Optics, Visual Quality, and Acuity

What is the impact of optics on patients' satisfaction?

BY WILLIAM B. TRATTLER, MD

This article discusses material and design issues with refractive IOLs and how they have an impact on patients' visual results. These issues include chromatic aberration, spherical aberration, glistenings, blue-light–blocking chromophores, and the reduction of posterior capsular opacification. Although independently these factors may not seem significant, their combined effect does play a significant role in patients' quality of vision postoperatively. It is therefore important to consider these issues when selecting an IOL.

CHROMATIC ABERRATION

The way certain IOLs split light can create a rainbow effect inside the eye that distorts and reduces visual quality (Figure 1). Chromatic aberration in IOL material is quantified by an Abbe number. The higher the Abbe number, the lower the chromatic aberrations and the crisper the lens' optics. The Abbe number is not related to whether a lens is diffractive, refractive, monofocal, or multifocal.

The natural crystalline lens has an Abbe number of 47. Abbott Medical Optics Inc. (Santa Ana, CA) makes an acrylic IOL material with a very high Abbe number (55), which means it has fewer chromatic aberrations and therefore provides a higher quality of vision.[1,2] The acrylic material made by Hoya Surgical Optics, Inc. (Chino Hills, CA), which recently gained FDA approval, has an Abbe number of 42. IOLs with higher Abbe numbers provide improved quality of vision. This not only helps patients with monofocal IOLs, but it is especially important in patients with presbyopia-correcting IOLs,

Rays of light enter the Tecnis Multifocal IOL (Abbott Medical Optics Inc.) through the optic's flat surface, and then they interact with the diffractive optics at the back of the lens. When this lens became available and I started providing it, my optometrist and staff members noticed that our patients experienced a significant "wow" effect after surgery. I believe the Tecnis Multifocal's material and high Abbe number contribute to the positive results our patients have with this lens.

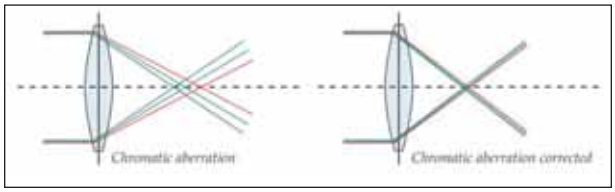
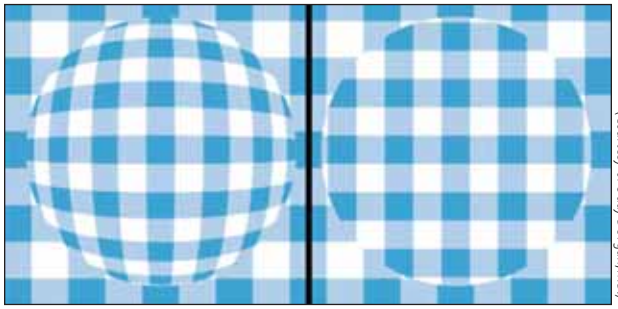


Figure 1. The way certain IOLs split light can create a rainbow effect inside the eye that distorts and reduces visual quality.



(Courtesy of Uday Devgan, MD.)

Figure 2. An aspheric optic corrects visual distortions.

SPHERICAL ABERRATION

After cataract extraction, surgeons have to adjust the eye's optics to the spherical aberration present in the cornea. Correcting refractive error with a sphere (positive spherical aberration) will give the patient crisp vision in one focal area but will distort his or her vision elsewhere. An aspheric optic corrects visual distortions (Figure 2). A study performed by Wang et al in 2003 found that the mean spherical aberration present in the cornea was +0.28.[3] This amount remains stable with age. Eyes that have undergone hyperopic LASIK have negative corneal spherical aberration, which is why those eyes see better with a spherical IOL (such as a standard, nonaspheric monofocal). Eyes that have undergone prior myopic LASIK are left with positive spherical aberration, so they see best with a negative spherical IOL like the Tecnis 1-Piece or Acrysof IQ (Alcon Laboratories, Inc., Fort Worth, TX) monofocals. For patients who have undergone myopic LASIK and desire presybopic correction, a

(Image created by Uday Devgan, MD.)

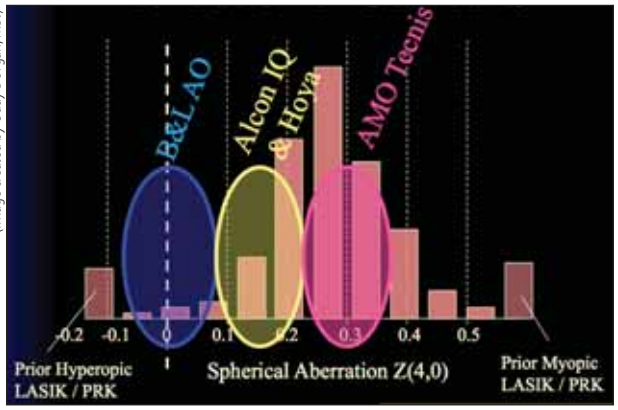


Figure 3. For some patients, a multifocal IOL with higher negative spherical aberration can be a better option than a presbyopia-correcting IOL without negative spherical aberration correction.

multifocal IOL with higher negative spherical aberration such as the Tecnis Multifocal or the AcrySof IQ Restor +3.0 D (Alcon Laboratories, Inc.) can be a better option than presbyopia-correcting IOLs without negative spherical aberration correction (Figure 3).

As Figure 3 shows, the Tecnis 1-Piece monofocal IOL corrects approximately -0.27 D, the range of spherical aberration that most patients have, and it reduces spherical aberration to zero. In fact, the Tecnis monofocal IOL gained new-technology IOL status from the FDA (surgery centers are reimbursed at a higher level when new-technology lenses are used) due to studies that demonstrated improved quality of vision at night for seniors. Ongoing studies are examining whether measuring a cornea's precise spherical aberration will allow surgeons to match IOLs with the correct spherical aberration value to optimize postoperative results.

GLISTENINGS

There is a key difference in how IOLs are made that may contribute to the phenomenon of glistenings. Some clinicians have observed the appearance of glistenings or vacuoles in the IOL at the slit lamp. Some manufacturers (such as Abbott Medical Optics Inc. and Hoya Surgical Optics, Inc.) set their IOLs in plastic and then cut them with a lathe. Other companies inject the acrylic material into a mold, a process that may leave tiny vacuoles that can trap water as the temperature of the material cools. These glistenings have been associated with a significant loss in contrast sensitivity at high spatial frequencies.[4,5]

Glistenings can cause more severe visual symptoms in multifocal IOLs, which split light to a greater degree than monofocal lenses.

BLUE ULTRAVIOLET LIGHT

Whether it is beneficial or detrimental for patients to have an IOL with a chromophore that blocks the transmission of blue light is an ongoing controversy in ophthalmology.[6] Some researchers argue that, at nighttime, much of humans' visual function comes from the blue area of the light spectrum and that blocking this transmission reduces quality of vision and contrast sensitivity.[7-10] Many IOLs come in a clear and tinted version to suit the surgeon's preference.

POSTERIOR CAPSULAR OPACIFICATION

Square-edged IOLs include the Tecnis 1-Piece monofocal and Tecnis Multifocal as well the AcrySof monofocal and AcrySof Restor. These IOLs have been shown to block the development of posterior capsular opacification compared with other lenses.[11]

SUMMARY

There is a great deal of detail that goes into the design and materials of an IOL. All of these factors contribute to the overall visual quality that a patient receives from the lens. Visual quality is imperative to patients' overall satisfaction with their cataract surgery. It is critical for surgeons to understand how the IOL can affect the success of the procedure and the patient's quality of vision. ■

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