOL optic in the right eye but only mild glistenings in the optic in the left eye. The symptoms did not improve with conservative management including topical lubrication and a hard contact lens trial, and the patient presented at Gavin Herbert Eye Institute 2 years after the cataract surgeries. He complained of unacceptable severe glare, fluctuations in vision, and overall cloudy vision in the right eye. A slitlamp examination revealed moderate to dense glistenings in the IOL optic in the right eye and trace glistenings in the optic in the left eye. The UDVA in the right eye was 20/50, and the CDVA was 20/25; the CDVA improved to 20/20 with a hard contact lens. However, the patient stated that the glare and haze persisted in the presence of the hard contact lens and remained unacceptable. No other ocular comorbidities were diagnosed. In October 2011, an IOL exchange was performed in the right eye with implantation of a +20.0 D monofocal Tecnis ZCB00 IOL. The visual symptoms ceased, the UDVA improved to 20/25, and the CDVA improved to 20/15. The multifocal IOL was explanted in 1 piece and stored in a saline solution at room temperature, and the same in vitro procedure was followed as in Case 1. The in vivo level of glistenings is illustrated in Figure 4.

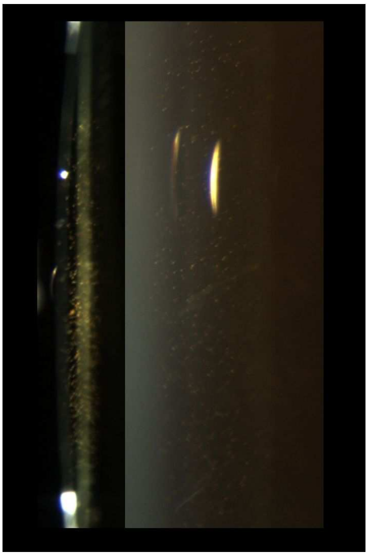

Figure 4.

Case 2: Two slitlamp images of 2 inspection angles.

Figure 5 shows the dark-field images before and after induction of glistenings. The measured MTF was low but appeared not to be affected by glistenings. The straylight level of the explanted IOL was well above that of a healthy 20-year-old crystalline lens (Figure 3). The glistening level resulted in approximately 9% of light scattered onto the retina, using the same methodology as in Case 1. The patient was more satisfied with the quality of vision in the right eye, which had the IOL exchange, than in the left eye. Although the IOL optic in the left eye had trace levels of glistenings, the patient had no complaints of visual symptoms and was unwilling to lose his ability to read. Because both eyes had a similar ocular history leading to the IOL exchange in the right eye, the level of glistenings is considered to be the major factor in the vision complaints.

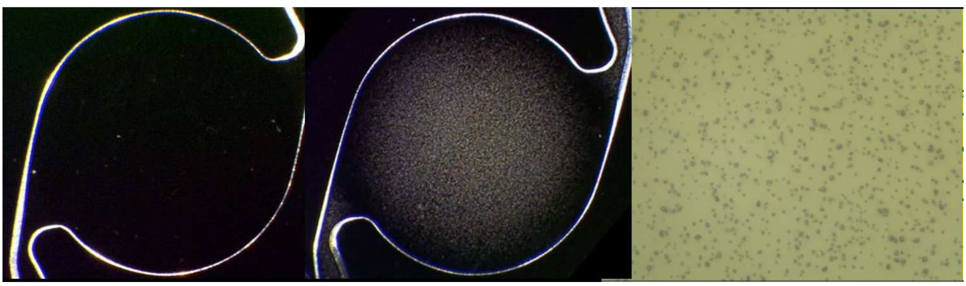

Figure 5. Case 2: Dark-field image before (left) and after (middle) the temperature procedure and a confocal image after the temperature procedure (right).

DISCUSSION

In the 2 cases presented, the light scatter and MTF were measured on a validated optical bench[12,13,A] and the scattered light percentage was determined by the measured size and density of the glistening level shown in the ImageJ[B] pictures in Figures 2 and 5 and calculated using the method outlined by van der Mooren et al.[14] Contrast sensitivity and visual acuity are standard vision tests assessing foveal visual quality most commonly performed under photopic conditions. Several clinical studies have investigated the effect of glistenings in IOLs on visual acuity and contrast sensitivity. Four of 6 studies report that glistenings adversely affect contrast sensitivity,[1,6,15,16] and 2 studies are ambiguous.[2,11] Two studies show a drop in visual acuity with elevated levels of glistenings.[7,11] More studies show that high-contrast visual acuity is not affected by glistenings.[2–4,6,8,15–17] In our first case, the severity of straylight was so high that visual acuity was reduced. The observed mild AMD still existed following IOL exchange, and therefore the AMD does not appear to have been a contributing factor to the visual symptoms. There are many potential glare sources in this case, such as the corneal state (dry eyes, tear film, higher-order corneal aberrations, or other corneal irregularities), the IOL multifocality, and the glistenings. The patient's cornea was normal and therefore unlikely to contribute to the visual symptoms. The Acrysof SN60AD3 diffractive multifocal IOL produces 2 primary foci[18]; when the patient is performing a distant task or a near task, 1 focus is out of focus, creating a halo that exhibits approximately 1% of intensity compared with the focal intensity. This halo is constrained in a retinal angle of 20 minutes of arc. In addition, veiling glare of less intensity is spread over the retina because of the higher order foci. Halos cause specific visual symptoms that are well described and different from the complaint symptoms noted in our 2 cases. Therefore, IOL multifocality does not seem to be the major contributing factor to the visual complaints, although it may be a confounding factor that reduced the retinal sensitivity. The glistenings produce 2 retinal glare peaks with maxima at 2 degrees and at 15 degrees, [14] each peak containing half of the 15% incident light scattered because of the glistenings. Because the scattered light due to the glistenings is localized and has the highest intensity of all potential sources, we think it is the major cause of the observed visual symptoms. The IOL exchange was performed with a replacement monofocal IOL because AMD had been diagnosed, reducing the retinal sensitivity. The UDVA and CDVA for monofocal and multifocal IOLs have generally been shown to be comparable.[19] This suggests that exchanging a monofocal IOL for a multifocal IOL played no role in the increase in visual acuity. The visual acuity improvement was larger in Case 1 than in Case 2 and may be explained by the severity level of the glistenings.

In the second case, the same IOL model was implanted in both eyes but only the right eye experienced severe visual symptoms. The IOL optic in the left eye had only trace levels of glistenings, reflecting the well-known variation in the severity of glistenings across Acrysof IOLs.[14] The patient had had LASIK in both eyes and later developed cataracts. To exclude the cornea as a factor in the vision complaints, the corneal stability was checked with a hard contact lens and no improvement in the symptoms of haze and glare were observed by the patient. Corneal topography was within normal parameters for a myopic LASIK; moreover, the patient did not have similar complaints prior to cataract formation and multifocal IOL implantation. The other potential glare source in this case is the IOL multifocality itself. However, the patient tolerated the multifocality in the contralateral eye. Although the patient could have elected an IOL exchange for a new multifocal IOL, the multifocal design of a different brand of IOL without the risk for glistenings would not have resolved the uncertainty associated with multifocality versus glistenings as the source of the visual complaints. The principle control was the tolerance of the multifocal IOL without glistenings in the contralateral eye.

In conclusion, both cases support the hypothesis that glistenings in combination with multifocal optics may result in clinically significant visual symptoms due to straylight.

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