Light-scattering characteristics of explanted opacified Aquasense intraocular lenses

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ABSTRACT

Aim: To study forward light-scattering characteristics of calcified explanted intraocular lenses (IOLs) (Aquasense, Ophthalmic Innovation International Ontario).

Methods: The amount of light scattered by the opacified IOLs was measured using a validated in vitro set-up for angles from 1.7° to 22°. This set-up gives results directly comparable with straylight values as valid for the in vivo situation.

Results: Straylight is highest at large angles and declines steeply approaching 0° angle. This corresponds to the in vivo findings that opacified IOLs cause important visual complaints but have little effect on visual acuity. At 7.5°, log (s) is around 1.8 and 2.9 for the two lenses respectively. This corresponds to 8× and 100× increases in straylight values compared with values in young, normal eyes.

Conclusion: High straylight values caused by opacified IOLs can explain subjective complaints of reduced quality of vision in patients with opacified implants, despite good visual acuity.

Cataract surgery is the most commonly performed surgical procedure in the world, and intraocular lens implants (IOLs) are the most commonly used prosthetic devices.[1 2] Any complication related to IOLs will have considerable implications for public health and health service resources.[1] Delayed post-operative intraocular opacification of hydrophilic acrylic IOLs has been reported for several types of IOLs, including the Hydroview model H60M (Bausch and Lomb Surgical Clearwater, Florida), the SC60B-OUV (MDR, Clearwater, Florida), the Memory Lens (Ciba Vision, Duluth, Georgia) and the Aquasense (Ophthalmic Innovation International, Ontario).[1–11]

Patients with opacified IOLs typically present with symptoms of reduced quality of vision, which may be due to decreased visual acuity, deterioration in contrast sensitivity or increased complaints of glare from 4 to 36 months postoperatively.[1–10] These symptoms are resistant to treatment of the capsular bag with the neodymium:yttrium-aluminium-garnet (Nd-YAG) laser.[3 7] In some patients, this opacity causes sufficiently severe symptoms to necessitate lens exchange surgery.[1–3 5–11]

Two aspects of lens behaviour influence the quality of vision independently: straylight and visual acuity effects.[12] For correct understanding of functional effects of lenticular optical disturbances, the size of these disturbances is of paramount importance.[12] Small irregularities, with sizes comparable with the wavelength of visible light, cause straylight.[12] Larger disturbances, with sizes of 100 μm to several millimetres, will influence visual acuity.[12] Typical straylight-dependent symptoms occur thus quite independently from visual acuity effects.[12] Opacification of IOLs is mostly due to multiple fine deposits that may be inside or covering the optic with sizes of <1 μm to 2–3 μm diameter.[1] Therefore, the quality of vision loss in patients with opacified IOLs can be expected to be mostly due to increased straylight. Increased straylight can give rise to a variety of subjective complaints, including glare in scotopic conditions, haloes around bright lights, colour and contrast loss and hazy vision.[12] The CIE (Commission International d'Eclairage) has defined disability glare as retinal straylight.[13]

The aim of the current study was a direct measurement of forward light-scattering characteristics of two explanted opacified Aquasense IOLs (Ophthalmic Innovation International, Ontario).

To isolate the straylight-causing effects of opacified IOLs, these IOLs will have to be measured separately from the rest of the eye. A specialised measurement set-up has been designed and validated for the purpose of establishing forward light-scattering properties of different kinds of lenses in vitro (fig 1).[14–18] This set-up gives results directly comparable with straylight values as valid for the in vivo situation.[14–17] Thus, the data are comparable with results that can be obtained in clinic on patients using a straylight meter such as the Oculus C-Quant. This is a clinically useful straylight meter specifically designed to objectively document and quantify the amount of straylight which a patient experiences.[19 20] With this instrument, a functional measurement can be made which determines the amount of straylight caused by optical disturbances in the entire eye.[19]

MATERIALS AND METHODS

The Aquasense hydrophilic acrylic IOL (Ophthalmic Innovation International) was used in several hospitals of the northwest UK between 1999 and 2001. The exact number of patients who received these implants is not clearly known. From 5 months to 2 years after cataract surgery, several implants lost their clarity and became opaque. Lens exchange surgery was performed when patients complained of symptomatic reduction in quality of vision. Two explanted opacified Aquasense IOLs were preserved for the present study. As is usual in this situation, before lens exchange surgery both patients had Snellen visual acuity of 6/6 but severe complaints of haziness of sight. Slit-lamp and microscopic examination of the two explanted opacified Aquasense IOLs was performed, and the

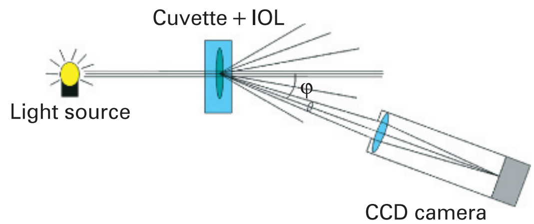

Figure 1 Simplified drawing of in vitro setup for measuring light scattering from intraocular lenses (IOL).

light-scattering behaviour of these lenses was studied.

Light scattering was measured with the same set-up used in previous studies to evaluate the scattered light of donor lenses and spectacle lenses (fig 1).[14–18] Following is a summary of methods that were described in detail previously.[14–18] The Aquasense IOLs were placed in a special holder filled with isotonic sodium chloride solution. All measurements were performed in scotopic light conditions. With a halogen lamp as light source, a pencil beam of 4 mm diameter was projected on the IOL. A Princeton Instruments NTE/CCD 512-TKB CCD measuring camera was moved in a plane around the sample, and measurements were made at different angles. The straylight parameter s could be calculated as a function of angle, based on the amounts of light registered by the camera and the total amount of light going through the IOL. After correction for the effects of reflection and refraction at the liquid–air interface of the lens holder—that is, as valid for the interior of the eye—angles of −22°, −15°, −11°, −7.5°, −5.2°, −3.0°, −1.7°, 3.0°, 5.2°, 7.5°, 11°, 15° and 22° were used. Usually, results are expressed as the logarithmic value of the straylight parameter s (log(s)).

RESULTS

Microscopic and slit-lamp examination of the two explanted IOLs revealed a diffusely and almost uniformly white opacity of the IOL optics (fig 2). The anterior surface of one of the IOL optics had a diffusely wrinkled appearance and a clear imprint of the capsulorhexis (fig 3).

Figure 4 shows the straylight values of both lenses expressed as logarithm of the straylight parameter s at different angles. The straylight parameter is highest at large angles. Around the 0° angle, the straylight parameter clearly drops to lower values. At 7.5°, log (s) is around 1.8 and 2.9 for the two lenses respectively.

DISCUSSION

Several studies have examined explanted opacified IOLs.[1 3 5 8 9 11] Most have focused on the composition of the deposits by examining the explanted implants by different techniques, including light microscopy, scanning electron microscopy and wavelength-dispersive *x* ray spectroscopy.[1 3 5 7–9 11] This is the first study to objectively document and isolate the effects of opacified lenses on quality of vision, by measuring the amount of straylight caused by opacified IOLs.

Visual acuity in patients with opacified IOLs can remain surprisingly good, despite severe complaints of reduced quality of vision.[6 10] Symptoms and subjective complaints correlate well with the severity of IOL opacity seen at the slit lamp and less well with visual acuity.[6] In the absence of straylight measurement, visual deterioration mostly corresponds to decreased contrast sensitivity or haziness of vision, and less with visual acuity.[2 6 10] These findings can be explained by the present

Figure 2 Explanted opacified Aquasense intraocular lens.

study. Spreading of light in the eye can be divided into two domains: (1) a small-angle domain of up to approximately 30 min of arc, affecting visual acuity and (2) a large-angle domain from approximately 1° to 90°, leading to straylight and, consequently, glare.[21] As can be seen in fig 4, around 0° a drop in straylight values is found for both lenses. This means that part of the light is projected directly on the retina, forming the retinal image, passing nearly undisturbed through the opacified IOLs, and the effect on visual acuity is negligible. However, in the large-angle domain, a whole different picture arises. To understand the complaints of the explanted opacified lenses on quality of vision, normal straylight values in the population have to be taken into account. Under 40 years of age, a normal value for log (s) is 0.9 (s = 8).[12] This value increases to log (s) = 1.2 (s = 16) at age 65, which corresponds to a doubling in the amount of straylight.[12] At 7.5°, which is close to the angle

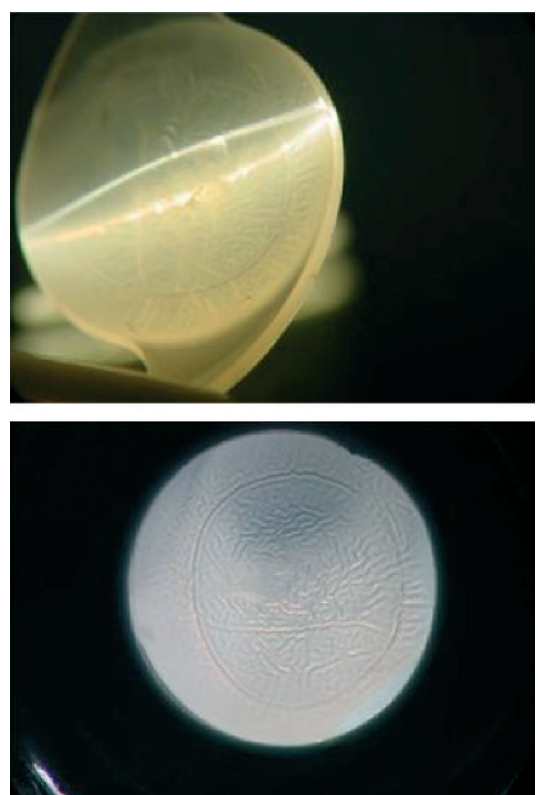

Figure 3 Diffuse opacification of one of the explanted implants with a wrinkled anterior surface and an imprint of the capsulorhexis on the anterior surface of the intraocular lens optic.

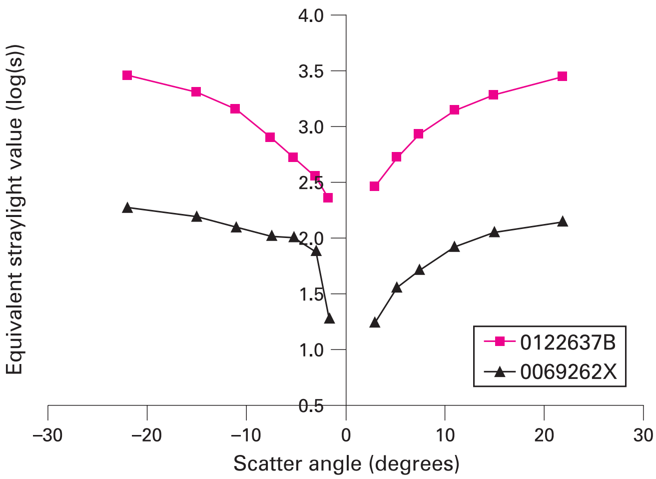

Figure 4 Straylight values of both explanted opacified IOLs expressed as the logarithm of the straylight parameter s (log(s)) at different angles. The numbers 0122637B and 0069262X are IOL identification numbers. The IOL numbered 0122637B has a wrinkled anterior surface and an imprint of the capsulorhexis on the IOL optic.

used in vivo in the C-Quant, straylight values of the opacified lenses are log (s) = 1.8 (s = 63) and log (s) = 2.9 (s = 794) respectively. It can be easily understood that these increases of 8× and 100× compared with young normal straylight values for the respective lenses will lead to a major reduction in quality of vision.

Considering the above, visual acuity alone is not a good criterion for deciding to exchange an opacified IOL. This is also found in a previous study.[6] After IOL exchange, Dagres et al found no significant improvement in visual acuity, because visual acuity before the exchange was surprisingly good, even when severe opacity was present.[6] However, even if IOL exchange was followed by deterioration in best-corrected visual acuity, many patients were still satisfied.[2] This postoperative satisfaction can be better understood when improvement in postoperative straylight is considered. Among a normal pseudophakic population, usually straylight values return to an age-normal level or even to levels normal for younger eyes (super normal).[12] For patients with opacified IOLs, this could mean an 8–100× reduction in amount of straylight.

In summary, in vitro straylight measurements show that opacified IOLs may lead to 8–100× increased straylight values as compared with young, normal eyes. This can explain and objectively document subjective complaints of reduced quality of vision in patients with opacified implants, despite good visual acuity. Lens exchange surgery can lead to significant visual improvement in these patients.

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