Biometry Software

Authors give an overview on a variety of technologies on the market.

BY JAIME ARAMBERRI, MD; ARTHUR B. CUMMINGS, FRCS(Ed);
CHARL G. WEITZ, MBCHB, Dip Ophth; EKKEHARD FABIAN, MD; DAVID GOLDBLUM, MD;
DETLEF HOLZWIG, MD; RAFI ISRAEL, MD; AND THOMAS OLSEN, MD

Galilei for Cataract/Lens Surgery

BY JAIME ARAMBERRI, MD

The need for accuracy in IOL calculations has been pushed to a demanding level with the introduction of so-called premium IOLs. Multifocal IOL patients expect excellent uncorrected vision postoperatively. Corneal astigmatism and asphericity can be accurately corrected with toric and aspheric IOLs, assuming the IOL calculations are based on good data. In this challenging scenario, precise anterior segment biometry is mandatory.

The Galilei Dual Scheimpflug Analyzer (Ziemer Group, Port, Switzerland) is based on an ingenious combination of two rotating Scheimpflug cameras, placed opposite each other, plus a Placido disc. This allows correction of any decentration by averaging the two sets of Scheimpflug data. Additionally, the central cornea is more accurately measured by merging the Scheimpflug data with the Placido-disc data using proprietary algorithms. This hardware-software combination produces reliable figures on which to base accurate IOL calculations.

I have been using the Galilei tomographer for almost 1 year, and I find it a helpful tool for IOL calculation. We did repeatability and reproducibility testing to define the device's precision. We were surprised to find standard deviation values near to the levels of autokeratometers. These figures were ±0.02 D for spherical, aspheric, and toric test lenses; ±0.08 D for normal corneas; and ±0.11 D for corneas that had undergone LASIK or PRK. By comparison, autokeratometers usually have a standard deviation of approximately ±0.05 D for repeated measurements in normal eyes. Posterior surface measurement showed low standard deviation values as well: ±0.04 D for normal corneas and 0.05 for corneas after LASIK or PRK. For the first time in my experience, we can use topography-based keratometric figures for IOL calculations without sacrificing precision.

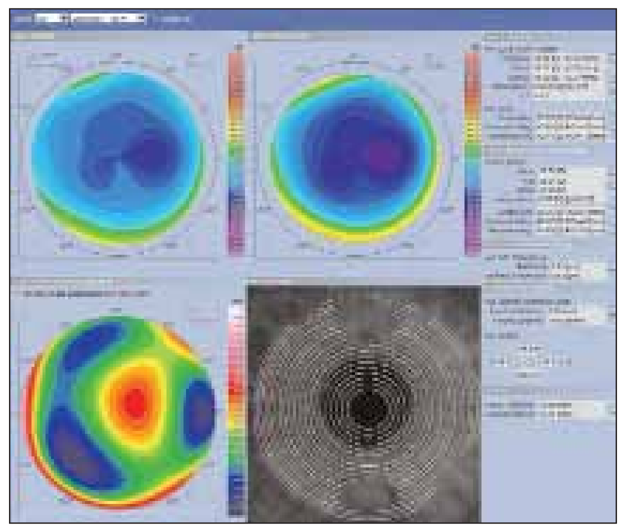

Figure 1. The Galilei's IOL power report displays parameters for IOL power calculation including Sim-K, corneal astigmatism, asphericity, spherical aberration, white-to-white distance, and anterior chamber depth.

The great advantage of using anterior and posterior corneal measurements is that we avoid the main, erroneous assumption of keratometry and Placido-disc–based topography. That is, that the anterior-to-posterior corneal curvature ratio is constant, and that total corneal optical parameters (eg, power, astigmatism) can be calculated by measuring only the anterior surface and using an arbitrary index of refraction. With both anterior and posterior measurements, accurate calculations can be done whenever the anterior-to-posterior ratio is altered, for example after corneal refractive surgery, or in eyes with corneal scars, keratoconus or previous keratoplasty.

The Galilei displays the parameters for IOL power calculation—including simulated keratometry, corneal astigmatism, asphericity, spherical aberration, white-to-white distance, and anterior chamber depth—in an IOL power report (Figure 1). Three maps are produced: axial curvature, total corneal power, and higher-order aberrations (HOAs) of anterior plus posterior cornea. If additional information is required, user-friendly software allows quick navigation through different reports, the most useful of which are the refractive quad map and the wavefront analysis screen.

I believe there are five principal uses of corneal tomography in cataract/lens surgery, and the Galilei is beneficial for all of them.

Selection of IOL asphericity. Currently, we targeting a slight positive spherical aberration (approximately 0.1 µm for a 6-mm diameter area) following some authors' recommendations. Asphericity of both anterior and posterior surfaces and spherical aberration Zernike coefficient of the total cornea are useful numbers that help us decide which type of IOL should be selected to achieve that goal: a spherical, neutral-aspheric, or negative spherical aberration–inducing IOL. In the current Galilei software (version 4.00), a spherical aberration coefficient is calculated for a 6-mm diameter area in the IOL power report. In aberrated corneas and when the pupil size is smaller, we may prefer to check this parameter for a smaller area of analysis. This can be easily done in the wavefront error report, two clicks away.

Selection of IOL toricity. Calculations for toric IOLs are currently done using topographic and keratometric measurements of astigmatism. It has been known for years that these overestimate the real total corneal astigmatism. The measurements are more properly performed by ray-tracing calculations using real anterior and posterior surface data. The error can be significant in high astigmatism as well as a significant axis error in low astigmatism. Galilei measures the total corneal astigmatism (anterior plus posterior) with exact ray tracing, resulting in the real astigmatism that should be compensated with the toric IOL.

IOL power after LASIK/PRK/RK. Change in the anterior-to-posterior corneal curvature ratio leads to an overestimation of central power after myopic correction and underestimation after hyperopic surgery when topography or keratometry are used. Galilei avoids these errors by ray tracing through accurately measured anterior and posterior surfaces and calculating the total corneal power in the central 4 mm of cornea. This number correlates closely with the one calculated using the clinical historical method after LASIK or PRK. So this can be used in any double-keratometry (K) modified vergence formula (eg, SRK/T, Hoffer Q, Holladay 1 or 2) or directly in the Haigis formula.

Disqualifying multifocal IOL candidates. Corneal optical quality is a good predictor of diffractive IOL patients' satisfaction. The presence of a significant level of astigmatism or HOAs must be evaluated before indicating a diffractive IOL. Moreover, corneal tomography information is essential to determine whether laser surgery (LASIK or PRK) can be done for any residual refractive error. If this is not possible, I prefer to implant other types of IOLs.

Advanced calculations. Galilei offers the possibility of performing more complex calculations with optics software, such as Zemax, Winlens, and Oslo. for the advanced user at paraxial or exact levels. Anterior and posterior radii with eccentricity values and even corneal data matrices can be exported for analysis.

In conclusion, Galilei is a powerful tool to perform anterior segment biometry, measuring the anterior and posterior corneal curvatures with a high level of precision. Accuracy of IOL calculations can be improved, making the surgeon more comfortable in the current challenging era of premium IOLs.

Jaime Aramberri, MD, practices in San Sebastian, Spain. Dr. Aramberri states that he has no financial interest in the products or companies mentioned. He may be reached at e-mail: jaimearamberri@telefonica.net.

The Allegro BioGraph

BY ARTHUR B. CUMMINGS, FRCS(Ed); AND CHARL G. WEITZ, MBCHB, Dip Ophth

The Allegro BioGraph (WaveLight, Erlangen, Germany) is a multifunctional biometry device that was designed to improve on the known shortcomings of traditional diode laser biometry. The BioGraph combines optical low coherence reflectometry (OLCR) and 820-nm superluminescent diode (SLD) technology.

Similar to the IOLMaster (Carl Zeiss Meditec, Jena, Germany), biometry measurements are aligned on the visual axis. Measurements can be taken in bright lighting conditions, although they are undoubtedly easier in a slightly darker room. Each scan takes four measurements, which in our opinion are not influenced by the patient's level of cooperation. The BioGraph simply freezes the scan until the uncooperative patient picks up fixation again, at which point the device continues the scan until the patient again loses fixation. It takes roughly 8 seconds to complete a scan in a cooperative patient.

A feature unique to the BioGraph is that all ocular structures, including the dimensions of the anterior chamber,

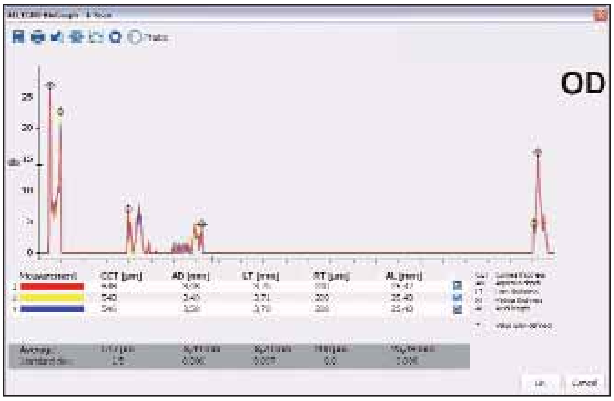

Figure 1. BioGraph scan of a phakic patient showing all the ocular structures along the visual axis.

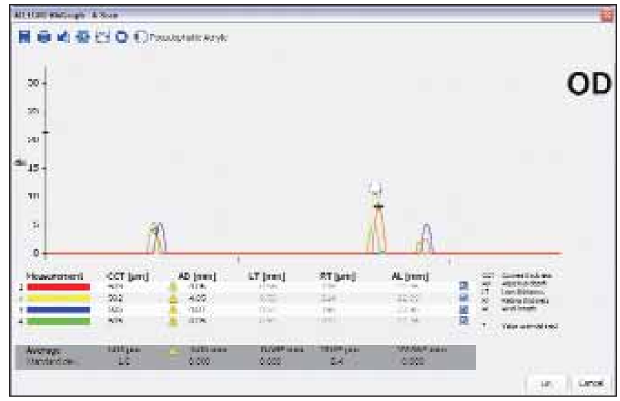

Figure 2. BioGraph scan of the anterior and posterior surface of a 19.50 D AcrySof IQ IOL. The posterior capsule is clearly visible.

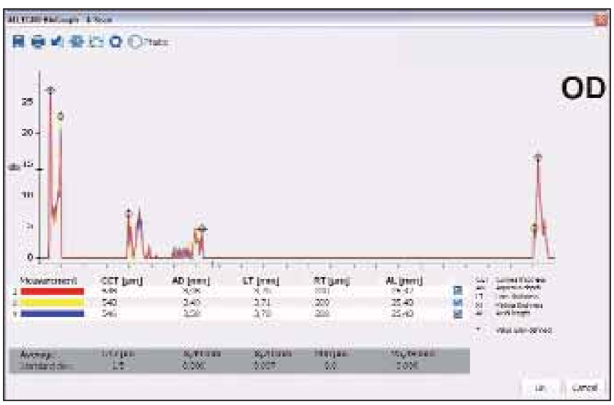

Figure 3. BioGraph scan of a normal cornea with a central corneal thickness of 573 µm. The two-peaked appearance is typical of normal corneas.

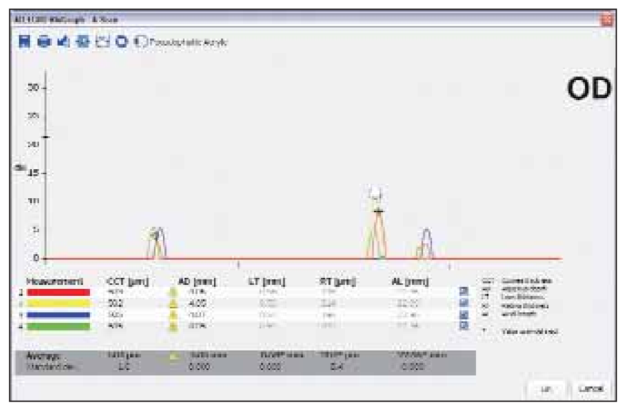

Figure 4. BioGraph scan of a crosslinked cornea with a central corneal thickness of 454 µm. Note the peak at 262 µm compared with the appearance of a normal cornea in Figure 3.

can be measured with great accuracy and repeatability (Figure 1). The BioGraph software gives the refractive surgeon the ability to magnify the ocular structures (ie, cornea, retina, crystalline lens, and IOL), documenting these structures along the visual axis in great detail. We evaluated a case in which the software assumed the posterior capsule to be the posterior surface of the IOL, but then on magnified view we manually moved the caliper to the posterior surface of the IOL (Figure 2).

The validation process of new diagnostic instruments starts with a solid foundation of peer-reviewed scientific research; the ophthalmic community can expect to see a plethora of BioGraph publications in the next few years. Time will tell if the BioGraph will be branded as more than simply another IOLMaster. At the Wellington Eye Clinic, the BioGraph is now firmly part of our diagnostic armamentarium. This instrument has a number of exciting features, and if the BioGraph passes the timely validation process of the scientific community it will become an indispensable instrument to refractive surgeons.

Some of the helpful features of the BioGraph include the following:

Measurement of central corneal thickness (CCT). To the best of our knowledge, the BioGraph is the only biometry instrument that can repeatedly measure CCT at exactly the same point along the visual axis. Repeatability is excellent, with standard deviations of less than 5 µm (Figure 3). This pachymetry feature can be used for accurate intraocular pressure (IOP) adjustment in glaucoma patients, during preoperative corneal refractive surgery planning, and for monitoring disease progression of Fuchs endothelial dystrophy. Unpublished data from the Wellington Eye Clinic suggest that BioGraph CCT measurements correlate well with Pentacam (Oculus Optgeräte GmbH, Wetzlar, Germany) measurements. BioGraph measurements done on LASIK patients show the same pattern of repeatability. It may be possible to extrapolate flap thickness in post-LASIK corneas and to measure the depth of effective crosslinkage in crosslinked corneas (Figure 4).

More measurement points for keratometry. The K-

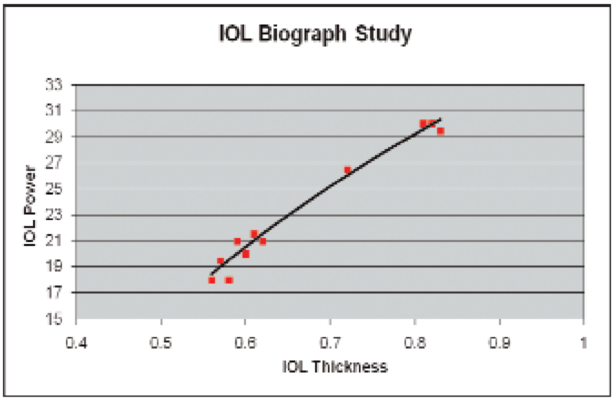

Figure 5. Scattergram clearly showing the correlation between IOL thickness (measured with the BioGraph) and known IOL power.

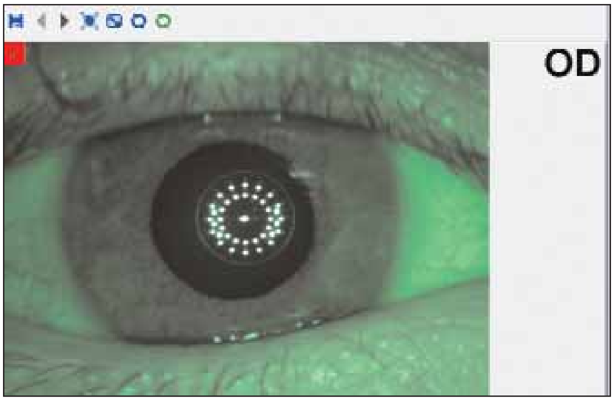

Figure 6. BioGraph anterior segment digital photograph. Angle kappa is clearly visible as the scan is done on the visual axis.

reading is calculated by analyzing the positions of 32 projected light reflections from the cornea, as opposed to six reference points measured by the IOLMaster. The 32 points are oriented in two circles at the 2.3- and 1.65-mm optical zones. Knowing that IOL calculations are almost in perfect unison with the IOLMaster, it came as a surprise that the keratometry values differ by more than 0.50 D between the two instruments. It was later found that the values differ only because the BioGraph uses a different refractive index from the IOLMaster. When the software was altered to match, the keratometry values were similar.

Anterior chamber measurements. Anterior chamber depth and crystalline lens thickness can be measured with the same degree of repeatability. The BioGraph can also measure IOL thickness. By expanding the biometry data (ie, zooming or enlarging any part of the image), one can measure the surfaces of an IOL with great accuracy. Even the posterior capsule is visible, and its signal peak correlates with the amount of posterior capsular opacification present clinically. The BioGraph measures these parameters pinpoint as part of the OLCR and 820-nm SLD biometry scan. The IOLMaster can estimate anterior chamber depth only by means of slit-lamp function. (Lenses, including IOLs can, unfortunately not be measured by the IOLMaster.) An ongoing study at the Wellington Eye Clinic clearly demonstrates that there is a linear relationship between known IOL power and IOL thickness as accurately measured by the BioGraph using the AcrySof IQ platform (Alcon Laboratories, Inc., Fort Worth, Texas; Figure 5).

Axial length accuracy. As with the IOLMaster, BioGraph axial length measurements are done on the line of sight. Our early data suggest that axial length accuracy and repeatability is comparable with the IOLMaster. Preoperative cataract patients at the Wellington Eye Clinic get both IOLMaster and BioGraph scans. The similarity in IOL calculation between the two instruments is remarkable. One of the shortcomings of the IOLMaster is its inability to penetrate posterior subcapsular cataracts. The IOLMaster utilizes 780-nm laser biometry; the 820-nm wavelength used by the BioGraph supposedly increases cataract penetration. Data presented by A. John Kanellopoulos, MD, of Greece, at the 2009 WaveLight User Meeting in Munich, suggest that the BioGraph can penetrate posterior subcapsular cataracts slightly better than the IOLMaster. We have had two cases of cataract so far that could not be measured with the IOLMaster but were successfully measured by the BioGraph. We have not seen the reverse situation to date. Accurate biometry can also be obtained with the BioGraph in silicone–oil-filled eyes.

Posterior measurements. Repeatable retinal thickness measurements suggest that the BioGraph may be used as a tool to diagnose and monitor cystoid macular edema in patients after cataract surgery.

Toric IOL assistance. BioGraph anterior segment digital photographs can be printed and used as an intraoperative guide for toric IOL axis orientation (Figure 6). The incorporation of a crosshair superimposed onto the digital pictures has been suggested to WaveLight. The surgeon can potentially take the crosshair picture to the operating theater and ensure 100% toric IOL axis orientation without the need for corneal markings.

Additional measurements. Other features that are useful to the refractive surgeon include the measurement of white-to-white distance, pupillary diameter, and angle kappa. These parameters are calculated from the anterior segment images taken during keratometry.

Research applications. The BioGraph offers a host of potential research capabilities. The optical characteristics of the BioGraph are used in the WaveLight custom ablation optimization (ray-tracing) study that is currently ongoing at three sites in Europe (IROC in Zurich, Sehkraft Augenzentrum Maus in Cologne, and the Wellington Eye Clinic in Dublin). The ability of the BioGraph to accurately measure anterior chamber dimensions including IOLs spurred us to start a study of effective lens position (ELP). Cataract patients get pre- and postoperative BioGraph scans to compare the actual position of the crystalline lens with that of the implanted IOL. We are hopeful that ELP data from this study will improve predictive refractive outcomes in the future.

We are convinced that the BioGraph's research and clinical potential will be ever-expanding as we learn more about this novel diagnostic device.

Arthur Cummings, FRCS(Ed), is a consultant ophthalmologist at the Wellington Eye Clinic, Dublin, Ireland. Dr. Cummings is a member of the CRST Europe *Editorial Board. He states that he has no financial interest in the products mentioned. He may be reached at e-mail: abc@wellingtoneyeclinic.com.*

Charl G. Weitz, MBChB, Dip Ophth, is a fellow at the Wellington Eye Clinic. He states that he has no financial interest in the products mentioned. He may be reached at e-mail: charl.weitz@gmail.com.

IOLMaster Biometry Brings Standard of Precision, Integration to EMR Network

BY EKKEHARD FABIAN, MD

The IOLMaster was the first device to combine different measuring methods for biometry into one device. Axial length measurement with the IOLMaster, based on partial coherence interferometry (PCI), is consistently accurate to within ± 0.02 mm. The possibility of an all-in-one measurement, the increased accuracy and repeatability of measurements, the noncontact method of use, and the ability to be operated by assisting personnel are among the reasons for the success of the IOLMaster, with 10,000 units sold since its introduction in 1999.

We have observed three changes during the 10 years we have used the IOLMaster: Biometry is now performed with (1) better comfort for the patient, (2) better prediction of postoperative refractive outcomes, and (3) better patient workflow. The last two aspects, better prediction, or rather expansion of the range of measurable eyes, and better workflow, not only in the office but also in the ambulatory surgery center (ASC), are improvements we greatly appreciate in our daily routine.

EVOLUTION

We have used the IOLMaster since September 1999 and reported our first results with the device at the 2000 American Society of Cataract and Refractive Surgery (ASCRS) meeting. We were involved in developing additional features, such as white-to-white measurements and detection of the optical axis. Other new features have been integrated with later software releases. In 2006, new hardware allowed better networking in the office; in 2007 a new software release (version 5.4) improved handling, measuring, and calculating significantly.[1]

As PCI is an optical measuring method, only 90% to 95% of patients can be examined with the IOLMaster. Others must be measured by ultrasound. Inability to measure with PCI is caused by general problems in the anterior or posterior segment, including media opacities. Axial length measurements with A-scan ultrasound have a resolution of 0.10 to 0.20 mm. Thus, measurements with the IOLMaster allow a fivefold increase in accuracy, a definite benefit for ophthalmologists.

The version 5.4 software incorporates advanced technology for digital signal processing in axial length measurement mode.[2] The number of scans is now 20, allowing improved internal processing and calculating a composite signal (Figure 1). This is not an averaged value as in the past; it is a hyperaccurate composite reading. The

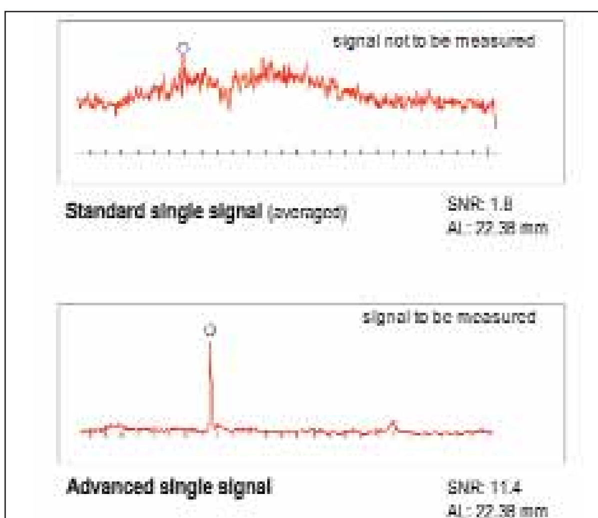

Figure 1. Signals after digital processing for better and automated measuring.

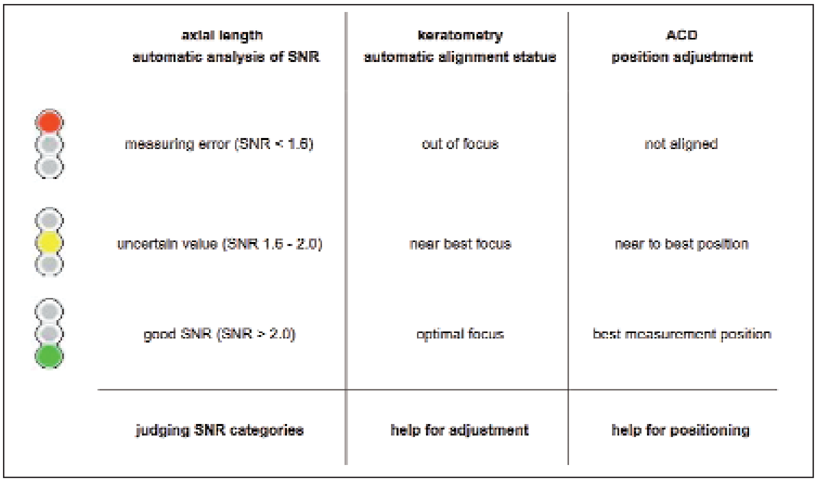

Figure 2. The traffic light symbols are used to judge the quality of the signal or to indicate adjustments.

Figure 3. Patient list of the OR timetable, generated in the office and presented in the OR.

signal-to-noise ratio is optimized to a higher level. Manipulation of the measurement is practically unnecessary. As a result of the advanced technology, we get a higher accuracy of measurement, more measureable signals, and results presented automatically.

New features increasing the ease of use of the IOLMaster include digital signal processing, real-time axial length analysis, a focus indicator for K-readings, and a focus indicator for anterior chamber depth measurements. A flashlight-type indicator (Figure 2) is integrated to allow easy, quick, and improved examination. This increases the quality of measurement and reduces the need for interactive manipulation.

INTEGRATED HAIGIS IOL FORMULAS

The major IOL power calculation formulas are integrated into the IOLMaster. Any one can be selected or all can be directly compared on the screen or on a printout. The optimized Haigis formula performs well across a wide range of axial lengths.[3] Tracking one's own outcomes to individualize the formula produces accurate results.

Eyes after corneal refractive surgery are challenging for IOL calculation. The Haigis-L formula produces accurate results with small residual dioptric errors. This is because of the different axial length range used for optimization of constants and IOL determination in calculation of IOL powers. This formula, integrated into the IOLMaster since version 4.0, allows IOL calculation after myopic and hyperopic laser surgery based solely on current IOLMaster measurements, without need for historical data.

NETWORKING

In 1999, the IOLMaster changed the workflow for clinical biometry, and in 2006 improvements for greater usability improved workflow again. Zeiss changed its philosophy from standalone devices to better connectivity with data input and export. To support data exchange, the IOLMaster in 2006 was equipped with powerful personal computer hardware and ports (eg, serial, parallel, VGA, Ethernet). When the device is integrated into a medical office computer network, the IOLMaster data can be present on all workplaces in the electronic medical record (EMR) system.

Workflow in and around the ASC is highly complex. Patient reception, patient monitoring, anesthesia surveillance, and documentation in words and images are demanding tasks that must be handled transparently. Callisto (Carl Zeiss Meditec) is a hardware and software system that can integrate all the necessary data.

The hardware is connected via a local area network (LAN) to different platforms (Windows, Mac OS X) and medical office programs for EMR. Callisto, together with the newly developed database Visupac, integrates and presents information from different hardware devices (eg, IOLMaster, optical coherence tomography, perimetry, topography, operating microscope). The software helps to handle OR management (operation dates and times, OR timetable; Figure 3), operative documentation (report, video documentation; Figure 4) and management of materials (eg, barcode scanner for IOL, ophthalmic viscosurgical device, medications).

This is the first system that provides documentation,

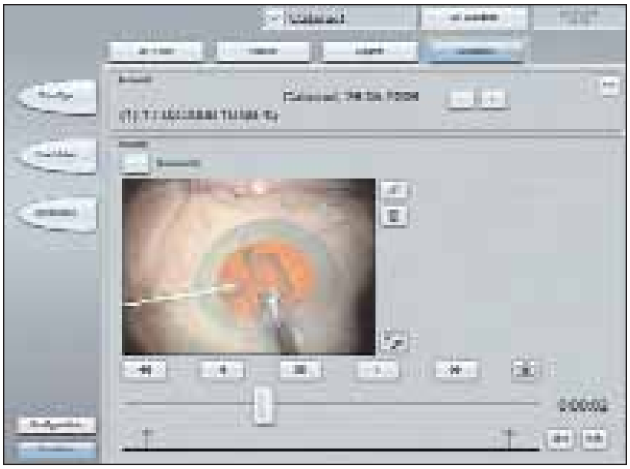

Figure 4. Video documentation and storage.

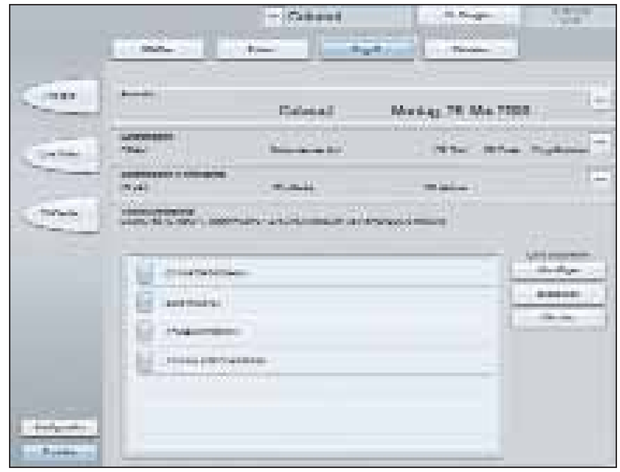

Figure 5. Electronic documentation of used materials.

data and video management, and management of materials for cataract and refractive surgery within a LAN. On the three workstations on which we have used the system, the workflow of patients demonstrated high transparency in actual procedures.[4] Documentation of structured processes, outcomes analysis, and integration into existing office computer systems makes Callisto an efficient system.

CONCLUSION

The evolution of the IOLMaster over the past 10 years has helped surgeons in many respects. One of these is the optimized processing of the PCI signal. The optimized signal-to-noise ratio raises the quality of measurements, allows more signals to be measured, gives more automated results, and thus improves ease of use. Another improvement is the availability of an internet database to share IOL parameters and constants in a user group.[5]

Connections built into the IOLMaster opened the door for integration into computer systems in the office. The newly developed Callisto and Visupac expand this connectivity into a computer network integration reaching now from the office to the ambulatory surgical center and back. The next step is on the horizon: integration of different databases for quality management and monitoring of surgical outcomes.

Ekkehard Fabian, MD, is in private practice in the AugenCentrum, Rosenheim, Germany, with an integrated ASC. Professor Fabian states that he is a consultant to Abbott Medical Optics Inc. and Carl Zeiss Meditec. He may be reached at e-mail: prof.fabian@augencentrum.de.

1. Hill W. IOLMaster Tutorial V5. Available at: http://doctor-hill.com/iol-master/iolmaster_main.htm. Accessed May 23, 2009.
2. Haigis W. Verbesserte Auswertung bei der AchslKngenmessung mit dem Zeiss IOLMaster. Paper presented at Congress of the Deutsche Gesellschaft fЯr Intraokularlinsen Implantation; Munich, Germany; February 26-28, 2009. Available at: http://www.DGII.org/2009/78.html. Accessed May 23, 2009.
3. Haigis W. IOL calculation for high ametropia. Ophthalmologe. 2008;105(11):999-1004.
4. Fabian E. Workflow-Management im OP mit CALLISTO. Paper presented at Congress of the Deutsche Gesellschaft fЯr Intraokularlinsen Implantation; Munich, Germany; February 26-28, 2009. Available at: http://www.DGII.org/2009/46.html. Accessed May 23, 2009.
5. User Group for Laser Interference Biometry. Optimized constants for the Zeiss IOLMaster. Available at: http://www.augenklinik.uni-wuerzburg.de/eulib/. Accessed May 23, 2009.

Lenstar LS 900 Provides Accurate and Fast Biometry

BY DAVID GOLDBLUM, MD

Accurate biometry is a necessity in modern lens surgery. Increasingly, patients, whether candidates for cataract surgery, phakic IOL implantation, or refractive lens exchange, expect excellent uncorrected vision postoperatively. Precise axial biometry is the first step in achieving accurate IOL power calculation.

The precision of biometry has improved through the years, first with the introduction of immersion ultrasound biometry, then with the emergence of optical biometry a decade ago. PCI performed with the IOLMaster has become a sort of gold standard since its introduction, with noncontact operation and a high degree of accuracy.

Recently, another method of optical biometry was introduced in the Lenstar LS 900 (Haag-Streit, Koeniz, Switzerland). This device uses OLCR generated by a superluminescent diode to measure axial length, anterior chamber depth, and lens and CCT.

COMPARISONS

Although optical biometry has advantages over ultrasound biometry, it has not completely replaced ultrasound technology. In approximately 10% of eyes, it is not possible to obtain a reading with optical biometry because of optical media opacities, such as a dense cataract or corneal scarring. For these cases, it is still necessary to have ultrasound biometry on hand.

My colleagues and I compared results with the Lenstar with those achieved with contact ultrasound biometry[1] (AL-3000; Tomey, Nagoya, Japan) and PCI with the IOLMaster[2] in nonrandomized, prospective clinical trials.

The Lenstar measured axial length, anterior chamber depth, lens thickness, and CCT accurately, with measurements that correlated well with contact ultrasound. The Lenstar showed greater reproducibility than ultrasound for all parameters measured.

Lenstar measurements of axial length and anterior chamber depth also correlated well with the IOLMaster. The device appears to be absolutely comparable with the IOLMaster in the parameters we measured.

DISCUSSION

The Lenstar is more accurate and less variable than ultrasound, in these patients in whom we can get a reading, because it uses a straight, orthogonal measurement. The optical device also has the advantage that it can measure patients with silicone oil in the eye, which is almost impossible with ultrasound. It is also a noncontact method, so patient comfort is improved, and there is no risk of transmitting infections or causing ocular surface problems.

The Lenstar's measurements are equal in accuracy to the IOLMaster. It has the advantage over the IOLMaster that allows one to perform corneal pachymetry and measurement of lens thickness, which the IOLMaster does not. Additionally, the Lenstar uses 32 measurement points in two rings on the cornea for keratometry—many more points of measurement than the IOLMaster—for potentially more accurate results. Also, the superluminescent diode used for OLCR in the Lenstar allows it to achieve greater resolution than the multimode laser diode used for PCI in the IOLMaster.

At the university hospital where I practice, trained ophthalmic technicians operate the Lenstar, not the physician. The device is quick to use and easy to learn. As the Lenstar has the same base dimensions as the Haag-Streit slit lamp, it can be mounted on to the same table (eg, instead of a Javal ophthalmometer) and can be used by the physician while the patient still remains on the examination chin rest.

CONCLUSION

Accurate IOL power calculation is a must in modern ophthalmic practice. The first step in assuring good postoperative uncorrected vision is an excellent diagnostic work-up, including precise biometric measurement. OLCR is a promising new technology for optical biometry that shows advantages over ultrasound and PCI biometry. Noncontact OLCR biometric measurements with the Lenstar correlate well with measurements taken using these two older biometry technologies.

David Goldblum, MD, is the Head of Anterior Segment and Oculoplastics in the Department of Ophthalmology at the University Hospital Basel, Switzerland. Dr. Goldblum states that he is a paid consultant to Haag-Streit. He may be reached at tel: +41 61 2652525; fax: +41 61 2658745.

1. Tappeiner C, Rohrer K, Frueh BE, Waelti R, Goldblum D. Clinical evaluation and comparison of the non-contact optical low coherence reflectometer (Lenstar LS 900) against a contact ultrasound biometer (Tomey AL-3000) in cataract eyes. Submitted for publication.
2. Rohrer K, Frueh BE, Waelti R, Clemetson IA, Tappeiner C, Goldblum D. Comparison and evaluation of ocular biometry using a new non contact optical low-coherence reflectometer. Ophthalmology. 2009; in press.

AL-3000 Provides Reliable, Compact Ultrasound Biometry

BY DETLEF HOLZWIG, MD

Ultrasound biometry remains an essential part of daily practice for cataract and refractive surgeons. In our busy practice, we use the AL-3000 Combined Bio- and Pachymeter (Tomey GmbH, Erlangen, Germany) for biometry, pachymetry, and IOL power calculation. I perform about 1,000 cataract surgeries per year, as well as refractive surgery, and the device is essential for both.

I have used Tomey ultrasound biometers since 1987, and I find that they work precisely and reliably. Assistant personnel in our practice use the instruments daily, and they do not require a lot of training on these user-friendly devices.

The AL-3000, which we currently use, is a compact, lightweight device with numerous applications in modern cataract and refractive surgical practices. Its 10-MHz A-scan probe may be used to measure axial length in a wide range of eyes by selecting the correct mode: normal, aphakic, pseudophakic, or with dense cataract.

The ability to measure axial length in eyes with dense cataract distinguishes the reliable, familiar ultrasound modality from some of the newer optical-based biometry systems, which cannot obtain a correct reading in approximately 10% of eyes because of dense cataract or other media opacities.

We also have an IOLMaster in our practice, and it may be that this optical biometer is more precise than ultrasound. However, the practice must also have ultrasound biometry; one cannot rely on optical biometry alone because of the number of patients in which it will not yield an accurate reading. With a mild nuclear cataract, the IOLMaster may be fine, but with a more difficult subcapsular cataract, the reading may not be accurate.

It should be noted that, in Germany, because of the way the health payment system is structured, patients must pay a charge for use of the IOLMaster for biometry. The same is not true for standard ultrasound biometry. It may be, therefore, that some physicians in Germany prefer to use the optical biometry device because they can charge for it. However, one must ask whether it is worthwhile to charge extra for that service when ultrasound biometry with the Tomey unit produces a suitably accurate refractive result. Given a good A-scan with the Tomey device and a well-performed surgery, the refractive outcome should be within 0.50 D of the target.

ACCURACY, FEATURES

The AL-3000 can measure biometry in either contact or immersion mode and can calculate the average axial length from up to 10 individual scans. Each scan can be displayed on screen for analysis and printed out with the built-in thermal printer. The device measures axial length from 15 to 40 mm and lens thickness from 2 to 6 mm, with accuracy of ±0.1 mm and resolution of 0.01 mm.

The 10-inch color touchscreen allows the user to move quickly to different menu options. A touch of the screen switches from biometry to IOL power calculation mode, with seven formulas available to choose from: SRK-II, SRK/T, Holladay, Hoffer Q, Showa, and the optimized and standard Haigis formulas.

We generally use the SRK-II or SRK/T and the Haigis formula, which is especially helpful in highly myopic or highly hyperopic eyes.

We have performed refractive surgery in our clinic since 1987 and LASIK since it was introduced in Germany in 1996. I prefer LASIK to other laser refractive techniques such as LASEK. In our clinic we use a WaveLight excimer laser and Tomey pachymeter.

The pachymetry mode on the AL-3000 allows measurement of corneal thickness at up to 25 points, which can be programmed on corneal maps. The range of measurement of the 20-MHz pachymetry probe is 150 to 1,500 µm, with accuracy of ±0.005 mm and resolution of 0.001 mm. A software program allows the automated calculation of CCT-corrected IOP, with a choice of up to three formulas.

CONCLUSION

We have been using Tomey ultrasound biometry equipment in our practice for more than 20 years. It has served us well in that time, reliably yielding accurate measurements to facilitate both cataract and refractive surgery. The device still provides good results, better in some cases than even the more high-tech instrumentation that has come to the market recently. The price is also more reasonable than many newer-technology devices, making Tomey ultrasound a good value in 21st-century ophthalmic practice.

Detlef Holzwig, MD, practices in Viersen, Germany. Dr. Holwig states that he has no financial interest in the products or companies mentioned. He may be reached at tel: +49 2162 22414.

PalmScan: Handheld Ultrasound Makes Biometry Portable

BY RAFI ISRAEL, MD

Handheld biometry devices—pachymeters and A-scans—simplify the layout of the refraction lane and facilitate examination of children, the elderly, and wheelchair-bound patients. They make biometry portable, not only between lanes within one office, but between multiple offices and other locations. Additionally, these devices help free up room in the practice for other diagnostic equipment, such as visual field analyzers and digital retinal imaging systems.

When purchasing a handheld pachymeter or A-scan, there are several important considerations: the accuracy of the device, whether it can be readily upgraded with the latest IOL calculation software algorithms, whether the data collected can be easily migrated into your EMR system, and associated costs.

Many handheld ultrasound biometers claim to be just as accurate as their stationary cousins. However, accuracy depends on several factors, including probe frequency and sampling rate. In general, the higher the probe frequency, the finer the spatial resolution. Probe frequency is typically 10 to 20 MHz for these devices. Sampling rate is a function of digitizing an analog echogram into digital samples; higher sampling rates improve the temporal resolution. In the case of the PalmScan Systems (Micro Medical Devices Inc., Calabasis, California), the sampling rate has been improved to 264 MHz for pachymeters and 132 MHz for A-scans. With an option for 20-MHz or superior 50-MHz corneal pachymeter transducer probe, this makes PalmScan the world's most accurate pachymeter and A-scan, according to the manufacturer.

ADDRESSING ASTIGMATISM

The 50-MHz pachymeter probe facilitates the planning of limbal relaxing incisions (LRIs) to address residual astigmatism in postoperative cataract patients. The PalmScan pachymeter also offers optional LRI nomogram software. The LRI option allows fast and accurate peripheral corneal measurement with the software that calculates the size, location, vector analysis of concurrent cataract-incision–induced astigmatism, and depth of LRI or astigmatic keratotomy incisions. The software allows selection among nomograms, including the Nichamin age- and pachymetry-adjusted nomogram. The results are displayed on the high-resolution color touchscreen display in the form of a graphic and textual surgical plan that can be printed, stored electronically, and archived. A study by Ray Oyakawa, MD,[1] using the PalmScan system, showed that LRIs done concurrently with cataract extraction were 96% effective and safe in treating preoperative astigmatism.

The PalmScan pachymeter also displays corneal waveforms, which are echogram A-scans of the cornea from epithelium to the endothelium that allow the user to self-verify pachymetry. The software allows users to display, store, and recall patient's corneal waveforms. The PalmScan also has a femtosecond flap mode, which allows the surgeon to measure corneal flap and bed thickness after laser microkeratome flap creation and before lifting the flap. This ensures accurate direct flap measurements without the need for subtraction pachymetry.

In A-scan mode, the PalmScan provides a high degree of accuracy. Another study by Dr. Oyakawa[2] found that axial length measurements with PalmScan immersion ultrasound were comparable to measurements taken with the IOLMaster. The average difference in axial length was 0.022 mm, and the correlation coefficient was 0.998. Immersion ultrasound units are still needed even if you have an IOLMaster, Dr. Oyakawa noted. This degree of accuracy and reproducibility allows the surgeon to confidently prescribe the right IOL regardless of where the patient is seen. The PalmScan's immersion A-scan capability and its ultrasonic alignment detection software ensure accurate results.

SOFTWARE, HARDWARE UPGRADES

These instruments can be field-upgraded to the latest software; new releases of the system software can be loaded to systems that are already in clinical use, ensuring that users have access to the latest software. Additionally, the hardware of the PalmScan A2000 (A-scan) and PalmScan P2000 (pachymeter) are upgradeable to the PalmScan AP2000 (A-scan/pachymeter combination).

Many practitioners in Europe have adopted EMRs. The ability to transfer captured data from a medical device to a networked computer has myriad benefits, including facilitating patient care, clinical research, and office administration, billing, and reimbursement. The PalmScan devices come with electronic medical software that synchronizes with the PalmScan to bring connectivity and efficiency to the ophthalmology practice.

ADVANTAGES OF PORTABILITY

Portability in combination with accuracy brings convenience and efficiency to the ophthalmic practice. I have multiple office locations with multiple lanes in each office, and I visit patients outside the office in settings such as nursing homes. The PalmScan reduces the costs associated with purchasing equipment for these multiple settings while increasing convenience and overall efficiency.

The PalmScan is one device I cannot do without. It saves me time and money and helps me to provide excellent patient care anywhere, not just in one lane of my office. It is battery operated, pocket size, and weighs only 9 oz. In fact, the PalmScan comes with me to the operating theater, to confirm biometry before surgery and to provide the astigmatic correction surgical plan during cataract surgery.

Rafi Israel, MD, practices at the Beverly Hills Eye Institute, California. Dr. Israel is the Medical Director of Micro Medical Devices. He may be reached at +1 310 276 3450.

1. Oyakawa RT. Vector-adjusted NAPA limbal relaxing incisions at the time of cataract surgery. Poster presented at American Society of Cataract and Refractive Surgery annual meeting, April 4-9, 2008; Chicago.
2. Oyakawa RT. Comparison of Palmscan and IOLMaster axial lengths. Poster presented at American Society of Cataract and Refractive Surgery annual meeting, April 4-9, 2008; Chicago.

Oculus Pentacam for Biometry and IOL Power Calculation

BY THOMAS OLSEN, MD

It has been known for some time that the K-readings taken by keratometers (using a standard index of refraction of 1.3375) are not the true corneal power.[1] However, IOL power calculation formulas have adapted to the intrinsic error by incorporating fudge factors, such as the A-constant.

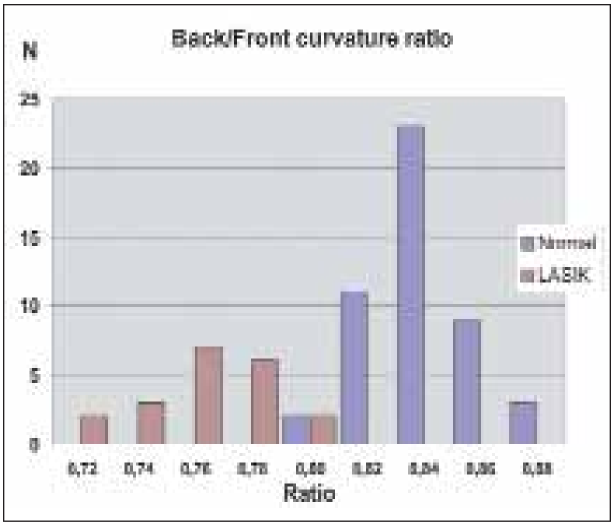

Figure 1. The Gullstrand ratio between anterior and posterior corneal curvatures, with the Pentacam for a group of 47 normal patients and 19 patients with a history of myopic excimer ablation of the cornea. The ratio is seen to be lower in the postexcimer cases, making it impossible to estimate the true corneal power from measurements of the anterior surface only, as is the case when taking keratometry readings with a keratometer.

Today we realize that the cornea is like a coin; it has two sides, and to fully understand the dioptric value of the cornea one has to know the optical properties (ie, curvatures) of both its front and back surfaces. The Pentacam helps us understand the optics of the cornea to improve our evaluation of patients scheduled for lens surgery, including complicated cases such as post-LASIK patients, or candidates for toric, aspheric, or phakic IOLs.

NORMAL AND POST-LASIK CORNEAS

A century ago, Alvar Gullstrand published his studies on the dioptrics of the eye,[2] including a description on how to use the Purkinje-Sanson second image to estimate the curvature of the back surface of the cornea. Based on a small series of normal eyes, he found that the ratio between the anterior and posterior curvatures of the cornea seemed fairly constant and could be used in model calculations of schematic eyes.

Recent studies have revealed that the ratio between the posterior and anterior surfaces of the cornea is not 0.88 as assumed by Gullstrand, but rather 0.82, as documented by Dubbelman and coworkers.[3,4] These results are confirmed by Pentacam measurements (Figure 1), which includes a population of patients with previous

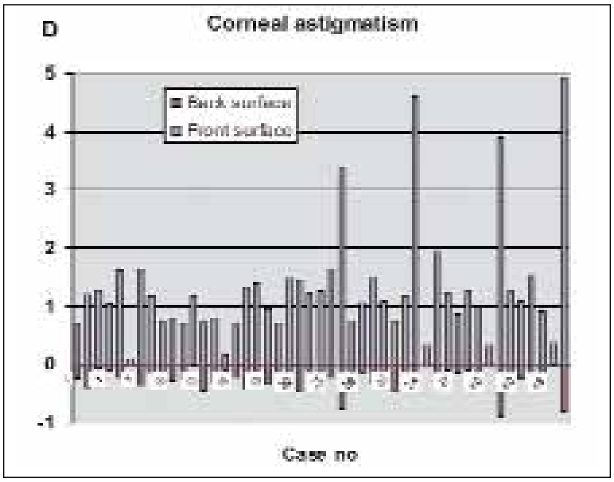

Figure 2. The corneal astigmatism of the front and back surfaces of the cornea as measured with the Pentacam in a series of 47 normal patients. The total astigmatism can be found as the sum of the front and back astigmatism.

LASIK. The mean value (±SD) was found to be 0.829 (±0.018) for normal corneas, compared with 0.748 (±0.024) for post-LASIK corneas. As can be seen, there was variation in the ratio in normal eyes but especially so in the post-LASIK corneas.

IOL POWER CALCULATION

Unfortunately, the abnormal Gullstrand ratio is not the only problem in IOL power calculation for the post-LASIK corneas.[5] Other problems include the method by which K-readings are used in the algorithm predicting anterior chamber depth and the difficulty obtaining valid central readings with conventional topography. The latter problem may not be an issue with Scheimpflug techniques, however.

The standard IOL power calculation procedure for post-LASIK cases is the historical method, which requires the knowledge of pre-LASIK keratometry and the refractive change induced by the procedure, to calculate the effective corneal curvature. Instead, however, I perform a Pentacam analysis in all cases to obtain central measurements of both sides of the cornea and get a reliable estimate of the net corneal power. These measurements can also be used to double-check calculations performed with the historical method.

TORIC IMPLANTS

Toric IOLs have greatly improved the surgical potential to minimize postoperative astigmatism. However, occasionally the patient ends up with unexpected postoperative astigmatism. Could it be that conventional K-readings do not tell the true story about corneal astigmatism? If we measure both the front and the back astigmatism of the cornea and add them as we add two spherocylinders, do we get a more reliable measurement of true corneal astigmatism?

In Pentacam readings of the front and back corneal astigmatism, the mean front (true) astigmatism (±SD) was found to be 1.06 D (±1.22), while the back astigmatism was found to be -0.34 D (±0.21). Most often, but not always, the axis of the back surface astigmatism is aligned with that of the front surface, giving a rough estimate that the back surface corrects approximately 30% of the front surface astigmatism. However, if the axis is taken into account, the calculations should be done by vector analysis. Figure 2 shows the result of a vector decomposition[6] of total astigmatism, depicting the front and back components of the net corneal astigmatism in a series of 47 normal patients. The mean value of the front component was 1.29 D (±1.00) and of the back -0.23 D (±0.20), giving a total of 1.06 D.

RESEARCH APPLICATIONS

Aspheric IOLs have been designed based on average spherical aberration measurements in a series of normal patients. As the Pentacam gives Q-values for both front and back corneal surfaces, the possibility arises to measure corneal asphericity in individual cases to customize the selection of aspheric IOL implants. This application awaits further study.

CONCLUSION

Newer diagnostic techniques, such as the Oculus Pentacam, challenge the formulas for IOL power calculation, most of which were developed at a time when ultrasound was the only technique for axial length measurement and standard keratometry was the only method for determining corneal power. As the technology expands, we will see more benefit from a detailed evaluation of the optics of the cornea, which will help us improve refractive results for normal patients as well as patients with previous refractive surgery. ■

Thomas Olsen, MD, is an Associate Professor at the University Eye Clinic, Aarhus Hospital, NBG, Aarhus, Denmark. Dr. Olsen states that he has no financial interests in the products or companies mentioned. He may be reached at e-mail: tkolsen@dadlnet.dk.

1. Olsen T. On the calculation of power from curvature of the cornea. *Br J Ophthalmol*. 1986;70:152-154.
2. Gullstrand A. In: Helmholz H, ed. Handbuch der physiologischen Optik. 3rd ed. Hamburg, Germany: L Voss; 1909:41-375.
3. Dubbelman M, Weeber HA, van der Heijde RG, Volker-Dieben HJ. Radius and asphericity of the posterior corneal surface determined by corrected Scheimpflug photography. *Acta Ophthalmol Scand*. 2002;80:379-383.
4. Dubbelman M, Sicam VA, van der Heijde GL. The shape of the anterior and posterior surface of the aging human cornea. *Vision Res*. 2006;46:993-1001.
5. Olsen T. Calculation of intraocular lens power: a review. *Acta Ophthalmol Scand*. 2007;85:472-485.
6. Olsen T, Dam-Johansen M. Evaluating surgically induced astigmatism. *J Cataract Refract Surg*. 1994;20:517-522.