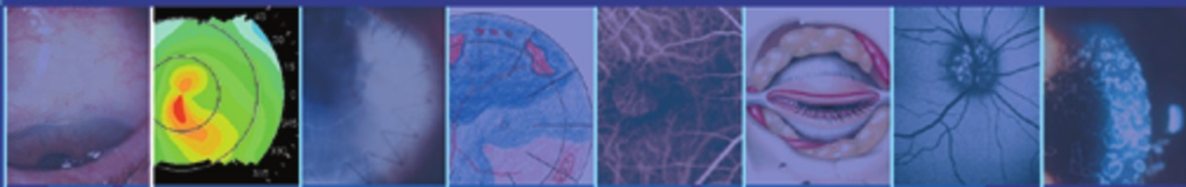
ESSENTIALS IN OPHTHALMOLOGY
G. K. KRIEGLSTEIN · R. N. WEINREB
Series Editors



Glaucoma | Cataract and Refractive Surgery | Uveitis and Immunological Disorders | Vitreo-retinal Surgery | Medical Retina | Oculoplastics and Orbit | Paediatric Ophthalmology, Neuro-ophthalmology, Genetics | Cornea and External Eye Disease

Cataract and Refractive Surgery

Edited by
T. KOHNEN
D. D. KOCH

Springer

Essentials in Ophthalmology

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Editors Thomas Kohnen
Douglas D. Koch

Cataract and Refractive Surgery

With 75 Figures, Mostly in Colour
and 22 Tables

Springer

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Foreword

The series *Essentials in Ophthalmology* was initiated two years ago to expedite the timely transfer of new information in vision science and evidence-based medicine into clinical practice. We thought that this prospicient idea would be moved and guided by a resolute commitment to excellence. It is reasonable to now update our readers with what has been achieved.

The immediate goal was to transfer information through a high quality quarterly publication in which ophthalmology would be represented by eight subspecialties. In this regard, each issue has had a subspecialty theme and has been overseen by two internationally recognized volume editors, who in turn have invited a bevy of experts to discuss clinically relevant and appropriate topics. Summaries of clinically relevant information have been provided throughout each chapter.

Each subspecialty area now has been covered once, and the response to the first eight volumes in the series has been enthusiastically positive. With the start of the second cycle of subspecialty coverage, the dissemination of practical information will be continued as we learn more about the emerging advances in various ophthalmic subspecialties that can be applied to obtain the best possible care of our patients. Moreover, we will continue to highlight clinically relevant information and maintain our commitment to excellence.

G. K. Krieglstein
R. N. Weinreb
Series Editors

Preface

In a field that changes as rapidly as ophthalmology, why do clinicians continue to buy books? There are probably several reasons, but a primary one is that a well-written book provides comprehensive, evidence-based, clinically relevant overviews that cannot be obtained elsewhere. The challenge is to provide this material to readers in a timely fashion, in a format that facilitates easy reference and clinical use, and in sufficient detail that basic science and theoretical aspects are provided. We hope that this volume accomplishes these goals.

This second edition of *Cataract and Refractive Surgery* includes topics that complement those in the first edition and represent new areas of clinical importance in cataract and refractive surgery. The cataract section emphasizes the management of complex cases, intraocular lens selection and power calculations. In the refractive surgery section, topics include both corneal and lenticular approaches, particularly new technologies in both realms.

We hope that the readers will find this edition to be of intellectual interest and substantial clinical value. We owe a great deal of gratitude to the authors who have worked so hard to mine their own and others' experiences and data to write these chapters.

T. Kohnen
D. D. Koch
Volume Editors

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Cataract Surgery

Chapter 1

Intraocular Lenses to Restore and Preserve Vision Following Cataract Surgery

1

Robert J. Cionni

Core Messages

- Our ability to restore vision lost to cataracts has improved tremendously over the last few decades.
- More focus on maintaining vision is essential, especially for patients with macular degeneration.
- Blue light has been shown to be potentially damaging to the retina.
- The normal human crystalline lens filters out much blue wavelength light. Removal of this lens and placing a colorless UV-blocking intraocular lens (IOL) leaves the retina exposed to higher levels of blue light.
- IOLs are now available that can filter out blue light similar to the normal human lens.
- These blue filtering IOLs have been shown to have no negative effect on vision in terms of visual acuity, contrast sensitivity, color perception, and night vision.

1.1 Introduction

Although cataract surgery has been performed for many centuries, technological advances now provide us with the opportunity to afford our patients vision more similar to the pre-cataract state than ever before. Advanced instrumentation and surgical techniques allow our patients to expect excellent uncorrected vision within 24 h of surgery. In addition, newer multifocal and accommodating intraocular lens (IOLs) offer the possibility of distance, near, and intermediate vision without glasses [2, 23, 32]. With these IOLs we can not only restore vision to the pre-cataract level, but also to the pre-presbyopia state, thereby reducing spectacle dependency. Unfortunately, many of our cataract patients suffer from age-related macular degeneration (ARMD) as well and are concerned about progressive vision loss following cataract surgery. Despite our success in restoring vision for our cataract patients, we have not gained much ground in preserving vision for those patients with macular degenerative disease. Over the last few decades more and more literature has surfaced suggesting that blue light may be one factor in the progression of ARMD [8]. The normal human crystalline lens filters not only ultraviolet light, but also much of the high frequency blue wavelength light. When we remove the crystalline lens, we remove the eye's natural blue light filter. If we replace the crystalline lens with an IOL that does not filter this blue wavelength light, we must wonder if we are increasing the risk of worsening ARMD. In recent years, blue-light filtering IOLs have been released by two IOL manufacturers. In this chapter we will look at the rationale for implanting blue-light filtering IOLs in an effort to not only restore our patients' vision, but also to preserve that vision.

1.2 Why Filter Blue Light?

It is well known that pseudophakic eyes are more susceptible to retinal damage from near ultraviolet light sources [11, 15]. Pollack et al. followed 47 patients with bilateral early ARMD after they underwent extracapsular cataract extraction and

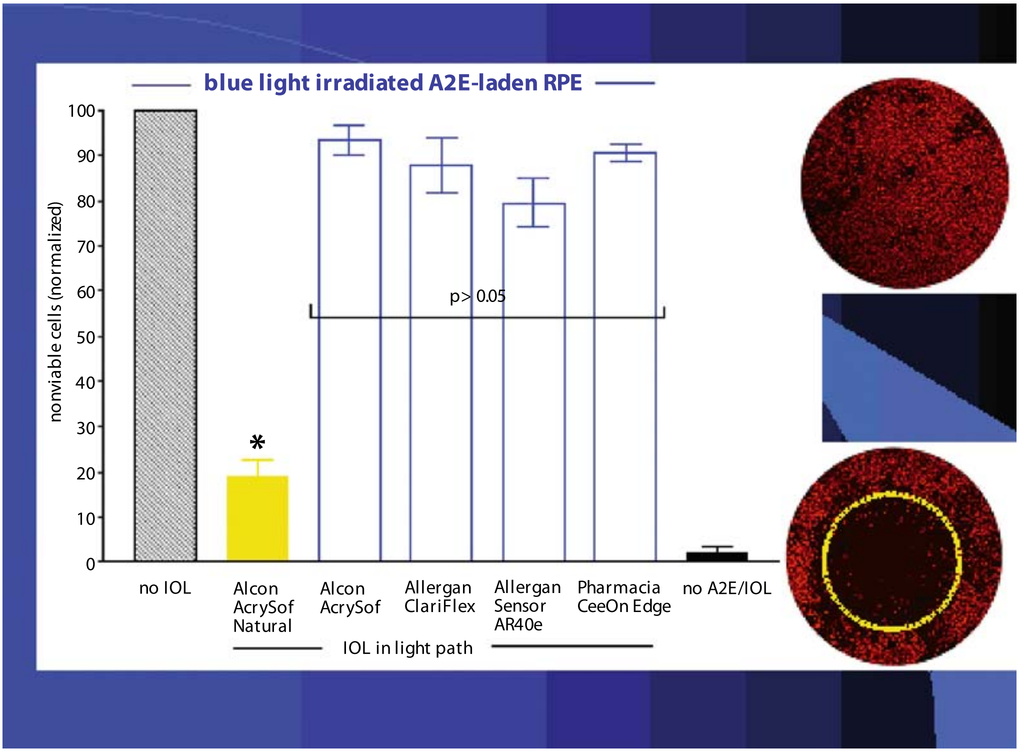

Fig. 1.1 Cultured human retinal pigment epithelial (RPE) cells laden with A2E exposed to blue wavelength light. Cell death is significant when UV blocking colorless intraocular lenses (IOLs) are placed in the path of the light, yet markedly reduce when the AcrySof Natural IOL is placed in the light path

implantation of a UV-blocking IOL in one eye, with the fellow eye as a phakic control [25]. Neovascular ARMD developed in 9 of the pseudophakic eyes versus 2 of the control eyes, which the authors suggested might be due to the loss of the "yellow barrier" provided by the natural crystalline lens.

Data from the Age-Related Eye Disease Study (AREDS), however, suggest a heightened risk of central geographic retinal atrophy in pseudophakic eyes [1]. The retina appears to be susceptible to chronic repetitive exposure to low-radiance light as well as brief exposure to higher-radiance light [17, 18, 31, 34]. Chronic, low-level exposure (Class 1) injury occurs at the level of the photoreceptors and is caused by the absorption of photons by certain visual pigments with subsequent destabilization of photoreceptor cell membranes. Sparrow and coworkers have demonstrated that a component of lipofuscin, known as A2E, is integral in blue light-induced retinal pigment epithelium (RPE) damage [3, 14, 29] and although the retina has inherent mechanisms from Class 1 photochemical damage, the aging retina is less able to provide sufficient protection [27, 37].

Several epidemiological studies have concluded that cataract surgery or increased exposure of blue wavelength light may be associated with progression of macular degeneration [5, 35]. However, other epidemiologic studies have failed to come to this conclusion [6, 7, 19]. Such conflicting epidemiological results are not unexpected since age-related macular disease is felt to be a multifactorial biologic process. Therefore, many of the studies concerning the effects of blue light on the retina have been conducted in animals and in vitro [13, 16, 17, 21, 24, 26]. Numerous of these laboratory studies demonstrate a susceptibility of the RPE to damage when exposed to blue light [28, 29].

If blue light can potentially induce retinal injury, what is felt to be the etiology of the damage? It is well known that lipofuscin accumulates in the RPE cells as we age. One component of lipofuscin is a compound known as A2E and it is this compound that is believed to be the culprit in RPE cell death. A2E has an excitation maximum in the blue wavelength region (441 nm) and when excited by blue light, A2E generates oxygen free radicals, which can lead to RPE cell damage and death. At Columbia University, Sparrow and colleagues exposed cultured human RPE cells laden with A2E to blue light and observed extensive cell death. They then placed different UV blocking IOLs or a UV blocking and blue light filtering IOL in the path of the blue light to see if any of the IOLs provided a protective effect. The results of this study demonstrated that cell death was extensive with all UV blocking colorless IOLs, but significantly diminished with the UV and blue light filtering IOL (Fig. 1.1) [30]. These experiments were conducted in vitro and therefore cannot take into account any natural protective mechanisms that might be present in vivo. Additionally, the light exposure employed was more representative of high-level short-term exposure rather than low-level chronic exposure. Still, this work demonstrates clearly that blue light-filtering IOLs can help A2E-laden RPE cells to survive the phototoxic insult of the blue light.

Summary for the Clinician

- A growing body of literature suggests that blue light exposure may be one factor in the progression of macular degeneration.

1.3 Why is the Consideration of Blue Light Important to Our Cataract and Refractive Lens Exchange Patients?

The human crystalline lens normally filters ultraviolet light and much of the light in the blue wavelength spectrum [12]. When the lens is removed during cataract or refractive lens exchange (RLE) surgery, this blue-wavelength light can now reach the retina, thereby exposing the RPE cells to much higher levels of blue light than they have ever known. If a *colorless* UV blocking IOL is implanted, the RPE cells remain exposed to this increased level of potentially damaging blue light ever after. At the time of writing, two manufacturers have developed IOLs that filter blue light in addition to UV light.

The AcrySof Natural (Alconlabs, Fort Worth, TX, USA) is a hydrophobic acrylic foldable IOL that incorporates a yellow chromophore cross-linked to the acrylic molecules. This yellow chromophore allows the IOL to filter not only UV light, but also specific levels of light in the blue wavelength region. Aging studies have shown that the chromophore will not leach out or discolor (unpublished, Alconlabs). The AcrySof Natural IOL was approved for use in Europe in 2002 and in the USA in 2003. Evaluation of its light transmission curve demonstrates that this IOL approximates the transmission spectrum of the normal human crystalline lens in the blue light spectrum (Fig. 1.2). Therefore, in addition to benefiting from less retina blue light exposure, color perception should seem more natural to these patients as opposed to the increased blue hues seen by patients who have received colorless UV blocking IOLs [39]. Hoya brought blue-light filtering IOLs to Japan in 1991 (three-piece PMMA Model HOYA UVCY) and in1994 (single-piece PMMA Model HOYA UVCY-1P). The blue-light filtering characteristics of the Hoya and the AcrySof Natural differ slightly (Fig. 1.3). Clinical studies of some of these blue light-filtering IOLs have been carried out in Japan. One study found that pseudophakic color vision with a yellow-tinted IOL approximated the vision of 20-year-old control subjects in the blue light range [9]. Another study found some improvement in photopic and mesopic contrast sensitivity, as well as a decrease in the effects of central glare on contrast sensitivity, in pseudophakic eyes with a tinted IOL versus a standard lens with UV blocker only [22].

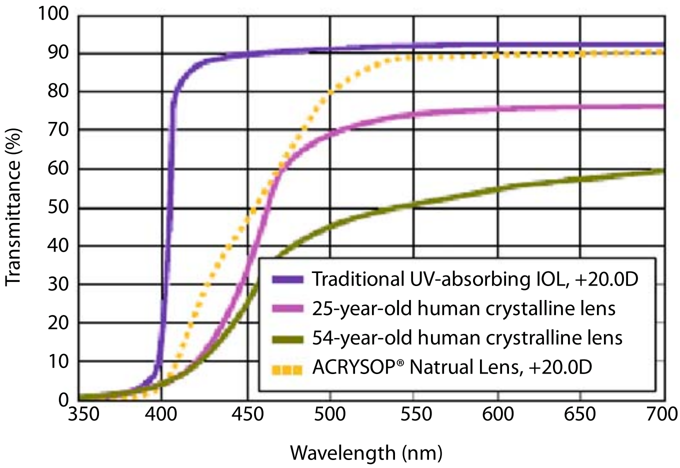

Fig. 1.2 Light transmission spectrum of the AcrySof Natural IOL compared with those of a 25-year-old and a 54-year-old human crystalline lens and a 20-diopter colorless UV-blocking IOL [12]

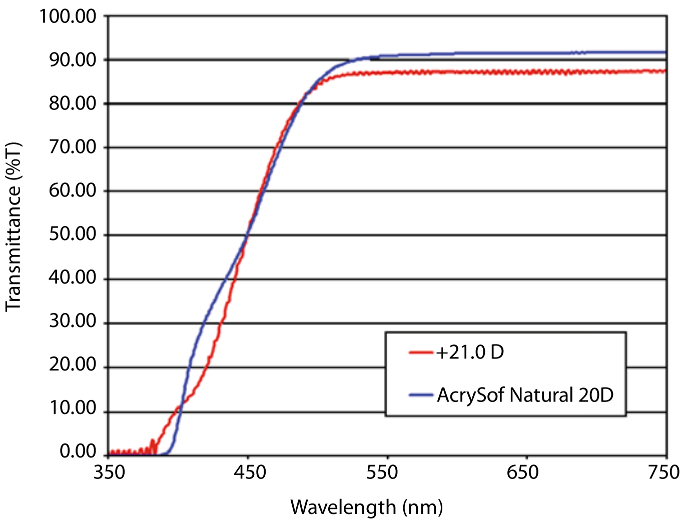

Fig. 1.3 UV/visible transmission spectra for AcrySof Natural and Hoya AF-1 blue light-filtering IOLs obtained using the same instrument under identical conditions (unpublished, Alconlabs)

Summary for the Clinician

- Removing the cataractous or noncataractous human lens removes the eye's natural blue light filter and exposes the retina to higher levels of blue light than ever before. IOLs are now available that can filter out much of that blue wavelength light similar to the normal noncataractous human lens.

1.4 Quality of Vision with Blue-Light Filtering IOLs

A multi-centered, randomized prospective FDA evaluation of the AcrySof Natural IOL was carried out before the lens gained approval for use in the USA. Three hundred patients were randomized to bilateral implantation of the AcrySof Natural IOL or the clear AcrySof Single-Piece IOL. All patients were screened to ascertain normal preoperative color vision before being deemed eligible for the study. Postoperative parameters measured included visual acuity, photopic and mesopic contrast sensitivity, and color percep-