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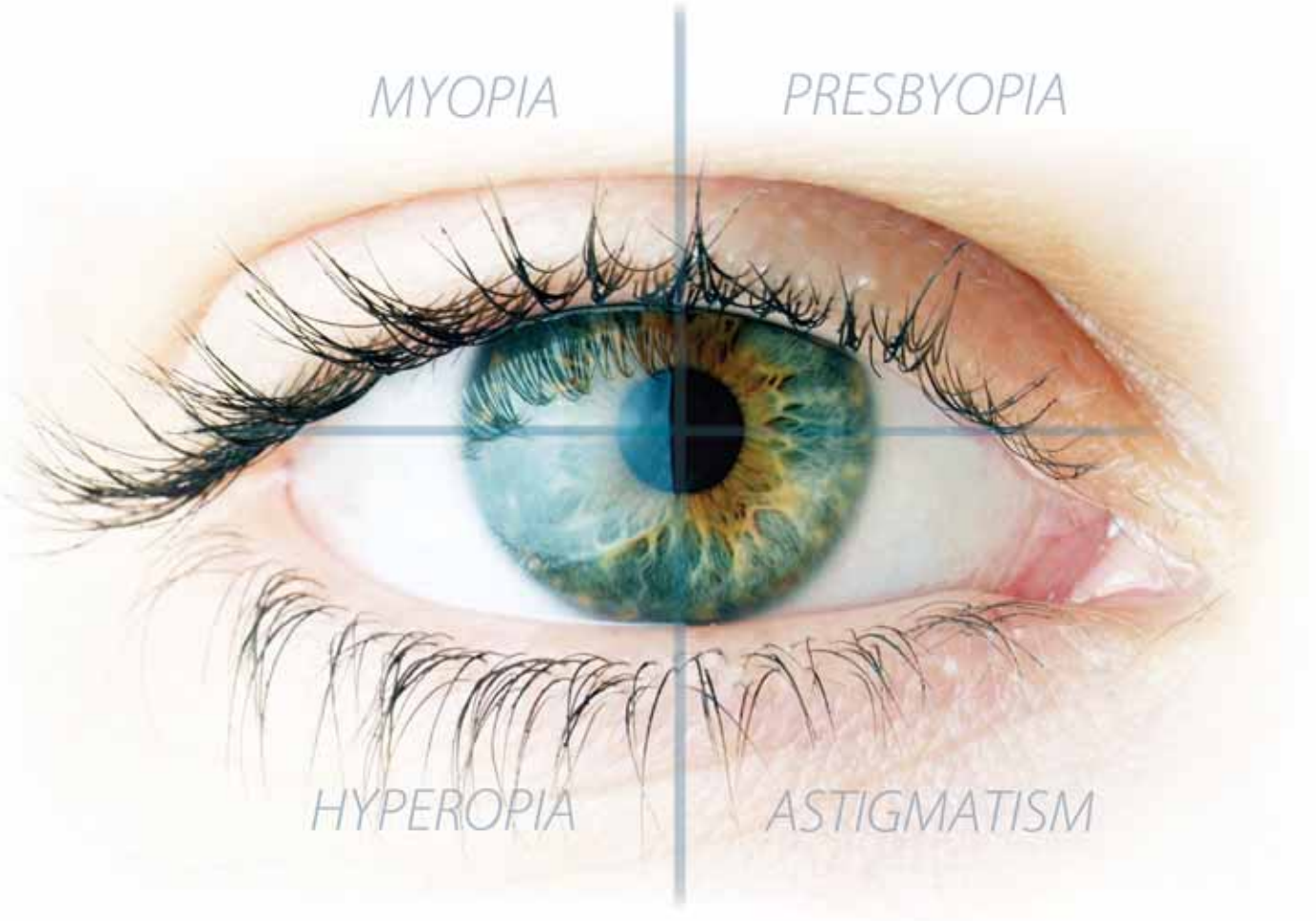
Cataract & Refractive Surgery TODAY

EUROPE

Refractive Solutions

Advanced-technology treatments for nearly every refractive problem.



Refractive Solutions

Advanced-technology treatments for nearly every refractive problem.

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A Solution for Every Condition

The WaveLight Refractive Suite and the AcrySof IOLs.

BY ARTHUR CUMMINGS, MB ChB, FCS(SA), MMed(Ophth), FRCS(Edin)

Today's refractive and refractive cataract surgeons are faced with five main patient groups: low-to-moderate myopes, high myopes, hyperopes, astigmats, and presbyopes. In our quest to please patients, we need to have an armamentarium of surgical technologies that can address these varying presentations, and we need the knowledge base to match the most appropriate technology to the ocular issue at hand. With some eyes, the practitioner can easily choose between a laser or an IOL treatment. Other conditions are more difficult to match with the best solution.

As a clinician faced with such challenges, I continue to be impressed with the surgical technologies produced by Alcon Laboratories, Inc. (Fort Worth, Texas). Between its advanced, integrated laser products and spectrum of AcrySof IOL products, the company has provided ophthalmologists with a treatment modality for the majority of visual complaints. This article provides an overview of these technologies. In the following pages, respected practitioners describe their experience with these new technologies in detail and share insights about how these modalities fit into the surgical arsenal.

THE TECHNOLOGIES

The WaveLight Refractive Suite

Alcon Laboratories, Inc., and its WaveLight subsidiary have built a state-of-the-art Refractive Suite (Figure 1) that

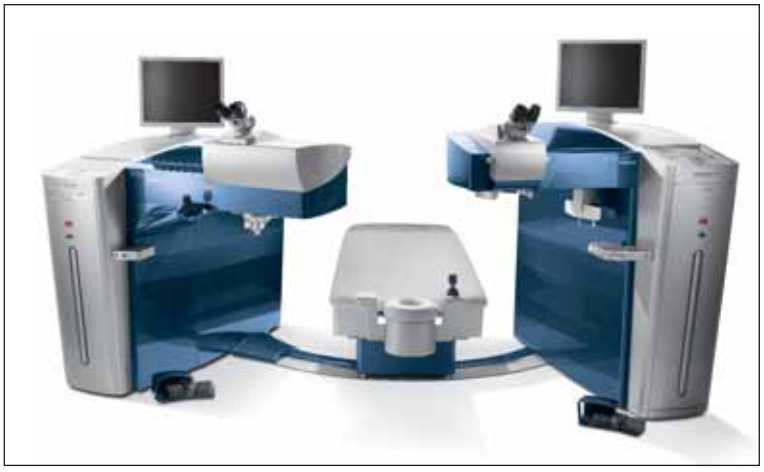


Figure 1. The WaveLight Refractive Suite, which includes the EX500 excimer laser and the FS200 femtosecond laser.

consists of a femtosecond laser (the WaveLight FS200) that fully integrates with the WaveLight EX500 excimer laser. The two lasers communicate freely with each other, and this Refractive Suite is currently being trialed in a network with the WaveLight ALLEGRO diagnostic devices (the Topolyzer, Oculyzer, WaveFront Analyzer, and Optical Biometer [OB820]—although the OB820 will not network with the system until later next year).

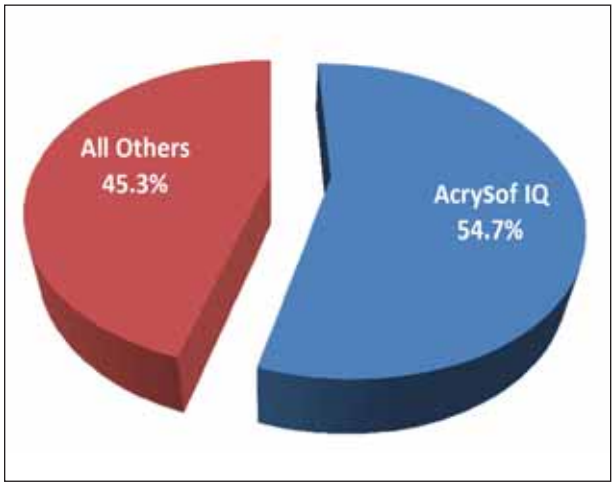
Already, the Refractive Suite provides an unprecedented level of patient customization in corneal laser vision correction. Not only can the 200-kHz WaveLight FS200 femtosecond laser cut flaps in a range of depths and diameters, but it also allows the surgeon to select the location of the hinge and to make the cut in either a round or elliptical shape. It can even make the incisions and channels for corneal inlays as well as perform lamellar or penetrating keratoplasty. Furthermore, the integration between the two lasers allows the FS200 femtosecond laser to see the EX500 excimer laser's ablation profile, so that the surgeon can digitally position the corneal flap over the area of ablation. No longer does the surgeon have to try to decenter the flap over a customized treatment by preempting where the ablation profile is going to be placed on the cornea. Another notable feature of the WaveLight FS200 femtosecond laser is that its ablation architecture creates an exhaust or channel for the cavitation plume to escape to the limbal area, thereby preventing an opaque bubble layer (see page 9 for further description of this channel).

The AcrySof IQ ReSTOR IOLs

The AcrySof family of IOLs is one of the most enduring and extensive platforms available. The newest additions to the line are the apodized, diffractive, aspheric AcrySof IQ ReSTOR IOLs. These lenses have more than 3 years of experience worldwide and greater market share in the United States than any other presbyopia-correcting IOL currently available (Figure 2). The newest of the IQ ReSTOR lenses, the AcrySof IQ ReSTOR Multifocal Toric IOL, treats from 0.50 to 2.32 D of astigmatism as well as presbyopia. All three lenses incorporate an aspheric component that provides additional negative asphericity to enhance depth of focus. The biconvex, aspheric toric design features the same stability as the original AcrySof Toric IOL but with a thinner optic profile to accommodate microincisional surgery.

The CACHET IOL

The new AcrySof CACHET IOL (Figure 3) is a phakic, anterior-chamber lens designed to treat moderate-to-high myopia (-6.0 to -16.5 D). It is built on the familiar foldable AcrySof platform and has shown promising outcomes in Conformité Européenne (CE)-Mark studies.[1] This lens features a unique "low-force" four-point bridged haptic design that stabilizes the lens in the anterior chamber and minimizes the inflammatory response. It also maintains a low, 0.5-mm vault to prevent contact with the posterior cornea. The AcrySof CACHET IOL can be placed through a clear corneal incision under topical anesthesia and does not require a peripheral iridectomy.



(Courtesy of Market Scope LLC, St. Louis, MO.)

Figure 2. Q1 2010 US market share for presbyopia-correcting IOLs.

THE BEST SOLUTION FOR THE PROBLEM

Low-to-Moderate Myopia

Laser vision correction is the obvious choice to treat low-to-moderate myopia whenever possible. Low myopes respond best to LASIK or advanced surface laser procedures, and moderate myopes can undergo LASIK or a surface treatment if their cornea is thick enough and if the final postoperative keratometry is 34.0 to 35.0 D or steeper. For both types of treatments (LASIK or ASA), the WaveLight excimer laser has proven itself to be one of the most capable and reliable lasers available. The current WaveLight Eye-Q laser's standard 400-Hz scanning-spot Wavefront Optimized ablation profile achieves excellent outcomes. The results are so good that 85% of my clinic's laser refractive patients are treated with this Wavefront Optimized profile. Patients with aberrated eyes (eyes with visual quality complaints despite best spectacle correction) are good candidates for customized wavefront-guided procedures, driven by the ALLEGRO Analyzer. The Analyzer works on Tscherning principles to capture the entire eye's individual wavefront aberrations.

Eyes for which we are unable to capture a reliable wavefront map (occasionally, those that have undergone previous surgery) can be treated with T-CAT, WaveLight's topography-guided customized ablation software. The ALLEGRO Topolyzer captures 22,000 measurement points of the corneal surface and then sends the information to the WaveLight EX500 excimer laser. Within the laser, the T-CAT software calculates the appropriate ablation pattern. The Topolyzer particularly excels at expanding and recentering optical zones and treating irregular astigmatism. This technology allows surgeons to expand our treatment range to include irregular corneas.

For topographic mapping as well as total pupillary input (centroid shift for each and every pupil size), the Topolyzer VARIO uses Placido-disk technology to capture 3-D images of the cornea relative to the pupil's center for every given pupil size. For those who prefer Scheimpflug imaging, the Refractive Suite's ALLEGRO Oculyzer is a version of the Pentacam Comprehensive Eye Scanner designed by Oculus, Inc. (Lynnwood, Washington) specifically for the WaveLight laser (this connection is called *OcuLink*). (For a brief discussion of the pros and cons of each topographic system, see the sidebar *Placido-Disk Versus Scheimpflug Topography* on page 5.)

Figure 3. The AcrySof CACHET IOL.

High Myopia

To treat older high myopes who are already presbyopic, we can either use laser vision correction with or without monovision, or we can consider performing a refractive lens exchange. Alternatively, we can consider the new AcrySof CACHET IOL for younger high myopes who are not yet presbyopic. This lens is good for high myopes who do not have enough corneal tissue for a laser ablation and who want a less invasive procedure than a lens exchange.

Hyperopia

Most surgeons are inclined to treat the higher levels of hyperopia with IOLs. The AcrySof IQ ReSTOR family of IOLs offers a range of powers for treating hyperopes. For complicated eyes such as hyperopic astigmats or those with a narrow anterior chamber, however, the AcrySof Toric IOL has extensive clinical experience and is known for its stability in the capsular bag.

The laser option also works particularly well for patients with hyperopia and hyperopic astigmatism. The upper level of hyperopic spherical corrections with the WaveLight excimer laser is around 5.50 D in my hands, although the laser has a higher range than this as approved by the FDA. My guideline is not to make the cornea steeper than 48.0 D once the treatment is completed. This refraction is steeper than I would have corrected before with other lasers, but with the WaveLight laser's excellent hyperopic profile, the quality of vision in a cornea of 48.0 D is still excellent.

Astigmatism

For spherical and cylindrical correction, the WaveLight Refractive Suite works beautifully. The laser has FDA approval for up to 7.0 D of astigmatism, which is sufficient for most astigmats. On occasion, however, for various reasons (a thin cornea, dry eye, etc.), refractive lens exchange with a toric IOL may be a better option than laser vision correction. I try to adhere to the following guideline: If the corneal astigmatism matches the refractive astigmatism, I try and treat the astigmatism on the cornea with laser vision correction. If the corneal astigmatism is more than the refractive astigmatism, I generally use a toric IOL or toric phakic IOL.

The AcrySof IQ ReSTOR Multifocal Toric IOL is available in powers from +6.0 to +30.0 D and can then treat additional astigmatism. This lens is not suitable for patients who have macular degeneration and diabetic retinopathy. For a multifocal IOL to function ideally, both maculae must be healthy, and both eyes must have good potential BCVA.

Presbyopia

Presbyopes can be treated with either a laser or a lens. The AcrySof IQ ReSTOR IOL offers these patients an aspheric, apodized, diffractive optic with +3.0 D of reading add (+2.5 D at the spectacle plane). This lens come in powers from +6.0 D to +34.0 D. The AcrySof IQ ReSTOR IOL +3.0 D is designed to provide true performance at all distances for patients who wish to reduce dependence on spectacles for near, intermediate, and distance vision.

Within the laser modality, the WaveLight Eye-Q excimer laser (Alcon Laboratories, Inc.) provides a range of treatment options to suit most presbyopes' needs. Here again, the standard Wavefront Optimized monovision ablation profile has a proven track record. Additionally, surgeons around the world are gaining experience with presby-LASIK, in which the surgeon gives the cornea two treatments: first, an intentional overcorrection of +1.5 D, with a second, immediate correction of this overcorrection. This works in both directions (ie, myopia and hyperopia). For example, a +2.0 D refractive error is treated with an initial ablation of +3.5 D, overcorrected to -1.5 D. This is immediately corrected with a -1.5 D treatment. For the -3.0 D myope, the treatment is -4.5 D, resulting in +1.5 D of overcorrection. This is immediately treated to correct the +1.5 D. The range for this type of treatment is -4.0 to +3.0 D.

Another laser technique that is currently used with the WaveLight excimer laser technology is the aspheric hyperprolate profile. This approach uses Custom Q, the laser's Q-adjusted global optimized ablation, to create increased depth of focus. The benefits of this ablation profile are a prolate cornea and a large optical zone, which improve depth of focus by inducing negative spherical aberration. At the same time, the uncorrected distance vision in this reading eye is better than one would expect for a "normal" -1.50 D eye, so the patient experiences a less-than-typical compromise for distance vision.

SUMMARY

With such a range of treatment modalities available, we ophthalmologists can confidently market our services to a wide range of patients with varying refractive errors. We need this kind of flexibility as the cataract and refractive subspecialties increasingly overlap, patients become more demanding, and the structure of private and public health coverage options changes. I encourage you to read more about these intriguing technologies in the following pages. ■

Arthur B. Cummings, MB ChB, FCS(SA), MMed(Ophth), FRCS(Edin), practices at the Wellington Eye Clinic & UPMC Beacon Hospital, Dublin, Ireland. He is a consultant and investigator for Alcon/WaveLight. Dr. Cummings may be reached at phone: +353 1 2930470; e-mail: abc@wellingtoneyeclinic.com.

1. Kohnen T, Klaproth OK. Three-year stability of an angle-supported foldable hydrophobic acrylic phakic intraocular lens evaluated by Scheimpflug photography. *J Cataract Refract Surg*. 2010;36(7):1120-1126.

PLACIDO-DISK VERSUS SCHEIMPFLUG TOPOGRAPHY

In most eyes, ablation profiles derived from the Topolyzer and the Oculyzer (Pentacam) are basically identical, so either one can be used to an equal effect. Scheimpflug imaging provides more data centrally, whereas Placido-disk imaging has a scotoma in the center where the camera is (data are interpolated for this area). Thus, I tend to use the Scheimpflug data if the corneal irregularity is located more centrally. If the problem is more peripheral, I use the Topolyzer data. If they are both reliable, I use the one that is reported as higher reliability/quality by the software. If corneal scarring is present, Placido-disk imaging is preferable, because it uses concentric rings on the eye that reflect off the tear film. Scheimpflug imaging looks at the anterior corneal surface, irrespective of the tear layer. For example, in an eye with subepithelial scarring, Scheimpflug imaging can give an artifact: it will read that area as being steeper. Thus, I do not use the Oculyzer for eyes that have corneal haze.[1]

1. Cummings AB, Mascharka N. Outcomes after topography-based LASIK and LASEK with the WaveLight Oculyzer and Topolyzer platforms. *J Refract Surg*. 2009;2:1-8.

The WaveLight EX500 Excimer Laser

An overview of the WaveLight Refractive Suite's updated excimer laser and its features.

BY ARTHUR CUMMINGS, MB ChB, FCS(SA), MMed(Ophth), FRCS(Edin)

WaveLight's most recent work has revolved around developing a fully integrated Refractive Suite consisting of an excimer laser, a new femtosecond laser, and the ALLEGRO diagnostic equipment. An integral component of this Refractive Suite is the excimer laser, the WaveLight EX500, which this article describes.

SPEED AND ENERGY STABILITY

The WaveLight EX500 is the fastest excimer laser on the market, operating at 500 Hz (1.4 seconds per diopter of treatment). Its closed-loop energy system and sealed path of the laser beam ensure consistent energy delivery throughout each ablation, irrespective of changes in temperature and humidity. Like its predecessors, the WaveLight EX500 is a 0.9-mm flying spot laser with a prolate treatment profile. Its treatment range is from -14.0 D to +6.0 D and up to +6.0 D of mixed astigmatism (Figure 1A and B).

The laser performs an automatic calibration of the system's fluence every morning, as well as an energy calibration before each treatment.

PerfectPulse Technology fully controls the laser's pulse from the source until it reaches the cornea. The technology works with the laser's 1050-Hz high-speed eye tracker to follow the slightest movements of the eye and ensure that each laser pulse is placed according to the treatment plan (Figure 2). Furthermore, the laser minimizes thermal impact to the cornea by overlapping every fifth pulse.

EYE TRACKER

Unique to the WaveLight EX500 excimer laser is an active, optokinetic, video-based eye tracker that recognizes any eye movement and actively tracks pupillary diameters from 1.5 to 8 mm (it does not require the pupil to be dilated). The latency time is 2 ms. The NeuroTrack feature prevents cyclorotation in the first instance by giving the patient a target to look at that has square elements and prevents that eye from rotating. A projected crosshair line over the patient's eye tells the surgeon the exact alignment of the patient's head and eye (Figure 3), and the active cyclorotational tracker tracks all movements actively. Moreover, the surgeon may manually decenter the ablation in order to perform decentred ablations for cases with large angle kappa. The customized procedures automatically decenter the ablations when required.

ABLATION PROFILES

Wavefront Optimized Ablations

The EX500 laser features the same prolate (aspheric) Wavefront Optimized ablation profile for which WaveLight is known. Wavefront Optimized ablations are the best treatment for the majority of corneal refractive patients who do not show higher-order aberrations and do not suffer from poor preoperative visual quality. This profile compensates for energy loss in the periphery, thereby preserving the cornea's curvature and reducing the amount of induced spherical aberration. Furthermore, Wavefront Optimized treatments produce a large true aspheric optical zone and a minimized transition zone, which improves mesopic and

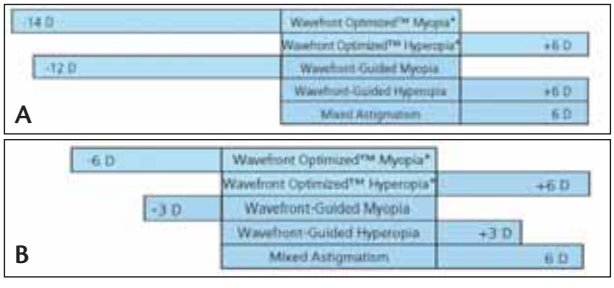


Figure 1. The WaveLight laser's international treatment range for sphere (A) and cylinder (B).

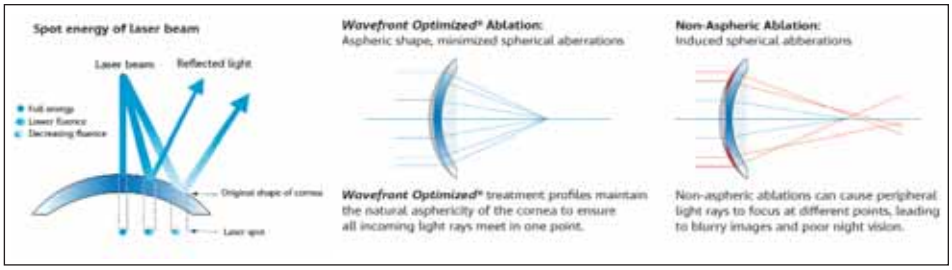


Figure 2. The WaveLight laser's PerfectPulse Technology delivers the aspheric Wavefront Optimized ablation profile that compensates for energy loss in the periphery, thereby preserving the contour of the cornea.

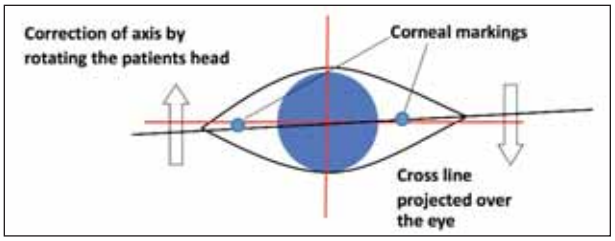


Figure 3. A representation of the WaveLight laser's cross line when the patient's limbus is marked at the 0º and 180º positions with a corneal marker at the slit lamp.

scotopic vision. Non-Wavefront Optimized treatments require large transition zones and thus create relatively small multifocal optical zones, which may induce higher-order aberrations and cause visual symptoms at night.

Wavefront-Guided Ablations

The EX500 laser has the ability to perform customized wavefront-guided ablations for patients who suffer from higher-order aberrations. The Refractive Suite offers integrated Tscherning-based wavefront aberrometry with the ALLEGRO Analyzer (called the *A-CAT treatment*). The A-CAT treatment permits a wavefront-guided offset of -3.0 to +1.0 D for sphere and -3.0 to 0 D for cylinder, and the surgeon may also adjust the cylindrical settings.

Topography-Guided Ablations

The EX500 laser's topography-guided treatments (called *T-CAT*) are for specific corrections, such as eyes with corneal irregularities, as well as for those for which the surgeon cannot capture a reliable wavefront map (such as eyes that have undergone previous refractive surgery). These treatments are calculated from the ALLEGRO Topolyzer VARIO, which creates a map of the eye from 22,000 measurement points, or the ALLEGRO Oculyzer, which derives the information from 25,000 data points obtained through Scheimpflug imaging. The Topolyzer VARIO also provides additional pupillary and centroid-shift data as well as keratometry and asphericity data for the Refractive Suite. Furthermore, the Topolyzer VARIO incorporates keratometric and asphericity data from the Refractive Suite.

Custom Q Treatments

As the cornea's asphericity (also referred to as *Q value*) changes with age, patients' visual acuity (particularly under mesopic and scotopic conditions) can degrade. The EX500 laser's Custom Q treatment (also known as *F-CAT*) enables surgeons to sculpt an aspheric hyperprolate cornea by adjusting transition zones and the optical zone in 0.1-mm steps and the refraction in 0.01 D increments. The Custom Q software permits the surgeon to create optical zones from 4.5 to 8.0 mm for sphere and cylinder (depending on the treatment type).

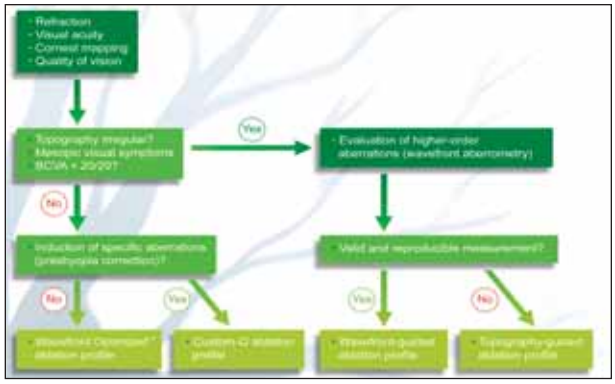


Figure 4. A decision tree helps refractive surgeons decide which WaveLight laser treatment to use for which patients.

A decision tree helps surgeons decide which treatment with the WaveLight EX500 laser is best for the patient (Figure 4).

MYRIAD ADVANCED FEATURES

The WaveLight EX500 excimer laser has numerous technological features that help surgeons deliver consistent, high-quality laser vision correction. Some of these features include online optical pachymetry ("no-touch") so that the surgeon is always aware of the corneal thickness before, during, and after surgery. The laser's Integrated Nomogram Optimization allows surgeons to track their operating parameters and outcomes data and adjust their personal nomogram accordingly.

SUMMARY

The key features of the EX500 laser are as follow: (1) Speed and accuracy. The Wavefront Optimized ablation profile is the "most basic" treatment possible. (2) A wide range of customized treatments based on wavefront, topography, tomography, or asphericity data. (3) The ability to perform even more advanced ablations derived from advanced ocular modeling profiles. (4) Integration with the FS200 femtosecond laser to form the Refractive Suite. (5) Networked to the diagnostic devices to increase safety with data transfer and reduce multiple entries on all the different devices and lasers. A once off-data entry populates all devices with the patient information such as name, date of birth, etc. (6) Online optical pachymetry. (7) Active cyclorotation eye-tracking, including NeuroTrack cyclorotational prevention.

All these features result in a laser that can provide consistently excellent refractive and visual quality outcomes and gives the surgeon with an unparalleled level of safety when performing laser vision correction. ■

Arthur B. Cummings, MB ChB, FCS(SA), MMed(Ophth), FRCS(Edin), practices at the Wellington Eye Clinic & UPMC Beacon Hospital, Dublin, Ireland. He is a consultant and investigator for Alcon/WaveLight. Dr. Cummings may be reached at phone: +353 1 2930470; e-mail: abc@wellingtoneyeclinic.com.

The WaveLight FS200 Femtosecond Laser

This component of the WaveLight Refractive Suite combines speed, safety, and innovation.

BY A. JOHN KANELLOPOULOS, MD

The new WaveLight FS200 femtosecond laser is one-half of the new, integrated WaveLight Refractive Suite (Alcon Laboratories, Inc., Fort Worth, Texas). The most exciting feature of this Refractive Suite is how the excimer and femtosecond lasers are able to communicate, thereby saving the surgical staff time, eliminating calculation and inputting errors, and improving laser refractive outcomes, among other benefits. On its own, however, the FS200 femtosecond laser offers myriad impressive advantages, most notably the ability to make an array of corneal cuts; to choose the diameter, shape, thickness, depth, angle, and location of corneal flaps and their hinges; to treat an array of corneal shapes and sizes; and to eliminate the incidence of opaque bubble layer (OBL).

At the podium at the recent 11th Annual Refractive User's Meeting, Theo Seiler, MD, PhD, said that although the FS200 laser is still undergoing clinical trials, it is the best femtosecond laser he has used. My staff and I have been working with the FS200 laser in Athens since it gained Conformité Européenne (CE)-Mark approval. This article describes the FS200 laser in detail.

SPEED AND ENERGY

One of the most impressive features about the FS200 laser is its combination of speed and safety. I have been cutting 8-mm, 120-µm flaps in 6 to 7 seconds. Yet, the FS200 laser delivers a surprisingly low amount of femtosecond energy to the cornea. The FS200's engineers put a lot of effort into optimizing the pulse energy and separation between the applanation spots and lines so that the laser uses the least amount of energy necessary without sacrificing speed, accuracy, or stromal smoothness. The laser applies spots of femtosecond energy in a raster pattern on the cornea. My settings for corneal flaps are 8 µm for the spot separation and 1 µm for the line separation. If I use a pulse energy of 0.7 µJ, the large energy density will be 1.09 J per square millimeter. For side cuts, the spots and rings should be slightly denser to avoid ripping the epithelium and prevent epithelial ingrowth postoperatively (Figure 1).

As a result, the laser produces very smooth stromal beds.

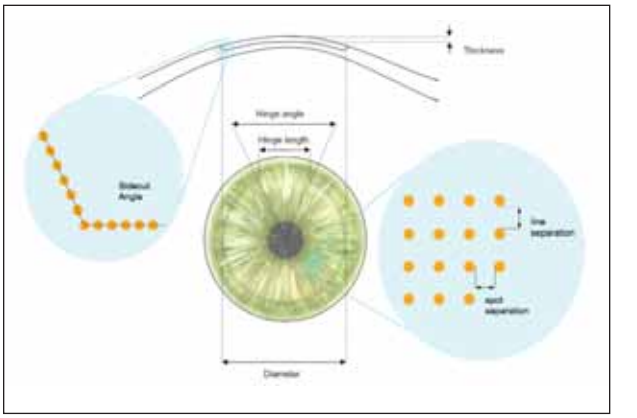


Figure 1. Spot parameters of the WaveLight FS200 femtosecond laser.

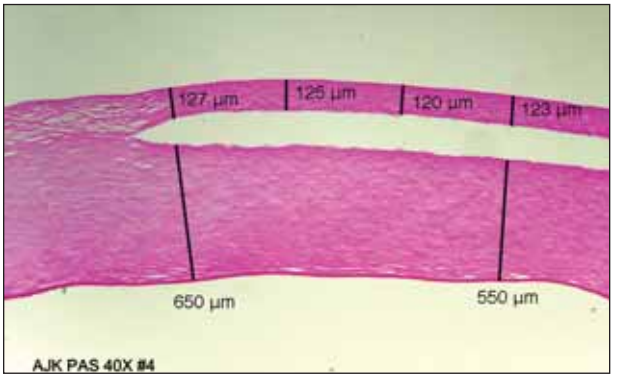


Figure 2. A histogram shows the smoothness of the stromal bed made with the WaveLight FS200 femtosecond laser.

My team and I are currently conducting histologic studies on human cadaver corneas, and the results thus far have been excellent (Figure 2).

CUSTOMIZABLE CUTS

The FS200 laser allows the surgeon to fully customize the size, shape, location, and depth of corneal cuts (Figure 3), allowing the surgeon to tailor the treatment to accommodate the needed ablation profile, corneal thickness, or other surgical considerations. The laser can make round or

elliptical cuts for corneal flaps as well as side cuts and reverse cuts for corneal segments and keratoplasties. Likewise, the FS200 laser offers presets for superior, nasal, and temporal hinges. For example, when planning a LASIK treatment for hyperopes or an ablation in the upper nasal area, the surgeon can place the flap's hinge in the lower temporal quadrant. For treating a patient who is -2.0 D @ -1.5 X 56º, he or she can position the flap hinge at 146º so it is out of the way. The surgeon may also adjust the angle of the hinge, which is beneficial for protecting the corneal nerves.

One particular advantage that the FS200 laser has over other femtosecond devices is the ability to relocate the centration of the flap within a 10-mm–diameter area, even after the suction ring has been applied. This capability is discussed in further detail in the information to follow.

CUSTOMIZABLE APLANATIONS

The FS200 laser allows the user to vary the spot size, depth, and energy delivery of the femtosecond beam. The laser is equipped with a 10-mm homogeneous beam that can be adjusted. The benefit of being able to adjust the laser's settings is customization—the laser can make stromal cuts as shallow as 30 µm away from Descemet's membrane and as deep as 900 µm.

Furthermore, the FS200 femtosecond laser can make large-diameter corneal APLANATIONS, up to 13 mm. Large applanation zones enable surgeons to make comfortable margins in hyperopic LASIK (adjusting the desired flap reticule on the laser's computer monitor does not reduce the flap size; Figure 4). The second advantage of large applanation areas is that no intracorneal pocket is needed to disperse the cavitation gas created by the lamellar cut of the flap. The laser automatically cuts a square tunnel through the flap's hinge that allows the gas to escape to the cornea's surface (Figure 4). In contrast, the IntraLase FS femtosecond laser* (Abbott Medical Optics Inc., Santa Ana, California) creates a pocket deep in the cornea to disperse the excess gas and prevent an opaque bubble laser (OBL). This vent is not located under the suction ring, but rather in the sclera. So, the gas escapes through the side of the cut, underneath the cutting area.

SAFETY FEATURES

The FS200 laser is equipped with several important safety features. First, the laser calibrates itself for the correct focal point every morning before the first surgery. Additionally, it runs a brief self-check before each use, called the *beam control check* (BCC). This calibration compensates for deviations on the z-axis and depth of field due to use and changing ambient conditions in the OR. This controlled, closed-loop energy management system sets the exact distance between the laser's optics and each new glass applanation plate. The BCC takes only 4 seconds and ensures a reproducible flap thickness. Similar to the WaveLight excimer laser's PerfectPulse Technology system, the FS200 laser continuously monitors its energy, pulse length, and beam profile.

SUCTION

The FS200 laser's two-part Advanced Suction Technology (AST) features a unique design and its own built-in safety features (Figure 5A and B). First, the surgeon or technician places the disposable plastic suction ring over the sclera and depresses the foot pedal to apply suction. The ring imparts rather low suction; IOP rises to only 60 to 100 mm Hg, and the patient can still see. This is

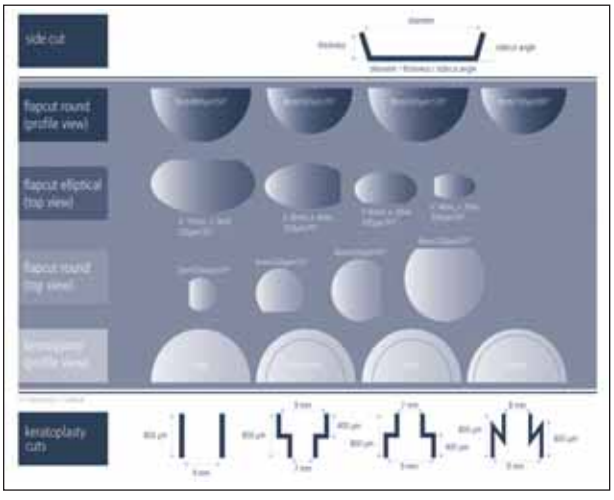


Figure 3. Possible flap and hinge cuts with the WaveLight FS200 femtosecond laser.

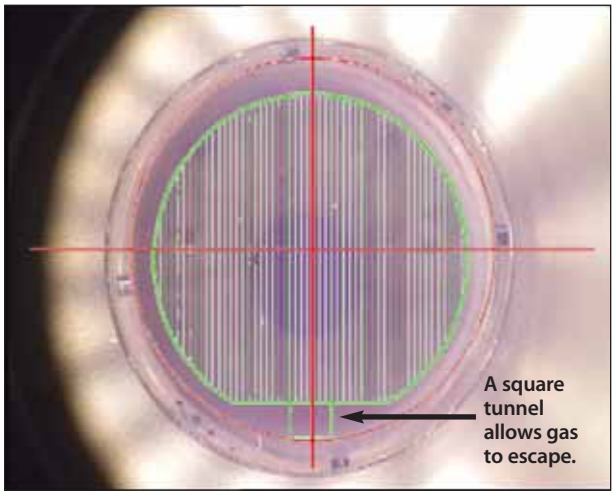


Figure 4. The FS200 femtosecond laser gives surgeons the ability to adjust flap placement after suction is applied.

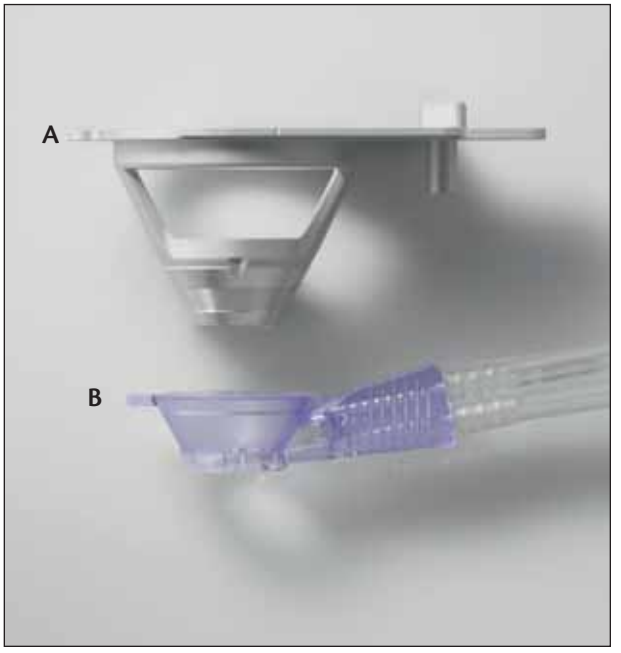


Figure 5. The WaveLight FS200 femtosecond laser's Advanced Suction Technology. First, a disposable plastic ring (A) makes contact with the sclera. After the surgeon applies suction, the cone that is attached to the laser's bridge (B) is suctioned to the scleral suction ring before the surgeon begins applanation.

the first opportunity to center or decenter the treatment area. Second, the operator lowers the applanation cone that is attached to the laser's bridge and docks it with the suction ring. A safety lock (a second suction ring) holds the cone in place. This second vacuum only interacts with the suction ring, not the eye. At this point, the surgeon may still adjust the cutting area before beginning the cut. When both vacuums are in place, the laser's screen shows a green bar indicating that the surgeon may apply the treatment. The suction ring remains on the eye for less than 30 seconds while the flap is cut.

This Advanced Suction Technology preserves the sclera's natural shape and minimizes IOP. The fixation ring contains peripheral spacers that minimize scleral deformation during suction and maintain IOP at a reasonable level (Figure 6). At the same time, the two-part system keeps the suction ring in place so the cornea cannot rotate.

ADDITIONAL FEATURES

The FS200 femtosecond laser also has a built-in high-quality Carl Zeiss microscope with stereo vision and a live video camera so the surgeon and staff may watch what is happening to the eye. The camera can also connect to an external television so that patients and family members in the waiting room can watch the surgery taking place in the OR. This is a valuable marketing tool—more impressive than watching corneal surgery on a DVD. Equally important, the camera lets the surgeon document the entire surgery for the patient's file.

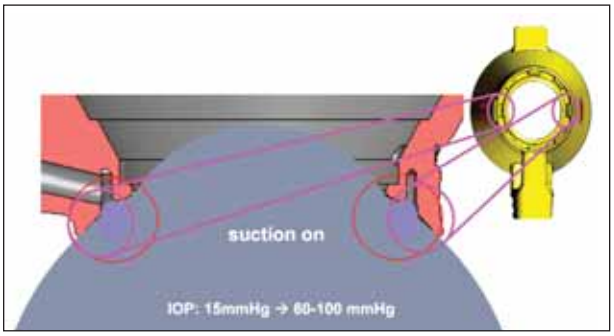


Figure 6. Peripheral spacers on the suction ring minimize scleral deformation during suction and maintain IOP.

In the OR, I really appreciate the new swiveling patient bed that transfers the patient very quickly between the two lasers. The bed's headrest can be raised and lowered without moving the bed. The headrest also tilts to make the patient comfortable. With femtosecond APLANATIONS, it is very important to keep the patient's nose out of the way. You do not want to press on the nose with the applanation cone and make the patient uncomfortable, because if he tries to move his head, you will lose the suction on his eye.

SUMMARY

Although the clinical results with this innovative laser are yet to be studied in large numbers, its performance appears promising. Time will tell if the FS200 femtosecond laser's innovative features will make it the leading contender for anterior segment surgeons. I look forward to testing the laser as part of the WaveLight Refractive Suite in a range of refractive applications. ■

**Trade names are the property of their respective owners.*

The author wishes to thank the Eye Bank for Sight Restoration of New York City for their invaluable support of his investigative work.

A. John Kanellopoulos, MD, is the Director of Laservision Eye Institute, Athens, Greece. He is a Clinical Associate Professor of Ophthalmology at New York University Medical School. Dr. Kanellopoulos is a WaveLight Ambassador and a consultant to Alcon Laboratories, Inc. He is a member of the CRST Europe *Editorial Board. Dr. Kanellopoulos may be reached at tel: +30 21 07 27 27 77; e-mail: ajk@laservision.gr.*

The AcrySof IOLs: An Overview

A description of the full AcrySof line.

BY TERRY KIM, MD

The first AcrySof IOLs (Alcon Laboratories, Inc., Fort Worth, Texas), the three-piece MA series, debuted in the United States in 1994. In 2000, Alcon launched the acrylic AcrySof single-piece IOL (SN60AT). Since then, the AcrySof line has continued to expand, and it is currently the most frequently implanted line of IOLs in the world. I have been using the AcrySof as my primary IOL platform in cataract surgery since 1996, and I continue to use it today, because the multiple innovations the platform has undergone over the years mean that AcrySof lenses still benefit my patients. This article provides an overview of the distinctions and benefits of the AcrySof material and design as well as the unique properties of each lens in the line that is currently available to physicians outside the United States.

CONTROLLED INTRAOCULAR UNFOLDING

For me, one of the things that has set the AcrySof Single-Piece IOL apart from other lenses is its ease of use. In comparison to silicone IOLs that suddenly jump open once out of the injector system, the AcrySof Single-Piece IOL opens gradually in the eye, providing time for proper positioning of the lens and increasing the safety of the delivery system. In addition, when repositioning the lens, there is no added pressure or stress on the capsule or zonules.

MATERIAL AND PREVENTION OF POSTERIOR CAPSULAR OPACIFICATION

Since Alcon first introduced the single-piece AcrySof platform, it has demonstrated a number of advantages in terms of biomaterials, biomechanics, and optics. For instance, the proprietary hydrophobic acrylic AcrySof material naturally adheres to both the posterior and anterior aspects of the capsular bag.[1] This material displays excellent fibronectin binding to the lens capsule, giving stability to the IOL's positioning both axially and radially. The union between the IOL and the lens capsule minimizes the amount of space in which residual lens epithelial cells can proliferate, which not only decreases the risk for posterior capsular opacification (PCO)[2] but also reduces the rate of Nd:YAG capsulotomies. The AcrySof material also offers long-term advantages in comparison to hydrophilic acrylic IOLs, which manifest multiple problems with calcification.[3] The square edge of the AcrySof lenses is another advantage that may induce a barrier effect against PCO, preventing the migration of epithelial cells across the lens' surface.

STABILITY

Stability within the capsular bag is critical to achieving refractive predictability with premium IOLs. The AcrySof single-piece construction ensures reliable positioning and stability in the eye (Figure 1),[4] thereby improving the predictability of the refractive result. The modified L-shape STABLEFORCE haptics provide the impressive stability for which the platform is known. Yet, the haptics are flexible enough to be placed easily in virtually any intact capsular bag.

HIGH REFRACTIVE INDEX

AcrySof lenses have the highest refractive index of any IOL (1.55), meaning they have excellent refractive properties, yet are very thin and can pass through 2.2- to 2.4-mm microincisions, which is a major benefit for cataract surgeons. I routinely utilize a 2.2-mm, temporal, clear corneal incision using the INFINITI Vision System (Alcon Laboratories, Inc.). The INTREPID Micro-Coaxial System, which is integrated into the INFINITI System, is specially designed for creating 2.2- to 2.4-mm incisions. Furthermore, the MONARCH III injector (Alcon Laboratories, Inc.) with the D cartridge adds another advantage in terms of allowing for the majority of dioptric ranges of the AcrySof aspheric line of lenses (SN60WF 6.0–27.0 D, SN6AT3–T5 6.0–25.0 D, SN6AD1 6.0–27.0 D) to be delivered seamlessly through such small incisions.

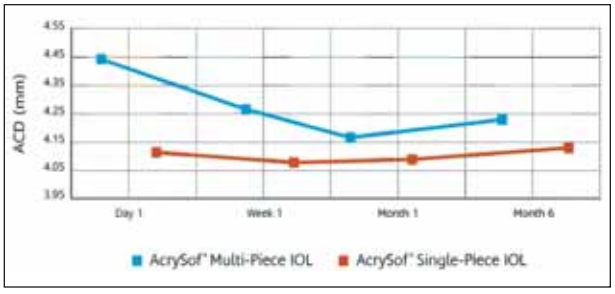


Figure 1. Refractive outcome stability and predictability of the AcrySof Multi-Piece and Single-Piece IOLs.[4]

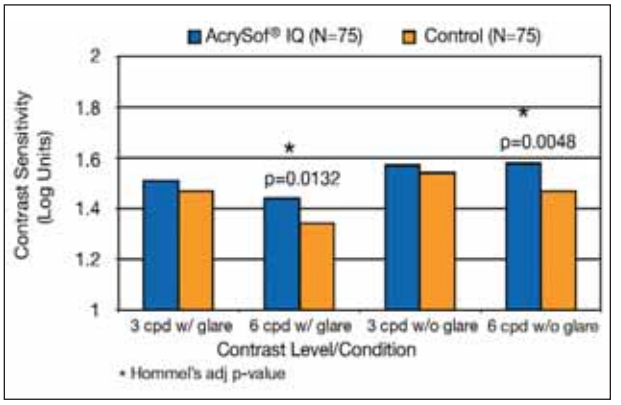


Figure 2. Mesopic contrast sensitivity (CSV-1000) with the AcrySof IQ IOL 90 to 120 days after the second eye's implantation.

AcrySof Natural Chromophore

In 2003, Alcon introduced a yellow chromophore to the AcrySof line that provides protection from chronic exposure to ultraviolet light for pseudophakic eyes.[5] This yellow chromophore is designed to mimic the natural yellowing of the aging human crystalline lens. Studies indicate that blue light can be harmful to the retinal pigment epithelial cells, and epidemiological research suggests a correlation between excessive exposure to blue light and the incidence of age-related macular degeneration (AMD).[6] In contrast, studies have concluded that the addition of the blue-light–filtering chromophore to the AcrySof platform approximates the same filtration of harmful light as a human crystalline lens.[7]

Six-mm Optic

Some spherical lenses boast a 6-mm optic but only have usable optical ranges of 5.0 to 5.5 mm. This reduction in optical range forces marginal rays in front of the paraxial rays, creating a small circle of blur rather than one single point of focus. AcrySof single-piece IOLs utilize the full 6-mm optic to ensure better refractive performance. The optic's square-edge design decreases aberrations in terms of light transmission and permits a better quality of vision by focusing the marginal and paraxial rays to a single point.

AcrySof IQ IOL for Asphericity

The AcrySof IQ IOL (SN60WF) is the single-piece platform with 0.20 µm of negative spherical aberration added to the optic. The average adult usually has some positive spherical aberration in the cornea, approximately +0.275 µm, which is cancelled by the negative spherical aberration of the young natural lens. As we age and as the crystalline lens matures, its spherical aberration becomes increasingly positive, giving the patient slightly positive spherical aberration in their overall visual system during what many studies have concluded to be a human's best years of vision, between the ages of 20 and 50.[8-14] With enough negative spherical aberration to cancel some but not all of the cornea's positive spherical aberration, the AcrySof IQ lens mimics these ideal optics.[15]

With a 6-mm pupil, the AcrySof IQ IOL leaves approximately -0.2 µm of lenticular spherical aberration. When coupled with the average amount of natural positive spherical aberration already present in the cornea, a small amount of overall positive spherical aberration (approximately 0.075 µm) is left to increase depth of field. This optical design focuses light rays coming through the lens to the retina and, hence, improves quality of vision. The aspheric optic is designed to enhance image quality, improve contrast sensitivity (Figure 2), and reduce the impact of spherical aberration and other higher-order aberrations in the visual system.

AcrySof IQ ReSTOR IOLs

The AcrySof IQ ReSTOR IOL is the apodized, diffractive, aspheric, multifocal option of the line (these models are also available without aspheric optics). The lens is available in a choice of two add powers, +3.0 D (SN6AD1) and +4.0 D (SN6AD3). The AcrySof IQ ReSTOR IOL +3.0 D has nine diffractive rings compared with 12 for the AcrySof IQ ReSTOR IOL +4.0 D, and the apodization of the rings allows patients to adjust their focal range with improved quality of vision. Practitioners have described the range of near vision for the two lenses as approximately 40 cm for the +3.0 D model and approximately 33 cm for the +4.0 D model (Figure 3). Just as in other aspheric AcrySof models, the asphericity in this model reduces patients' visual

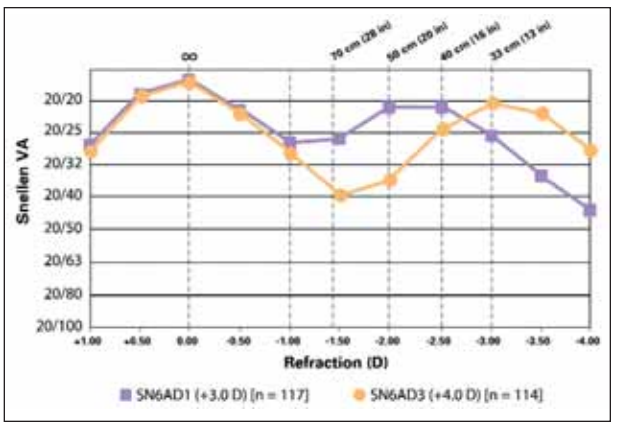


Figure 3. Binocular defocus curves of the AcrySof IQ ReSTOR IOLs, 6 months after implantation.

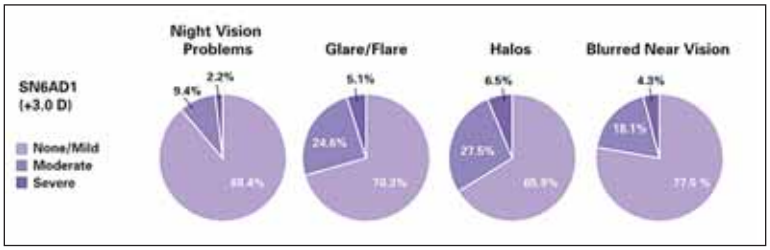


Figure 4. Visual disturbances 6 months after second-eye implantation of the AcrySof IQ ReSTOR IOL +3.0 D (SN6AD1).

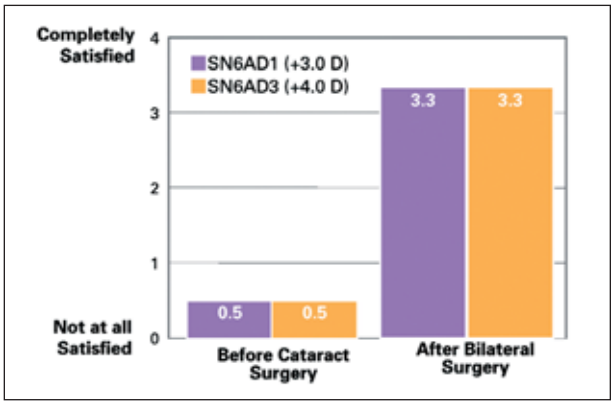


Figure 5. Patients' overall postoperative satisfaction without glasses with both models of the AcrySof IQ ReSTOR IOL.

symptoms 6 months after bilateral implantation (Figure 4). Both the +3.0 D and the +4.0 D models have demonstrated a high rate of patient satisfaction (Figure 5).

AcrySof IQ Toric and AcrySof IQ ReSTOR Toric IOLs

The AcrySof Toric IOL (SA60TT) is the traditional, spherical option that has an extensive track record of performance and reliability. The recent approval of the AcrySof IQ Toric IOL (SN6AT3–SN6AT9) adds asphericity to this proven platform. With the addition of asphericity, the AcrySof IQ Toric IOL is designed to deliver enhanced contrast sensitivity and depth of focus while providing the stability and reliability surgeons have come to know in the AcrySof platform. It is exciting to have this reliable option with asphericity, proven stability, and a full range of cylindrical correction available to treat astigmatism at the time of cataract surgery.

AcrySof CACHET IOL

The new AcrySof CACHET phakic IOL is approved in Europe and is currently undergoing clinical studies in the US. It is showing promising preliminary results. This lens is designed to correct moderate-to-high myopia. Its features include a low compression force, a high rate of stability, and the ability to pass through microincisions to minimize surgically induced astigmatism. The lens is made of the same foldable AcrySof material, has a refractive index of 1.55, and is available in powers ranging from -6.0 to -16.5 D. It is an anterior chamber, angle-supported IOL with a unique bridged, four-point haptic design. The optic's diameter is 6 mm. The lens is designed to have a low vault (<0.5 mm) that divides the anterior chamber two-thirds above the optic and one-third below the optic. It is also designed to avoid contact with the cornea and crystalline lens to help prevent endothelial cell loss and premature cataract formation.

A FULL RANGE OF OPTIONS

Having access to a full range of refractive powers and optical options on one IOL platform gives me a combination of versatility and confidence that I have not had with previous lines of IOLs. I like using AcrySof lenses because I feel confident in their performance and predictability, and now with the expanded range of options, I have been able to increase my utilization of these lenses. I look forward to future innovations in the AcrySof line of IOLs. ■

Terry Kim, MD, is a professor of ophthalmology, cornea, and refractive surgery at the Duke Eye Center in Durham, North Carolina. He is a consultant for Alcon Laboratories, Inc. Dr. Kim may be reached at (919) 681-3568; terry.kim@duke.edu.

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Advancements in Refractive IOLs

A newly available refractive IOL is designed to improve visual outcomes and provide true visual performance at all distances for patients with astigmatism.

BY FRANCESCO CARONES, MD

A newly approved refractive IOL now gives surgeons the ability to provide greater options for astigmatic patients seeking to reduce their dependency on glasses and contacts. The AcrySof IQ ReSTOR Multifocal Toric IOL (Alcon Laboratories, Inc., Fort Worth, Texas; Figure 1) combines the proven performance of the AcrySof IQ ReSTOR IOL with the precise astigmatic correction of the AcrySof IQ Toric IOL. This new lens was recently approved and made available to European surgeons in June of this year. The lens has been designed to offer a single surgical procedure for the correction of presbyopia and astigmatism, eliminating the need for additional procedures. The lens is currently available in +16.0 to +25.0 D and cylinder correction in the T2 to T5 range, and it will soon be expanded to powers in the range of +6.0 to +30.0 D (Table 1).

ONE PROCEDURE TO CORRECT TWO PROBLEMS

It is estimated that 87% of cataract surgery patients have preoperative astigmatism.[1] Within this patient population, approximately 64% of patients fall within 0.50 to 1.25 D of astigmatism, with the remaining 36% of patients having greater than 1.26 D. The AcrySof IQ ReSTOR Multifocal Toric IOL is designed to treat from 0.50 D of astigmatism with the T2 model up to 2.32 D of astigmatism with the T5 model. The introduction of this new lens will have a significant impact on surgeons' ability to offer multifocal technology to more patients within their existing practice as a result of expanded ranges of cylindrical correction.

Among cataract surgeons, it is widely known that even minor amounts of residual corneal astigmatism following cataract surgery can significantly affect a patient's quality of vision. Current options for managing residual astigmatism at the time of surgery include limbal relaxing incisions (LRIs) and laser vision correction. In my experience, LRIs are often unpredictable and have a limited range of treatment. Laser vision correction of astigmatism is an additional procedure for patients, requires a separate skill set, and can increase the risk of dry eye and associated visual symptoms. Having the ability to reduce residual astigmatism in multifocal patients without the need for an additional procedure will be a benefit to both the surgeon and the patient. The AcrySof IQ ReSTOR Multifocal Toric IOL allows for a single procedure to manage both presbyopia and residual refractive cylinder.

TABLE 1. ACRYSOF IQ RESTOR TORIC MODEL

AcrySof IQ ReSTOR Multifocal Toric IOL (models SND1T2 to SND1T5)

- Cylinder power: 1.0 to 3.0 D
- Cylinder power at the corneal plane: 0.68 to 2.25 D
- Power range: +6.0 to +30.0 D
- Add power: +3.0 D
- Add power at the spectacle plane: +2.5 D
- Suggested A-constant: 118.9

A FAMILIAR PLATFORM

Surgeons who have used both the AcrySof Toric IOL (Alcon Laboratories, Inc.), which is the monofocal toric option in the AcrySof line, and the AcrySof IQ ReSTOR IOL, will be comfortable using the AcrySof IQ ReSTOR Toric IOL (the SND1TT), which is the multifocal, aspheric, toric option in the line. The apodized, diffractive component of the AcrySof IQ ReSTOR Toric IOL's optic is located on the anterior surface of the lens. The anterior surface also contains -0.1 µm of asphericity, which is designed to balance the mean positive corneal spherical aberration found in most corneas of patients in the cataract age population. The curvature focuses more light rays on the retina and therefore helps to increase contrast sensitivity for patients, especially in mesopic and scotopic conditions.[2] Leaving a small amount of positive spherical aberration also enhances patients' depth of focus.

The asphericity mimics the optics of a prolate cornea, thereby giving patients better depth of field and contrast sensitivity. The toric component of the optic is located on the posterior surface of the lens.

ACRYSOF TORIC IOL CALCULATOR

An essential step to implanting the AcrySof ReSTOR Toric IOL is that it must be accurately aligned along the steep axis of the cornea. Alcon's Web-based AcrySof IQ ReSTOR Toric Calculator (http://www.acrysoftoriccalculator.com/) is a very effective tool. By inputting basic information such as

Figure 1. The AcrySof IQ ReSTOR Multifocal Toric IOL.

keratometry, IOL power, spherical power, surgically induced astigmatism, and incision location, the AcrySof IQ ReSTOR Toric Calculator enables the surgeon to determine the lens model to use and the axis of placement to optimize patient outcomes. As most surgeons who implant multifocal lenses know, these patients are happiest when they have the least amount of residual astigmatism possible. The AcrySof IQ ReSTOR Toric Calculator has been designed to target emmetropia to enhance overall lens performance.

GROWING ELECTIVE IOLs

An Expanded Range of Options

The AcrySof IQ ReSTOR Multifocal Toric IOL is a much-needed addition to our refractive options, offering multifocality and astigmatic correction in a single step. Surgeons who have experience implanting multifocal IOLs will especially appreciate having an aspheric multifocal toric option on the proven AcrySof platform. They will no longer need to schedule patients for multiple procedures, and they will feel confident that this new lens will perform as well as its predecessors.

In my practice, laser vision correction volumes have been decreasing, and my implantation rates of multifocal IOLs have been rising accordingly (Figure 2). Surgeons should prepare their practices for such market shifts by offering both cataract and refractive services. Intraocular surgery allows surgeons to correct a wide range of refractive errors as well as presbyopia. However, it is important to offer the most advanced-technology IOLs to ensure patient satisfaction.

Tips for Marketing Elective IOLs

I use several tactics for marketing premium refractive IOLs in my practice. First, I have trained my staff to "think refractive" by teaching them to identify astigmats, medium-high myopes, and presbyopic patients. During the patient's first consultation and subsequent work-up, every staff member he or she comes in contact with will mention that elective IOLs offer the greatest benefits and impart the highest rates of postoperative satisfaction. We also use a variety of tools to market these lenses, from our Web site to brochures, multimedia, and our clinic's patient satisfaction statistics. Finally, we encourage word-of-mouth referrals by asking happy patients to provide written testimonials about their experience in our clinic and with their vision, and we even ask them to be available to meet one-on-one with interested premium IOL candidates to answer questions.

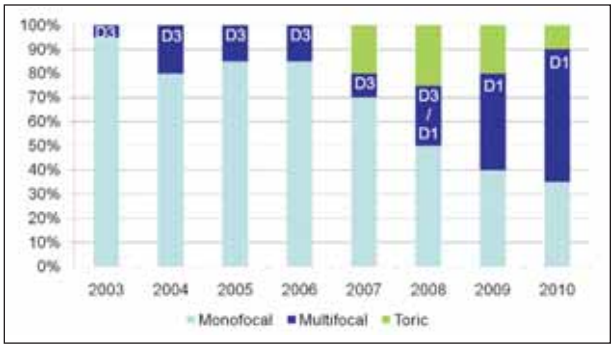

Figure 2. Pseudophakic IOLs as a percentage of total procedural volume in the author's practice.

SUMMARY

In short, I am pleased to have an aspheric, multifocal, toric IOL option that enables me to correct both astigmatism and presbyopia. My experience thus far with this implant has shown the same refractive stability as previous AcrySof Toric models, true performance at all distances as seen with the multifocal AcrySof IQ ReSTOR IOL +3.0 D, and excellent contrast sensitivity and depth of focus thanks to the lens' aspheric optics. When I implant this lens based on calculations from the online AcrySof IQ ReSTOR Toric Calculator, I am able to achieve my desired refractive outcomes and eliminate the need for additional procedures to reduce residual astigmatism. ■

Francesco Carones, MD, is the Cofounder and Medical Director of the Carones Ophthalmology Center, Milan, Italy. Dr. Carones is a paid consultant to Alcon Laboratories, Inc., and he is a member of the CRST Europe *Editorial Board. Dr. Carones may be reached at tel: +39 02 76318174; e-mail: fcarones@carones.com.*

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2. Results of a controlled, randomized, double-masked, multicenter, contralateral implant clinical study of the AcrySof® IQ IOL versus an AcrySof® Single-Piece IOL (SA60AT). See Directions for Use.

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