10 Years of Tecnis

Aspheric optics introduced the new era of refractive cataract surgery, in which improving visual performance has become the driving force in IOL design.

BY JACK T. HOLLADAY, MD

It has been a decade since we surgeons first realized that IOL optics could reduce or eliminate spherical aberration (SA) to restore a youthful quality of vision for pseudophakes. That discovery, which led to the introduction of the first successful aspheric IOL, also set us on a course for a greater emphasis on visual performance and refractive outcomes after cataract surgery.

Throughout the 1990s, an awareness of the effect of laser refractive surgery-induced aberrations on visual quality was growing. SA and the night vision difficulties it created were of particular concern. Around the same time, researchers such as Pablo Artal, PhD; Antonio Guirao, PhD; Adrian Glasser, PhD; and others demonstrated that the average optical performance of the human eye progressively declines with age and that this is primarily due to increasing SA of the crystalline lens.[1-4]

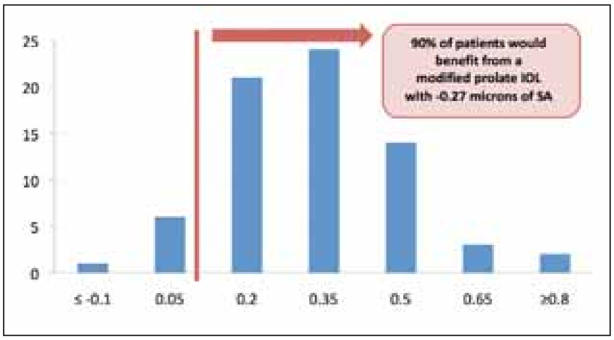

Figure 1. Distribution of corneal SA for a 6-mm pupil in 71 cataract patients. The dark line shows the point at which patients would benefit from a lens with -0.27 µm of negative SA. Holladay et al[5] demonstrated that 90% of patients (those to the right of the line) would benefit.

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The negative SA of the crystalline lens in youth compensates for the cornea's positive SA until about age 20, after which lenticular SA becomes increasingly positive. Eventually, the dual contribution (lens + cornea) to positive SA reduces quality of vision, which manifests as halos and glare. Cataract surgery and the placement of an IOL are beneficial, but conventional spherical IOLs still add slightly positive SA to the already positive SA of the cornea.

Just 10 years ago, none of this was widely recognized by the ophthalmic community, but Patricia Piers, Sverker Norrby, and colleagues, including myself, were intrigued. The SA of the human lens had previously been analyzed. We set out to determine the mean corneal SA for a population of cataract surgery patients and to design a lens to compensate for that SA in a majority of people.[5]

Corneal topography measurements on 71 cataract patients showed that the average SA of the human cornea was +0.27 µm over a 6-mm zone. A model cornea based on these measurements was used to design modified prolate IOLs with a fixed amount of negative SA to compensate for the cornea's mean positive SA. Our calculations showed that 64 of 71 patients (90% of the population) would have a reduction in total ocular SA with the new IOLs compared to spherical lenses.[5]

An earlier attempt by Ophthalmic Radiation Corp. at making an aspheric IOL in the 1980s had failed because of the degree of tilt and decentration inherent in cataract surgery techniques at the time. These early aspheric lenses actually performed worse optically than a spherical IOL due to large amounts of lens tilt and decentration inherent in extracapsular surgery without a capsulorhexis and viscoelastics. By the 1990s, these values had dropped to an average of 0.2-mm decentration and 2° of tilt, due to the increased precision of the surgery. In our study, however, ray tracing demonstrated that the modified prolate IOL could tolerate decentration of up to 0.4 mm and tilt of up to 7° for polychromatic light—well within the capabilities of modern, in-the-bag IOL implantation with a continuous curvilinear capsulorhexis. In the same issue of the journal in which this study appeared, Mark Packer, MD, and colleagues published their clinical results with the new IOL, confirming a statistically significant improvement in scotopic and photopic contrast sensitivity predicted with the modified prolate IOL.[6]

INTRODUCTION OF THE TECNIS ASPHERIC IOL

The Tecnis IOL was introduced by Pharmacia (now, after several acquisitions, owned by Abbott Medical Optics Inc., Santa Ana, CA) and approved by the FDA in 2004. The lens had -0.27 µm of negative SA compared with +0.05 µm for a conventional spherical IOL.

At first, surgeons were skeptical of the value of asphericity. The biggest factor in changing their perceptions was a series of driving simulations to determine the lens' impact on functional vision.[7] On average, the Tecnis lens improved drivers' reaction time by 0.5 seconds, offering a meaningful safety benefit for elderly patients. The addition of a rear window taillight improved reaction time by 0.3 seconds, as a comparison. Since then, many other articles have demonstrated better visual performance, including contrast sensitivity and night vision, with the Tecnis IOL compared with spherical lenses.[8-14]

After the Tecnis, other IOL manufacturers rapidly followed suit, introducing their own aspheric IOLs. These lenses aim either to be SA neutral (Sofport AO, Bausch + Lomb, Rochester, NY) or to leave a small amount of residual positive SA (Acrysof IQ; Alcon Laboratories, Inc., Fort Worth, TX). Studies continue to show that most emmetropic eyes achieve the best image quality when the total ocular SA is -0.10 to 0.00 µm.[15] If the surgeon must deviate from zero SA due to the availability of asphericities, it is better to err on the negative side, because the patient gains some accommodative effect from the negative SA when the pupil constricts for near tasks.

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Today, many surgeons routinely customize the IOL's selection to the patient's actual amount of spherical aberration. Topography and tomography printouts include the SA Zernike term {Z(4,0)}, making it easy to quickly decide which aspheric lens will bring the patient's total SA closest to zero.

ONGOING INNOVATION

The idea that surgeons could eliminate SA, achieve the contrast sensitivity of a 20-year-old, and even improve near vision with aspheric optics was a step along the way to the latest generation of IOL innovation and multifocal and accommodating optics. Multifocal IOLs inherently involve some loss of contrast sensitivity. Aspheric optics make it possible to create a higher-contrast image on the retina, even with a multifocal IOL. The improvement in contrast from the aspheric surface provides a platform for better-performing multifocal IOLs.

Surgical technique has evolved with the technology. We now understand, for example, that diffractive multifocal IOLs need to be implanted with their rings concentric with the patient's pupil to achieve the best optical performance. This approach has virtually eliminated the earlier problem of waxy vision with diffractive multifocals and helped these lenses perform to their full potential.[16-21] A one-piece design for the Tecnis lenses has also been very helpful. A single-piece lens with a squared edge is simple to implant and lowers the rate of posterior capsular opacification.

There are many important developments for this platform still in the pipeline, including toric and toric presbyopia-correcting versions. I can imagine a time when we might have an aspheric, toric, SA- and coma-correcting IOL. Surgeons would calculate the IOL power, measure the patient's corneal spherical aberration and coma, and then match those to the correct lens for each eye, further improving patients' vision. I also expect we will have presbyopia-correcting lenses capable of offering 4.00 D of accommodation with no night time dysphotopsias within the next 5 years.

From the introduction of the first Tecnis aspheric lens through today's technological focus on presbyopic correction, the goal has been consistent: to improve optical performance. The Tecnis has been important not just for the quality-of-vision gains that result directly from the aspheric optics but also for pushing cataract surgeons to think more about maximizing refractive outcomes in general. ■

Jack T. Holladay, MD, is a clinical professor of ophthalmology at Baylor College of Medicine in Houston and founder and medical director of the Holladay LASIK Institute in Bellaire, Texas. Dr. Holladay is a consultant to Abbott Medical Optics but stated he holds no financial interest in any IOL. Dr. Holladay may be reached at fax (713) 669-9153; holladay@docholladay.com.

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