"Light Transmittance of Explanted Hydrophobic Acrylic Intraocular Lenses with Surface Light Scattering"

Program Number: 834

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Purpose

Surface light scattering of intraocular lenses (IOLs) is related to subsurface nanoglistenings, which becomes notable only under oblique light (off-axis light) conditions at an angle of incidence of 30 degrees or greater during slit lamp examination, or during image capture at an angle of 45 degrees with Scheimpflug photography.[1,4-6] Some studies suggested that IOL light scattering was caused by a surface-bound biofilm.[2-3] However, recent studies analyzing explanted lenses in dry and hydrated states, as well as analyses under cryo-focused ion beam scanning electron microscopy confirmed that scattering was predominantly caused by phase separation of water (from aqueous humor) as subsurface nanoglistenings.[4-6] The aim of this study was to investigate the potential effect of surface light scattering on the light transmittance of single-piece hydrophobic acrylic IOLs made of AcrySof material (Alcon) with or without blue light filter (BLF).

Methods

The following methods were conducted as previously described.[6-7] IOLs were obtained from human cadavers (49 lenses total; 36 with BLF), and from finished-goods inventory (controls). The IOLs were explanted from the cadaver eyes and power/model matched to unused control IOLs. Explanted lenses with their respective control IOLs were fixed in 10% neutral buffered formalin for 1 hour. Proteins on all IOLs were then stained and removed. Briefly, proteins were stained with Coomassie blue G-250 dye. After light microscopic evaluation of the lenses, proteins were removed with a mixture of enzymes (subtilisin A and trypsin) and a chelator (ethylenediaminetetraacetic acid [EDTA]), and then with a solution of 0.6% sodium hypochlorite in phosphate-buffered saline. The protein-stripped IOLs were rinsed with distilled deionized water and re-stained again with Coomassie blue G-250 reagent to confirm protein removal. Residual stain was removed with the 0.6% sodium hypochlorite solution, and then rinsing in distilled deionized water. The lenses were then allowed to dry overnight at room temperature. Explanted and control lenses were re-hydrated in balanced salt solution (BSS) for at least 15 hours before measurement of light scattering and light transmittance. Bright-field and dark-field images were captured for all explanted and control IOLs, before and after hydration. Dark-field images were obtained with a 90-degree off-axis illumination. Surface light scattering was then measured with a Scheimpflug camera (EAS-1000 Anterior Segment Analysis System, Nidek Ltd; *Figure 1*) with the following settings: flash level 200 W; slit length 10 mm; meridian angle 0. Light transmittance was measured with a Perkin Elmer Lambda 35 UV/Vis spectrophotometer (single-beam configuration with RSA-PE-20 integrating sphere; *Figure 2*). Results were expressed as % light transmittance in the visible light spectrum (700-400 nm).

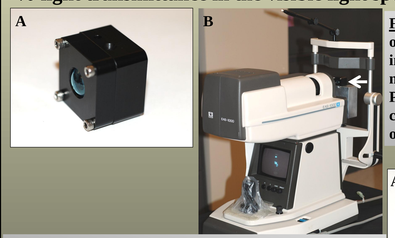

Figure 1: Light scattering measurements. A: Gross photograph of the customized dark eye model used to hold the IOL under immersion in BSS. The PMMA cornea is shown on the left; the model is filled with BSS though the holes shown on top. B: Photograph showing the Nidek EAS-1000 Scheimpflug camera. The eye model sits elevated on a metal bridge located on the chin rest (arrow).

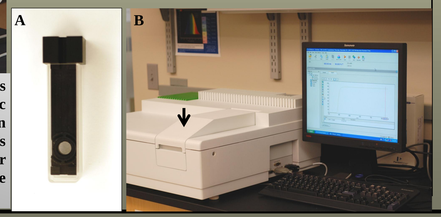

Figure 2: Light transmittance measurements. A: Gross photograph of the cuvette containing the black plastic insert designed to hold the IOL in place under immersion in BSS. B: Photograph showing the Lambda 35 UV/Vis spectrophotometer. The arrow indicates the chamber where the cuvette containing the IOL is placed for the measurements.

Results

A total of 49 single-piece AcrySof lenses were explanted from cadaver eyes; 36 were yellow lenses with BLF, and 13 were lenses without BLF. Implantation time ranged from 0 (less than 12 months) to 10 years in the BLF group (3.80 +/- 3.26 years), and from 0 to 10 years in the non BLF group (4.38 +/- 3.12 years). Hydrated surface light scattering values ranged from 4.8 to 202.5 CCT (mean = 38.4 +/- 46.1 CCT) for BLF explanted IOLs and 1.5 to 11.8 CCT (mean = 5.4 +/- 2.3 CCT) for controls; values ranged from 6.0 to 137.5 CCT (mean = 64.6 +/- 43.6 CCT) for explanted IOLs without BLF and 3.5 to 9.6 CCT (mean = 6.1 +/- 1.8) for controls. Significant differences in CCT values were observed between explanted IOLs and controls for both groups of lenses (P<0.001, Paired T-Test). Figure 3 shows the analyses of surface light scattering as a function of implantation time in both groups of lenses. There was a tendency for increasing scatter values with increasing postoperative time for both groups (BLF lenses: r = 0.3772, P = 0.0226; non BLF lenses: r = 0.6310, P = 0.0188), consistent with clinical observations.[8,9] Light transmittance was measured as 83.69 +/- 1.05 % for the explanted lenses, and 83.76 +/- 0.88 % for the control lenses in the BLF IOL group. It measured 95.91 +/- 0.66 % for the explanted lenses, and 96.02 +/- 0.75 % for the control lenses in the non BLF IOL group. No differences in % light transmittance in the visible light spectrum were observed between explanted IOLs and controls for both groups of lenses (BLF IOLs: P = 0.407, Paired T-Test; Non BLF IOLs: P = 0.487, Paired T-Test). Figures 4 and 5 show representative dark-field images, EAS scans, and % light transmittance curves from IOLs in both groups. *All IOLs (explanted and controls) were clear with on-axis illumination; dark-field images showed surface light scattering of hydrated explanted lenses with angled illumination.*

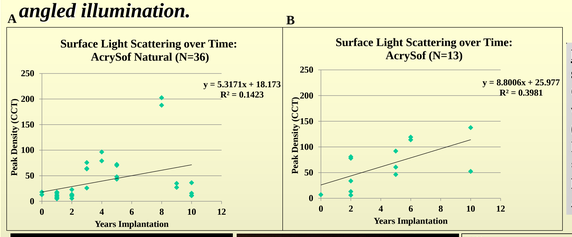

Figure 3: Graphs showing analyses of surface light scattering as a function of postoperative time. A: Graph for the group of intraocular lenses (IOLs) with blue light filter (BLF). Correlation coefficient (R1) = 0.377; P = 0.023. B: Graph for the non BLF IOL group. Correlation coefficient (R2) = 0.631; P = 0.019. Correlation coefficient comparison (R1 vs. R2) P = 0.338; Slope comparison P = 0.432 using Analysis of Covariance.

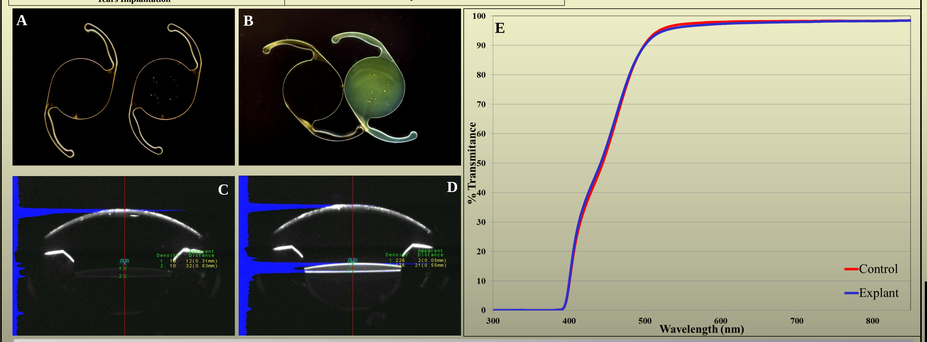

Figure 4: Gross photographs (dark-field images with a 90-degree off-axis illumination) of an explanted BLF IOL (right) with corresponding control lens (left). A: Photo taken in the dry state; no optic haziness is observed. B: Photo taken in the hydrated state; the lenses are immersed in BSS. The explanted lens exhibits an overall haziness in comparison to the control. Optic pits, probably caused by Nd:YAG laser application can also be observed on the explant.
C and D: Scheimpflug images with densitometry analyses of the same BLF lenses. Light scattering measurements at the central part of anterior and posterior optic surfaces are as follows: 10 and 10 CCT for the control lens; 226 and 176 CCT for the explanted lens. The postoperative time of the explanted lens was 8 years.
E: Graph depicting % light transmittance between 850-300 nm of the same BLF lenses. Light transmittance in the visible light spectrum was 83.19% for the control lens, and 83.20% for the explant.

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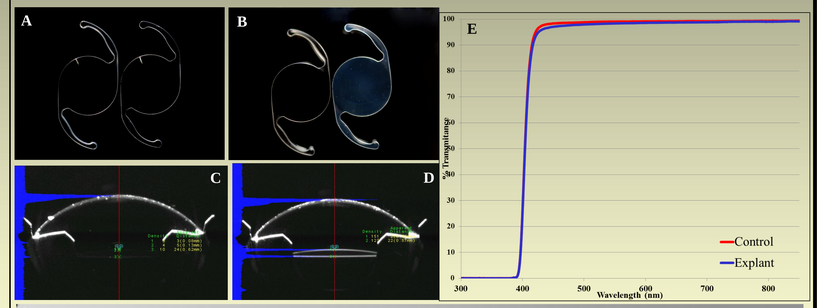

Figure 5: Gross photographs of an explanted non BLF IOL (right) with corresponding control lens (left). A: Photo taken in the dry state; no optic haziness is observed. B: Photo taken in the hydrated state; the lenses are immersed in BSS. The explanted lens exhibits an overall haziness in comparison to the control. C and D: Scheimpflug images with densitometry analyses. Light scattering measurements at the central part of anterior and posterior optic surfaces are as follows: 4 and 10 CCT for the control lens; 151 and 127 CCT for the explanted lens. The postoperative time of the explanted lens was 10 years. E: Graph depicting % light transmittance between 850-300 nm. Light transmittance in the visible light spectrum was 96.88% for the control lens, and 96.06% for the explant.

Discussion/Conclusions

Previous studies measuring light scattering and light transmittance of AcrySof lenses in vitro mostly involved 3-piece designs made of ultraviolet-blocking material.[2-5] This is the first study using a significant number of single-piece lenses explanted from cadaver eyes with known implantation duration, especially with regards to the material with BLF. Protein deposits were removed prior to measurements in order to specifically assess the effect of subsurface nanoglistenings independent of surface deposits, although a previous study demonstrated that protein films on the IOL surface are not a significant source of light scattering.[6] That same study also confirmed that the 10% formalin treatment, staining, and protein removal processing steps did not alter the surface chemistry of the Acrysof IOL material.[6] A spectrophotometer operated in a single beam configuration with an integrating sphere was used for light transmittance measurements. This set up was found to eliminate variations due to lens power, spherical aberration, and misalignment of the IOL in another study.[10] Also, single-beam measurements were unaffected by temperature, and detected real differences due to surface light scattering in comparison to dual-beam configuration.[10] In both groups of lenses (with or without BLF), light scattering of postmortem explanted lenses was significantly higher than that of matching controls. However, this was not associated with a significant decrease in light transmittance.

In conclusion, although surface light scattering of explanted lenses was significantly higher than that of controls and appeared to increase with time, no effect was observed on the light transmittance of single-piece hydrophobic acrylic lenses with or without blue light filter.

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