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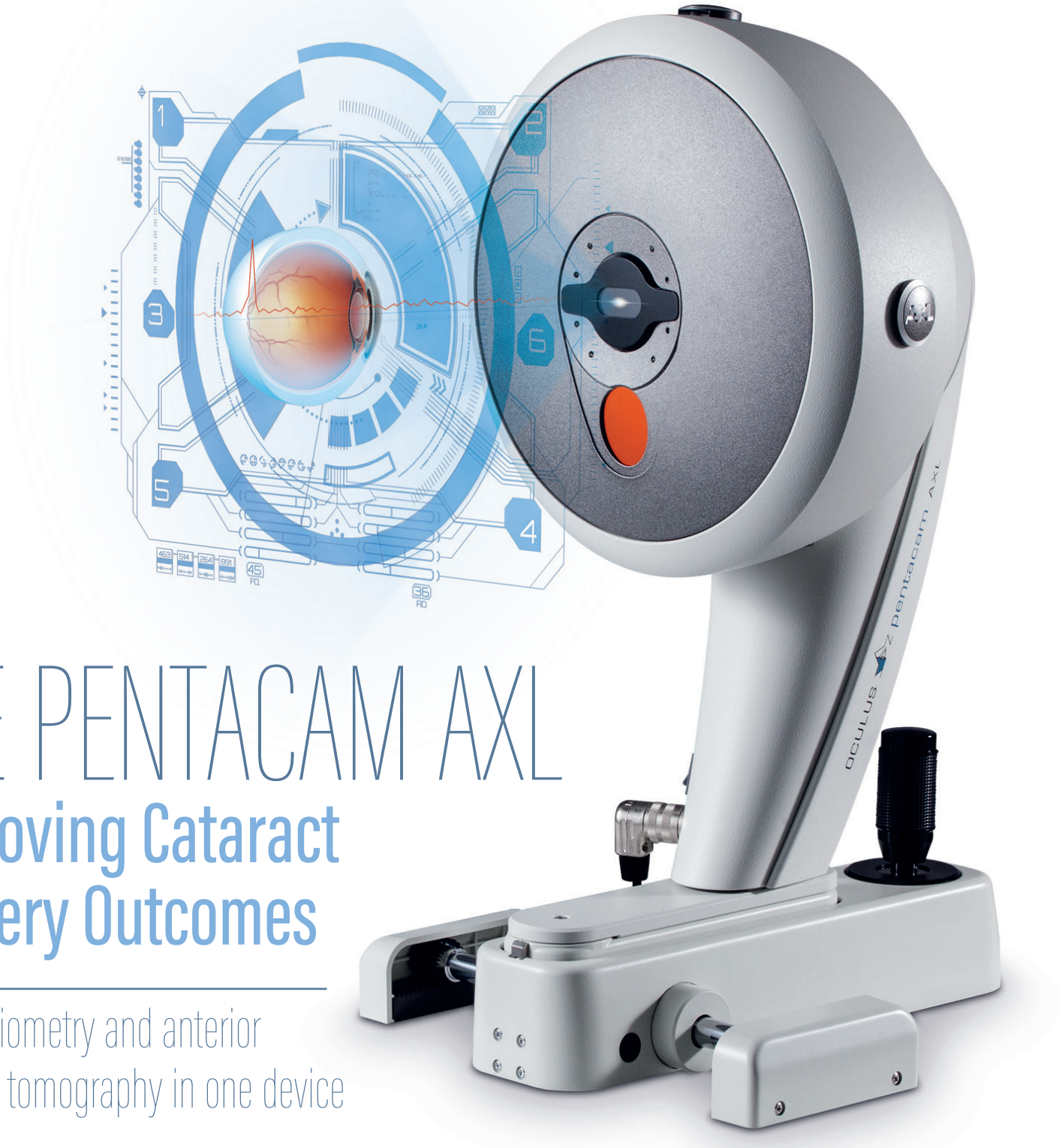

THE PENTACAM AXL

Improving Cataract Surgery Outcomes

Optical biometry and anterior segment tomography in one device

A New Way to Calculate IOL Power

Axial length measurements taken with the Pentacam AXL correlate well with those taken with the IOL Master 500.

BY H. JOHN SHAMMAS, MD

For years, the IOL Master 500 (Carl Zeiss Meditec) has been the most commonly used optical biometer on the market for IOL power calculations. As a result, this device is typically held as the gold standard. However, the introduction of the Pentacam AXL (OCULUS) may challenge this position. The new device integrates partial coherence interferometry to the original Pentacam HR technology in order to provide surgeons with the ability to take biometric measurements of the eye, including axial length, anterior chamber depth, and corneal radius of curvature (steep, flat, and average). As a result of the integration of partial coherence interferometry into the Pentacam AXL, it is now possible to perform IOL power calculations, all using one device with one measurement procedure.

FIVE TIMELESS ADVANTAGES OF THE PENTACAM

I have used the Pentacam AXL for 13 months now, but I have been using the Pentacam technology for many years. What I have always liked about the Pentacam includes the following five advantages.

Advantage No. 1: In patients who have had prior myopic or hyperopic LASIK, the Pentacam provides better keratometry (K) readings, and I can use the device's wavefront analysis to determine what IOL to implant.

Advantage No. 2: In patients who have previously undergone radial keratotomy (RK), the Pentacam produces better central K readings for more accurate IOL power calculations.

Advantage No. 3: In patients with keratoconus, the Pentacam confirms the K readings in the optical axis (vertex normal), not on the corneal apex (steepest point).

Advantage No. 4: The Total Corneal Refractive Power map of the Pentacam provides a more accurate total astigmatic value and a more accurate astigmatic axis, which is useful when I am evaluating patients who are considering a toric IOL.

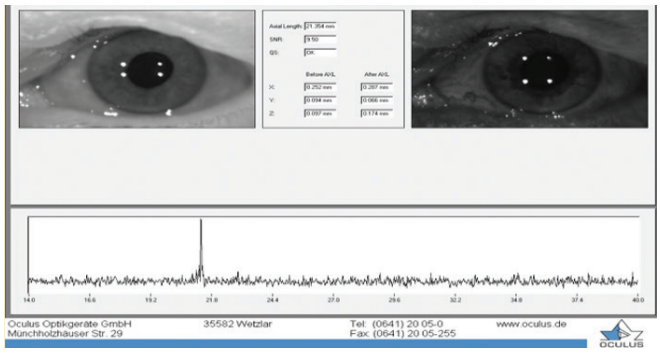

Figure 1. The Pentacam AXL can be used to deliver precise axial length measurements for accurate IOL power calculation.

Advantage No. 5: Because the Pentacam creates a wavefront analysis, it provides a better assessment of the corneal optical quality, which is useful in patients who are selecting a bifocal IOL.

MORE BENEFITS THAN EVER BEFORE

Having the Pentacam AXL in my practice strengthens the clinical relevance of the Pentacam HR technology. Now it is like having two devices in one: In addition to the 3-D scans, I can also use the optical biometry function of the Pentacam AXL to deliver very precise axial length measurements for accurate IOL power calculation (Figure 1). It has become a total screening tool for cataract surgery, allowing me to examine each and every patient with one device instead of two.

With the Pentacam AXL, the axial length and 3-D scan measurements are taken in succession, on the same measuring axis and using the same centering function. In both measurements, the corneal vertex normal is used as the reference point. Any eye motion during the measurement process is detected with the pupil camera and corrected during the calculation process.

The Pentacam technology now has more benefits than ever before. In addition to the five advantages mentioned previously, below are four things I appreciate about the Pentacam AXL.

Advantage No. 1: The Fast Screening Report (Figure 2) alerts me to any possible abnormalities, including possible keratoconus and corneal and anterior chamber changes.

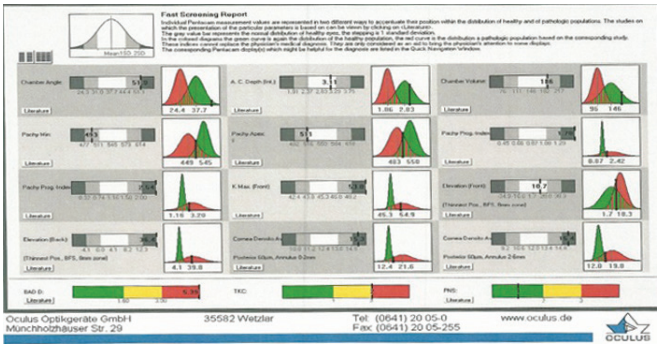

Figure 2. The Fast Screening Report identifies abnormalities, including keratoconus and corneal and anterior chamber changes.

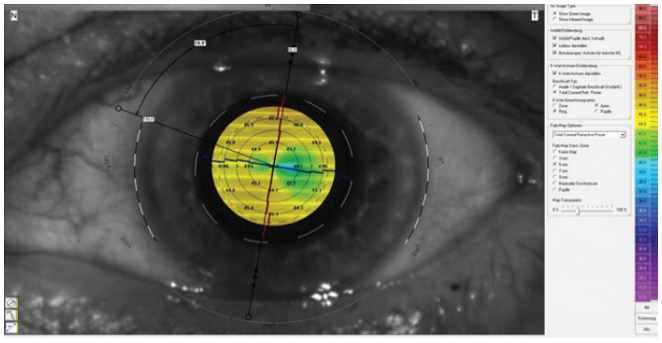

Figure 3. The Pentacam AXL overview image and keratometry overlay can be useful for toric IOL positioning.

Advantage No. 2: IOL power calculations are done automatically, not only for routine cases but also for post-RK and post-LASIK eyes, with no other calculators. Rather, customized formulas developed specifically for the Pentacam AXL are used.

Advantage No. 3: Toric IOL calculations have become easier and more accurate. Just as with standard IOL power calculations, there is no need for additional calculators.

Advantage No. 4: The Pentacam AXL also includes an overview image and keratometry overlay (Figure 3), which I have found useful for toric IOL positioning.

CLINICAL EVALUATION

In a preliminary evaluation of the Pentacam AXL, I compared axial length measurements taken with the device to those taken with the IOL Master 500. In total, 30 eyes with cataracts were included in the evaluation. The average axial length with both devices was 23.76 mm. The arithmetic and mean absolute differences between the devices were 0.00 ±0.04 and 0.026 mm, respectively (range, -0.09 to 0.04 mm). What I found was that all IOL power calculations with the Pentacam AXL were within ±0.25 D of the calculations done with the IOL Master 500.

I also participated in a larger, multicenter study in which measurements were taken from 600 eyes of 600 patients who had undergone cataract surgery at the University of Bochum (n=305), the University of Frankfurt (n=91), the Augenklinik Bad Rothenfelde (n=147), and the Shammas Eye Center (n=47). Although the final results are forthcoming in a future publication, I can share the following now: The agreement and correlation between the mean axial length values taken with the Pentacam AXL and with the IOL Master 500 were excellent. Additionally, the major differences between the two devices were in the measurement of anterior chamber depth, as the Pentacam AXL produced higher mean values, and in the measurement of corneal radius of curvature, as it measured slightly deeper mean values. These differences were statistically significant and were accounted for by optimization of the IOL power formula constants. These differences are likely due to the fact that the Pentacam AXL measurements are taken with optical biometry in the optical axis, as compared with lateral slit illumination with the IOL Master 500.

CONCLUSION

The Pentacam AXL is the next generation in optical biometry. Combining two devices in one, the Pentacam AXL keeps all of the Pentacam HR's features advantageous in the preoperative evaluation of cataract surgery patients and adds the ability to measure axial length, thus supplying surgeons with IOL power calculations. Additionally, with more precise measurements, surgeons can now customize IOL power calculations with the Pentacam AXL. ■

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Pentacam AXL: The Next Gold Standard

Comparative studies have shown that the device can be safely and reliably used to create IOL power calculations.

BY THOMAS KOHNEN, MD, PHD, FEBO

For many years, I have trusted the Pentacam HR (OCULUS) as the gold standard in anterior segment tomography. In cataract surgery, I have relied on this device for topography, implantation of toric IOLs, densitometry, and positioning of IOLs. In refractive surgery, I use it for topography, ectasia and keratoconus screening, and implantation of phakic IOLs. In corneal surgery, I use it for ectasia and keratoconus screening, CXL procedures, and placement of intrastromal corneal rings. Finally, in presbyopia correction, I use the Pentacam HR for densitometry. However, one thing was lacking, and that was the ability to perform IOL power calculations solely based on variables measured with the device.

That has now changed with the introduction of the next-generation Pentacam AXL (Figure 1). In addition to providing me with anterior segment tomography, this enhancement of the Pentacam HR technology also allows me to make accurate IOL power calculations, thanks to the integration of axial length measurements taken with partial coherence interferometry optical biometry (Figure 2).

HOW IT WORKS

Just like the Pentacam HR, the Pentacam AXL is a high-tech device that is capable of myriad functions. A list of features available on the latest-generation Pentacam can be found in the sidebar *Features of the Pentacam AXL*, but the most important of them is axial length measurement. Several axial length measurements are taken in succession, on the same measuring axis and using the same centering function. The software selects the single best of these measurement. The corneal vertex normal is used as the reference point, and any eye movement during the imaging process is detected with the pupil camera and corrected during the calculation process. A 3-D model of the anterior segment is then calculated with ray tracing, allowing any optical distortions to be individually corrected.

The IOL power calculation software of the Pentacam AXL uses customized formulas to create power calculations automatically for routine cases and for post-RK and post-LASIK eyes, without the need for additional calculators. Additionally, toric IOL power calculations have become simpler and more accurate. An added benefit is the device's overview image and keratometry overlay.

The IOL power calculation software takes into account posterior corneal astigmatism and any prior refractive surgery, as well as other conditions of the eye. Most important is that the Pentacam AXL is not restricted to only measuring the anterior corneal surface, meaning that I am less likely to miss detecting anything abnormal on the posterior corneal surface. Being able to take into account posterior corneal astigmatism provides the foundation for a more reliable IOL power calculation, which I have found leads to improved postoperative outcomes and happier patients.

Figure 1. The next-generation Pentacam AXL.

The Pentacam AXL software includes the triple IOL constant optimization algorithm, developed by Wolfgang Haigis, PhD. This is designed to streamline the process of tracking postoperative outcomes, with all of the respective data added with just a few entries. Due to the network-compatible software, the Pentacam AXL can be used in both the operating room and the consulting room.

FEATURES OF THE PENTACAM AXL

Axial Length Measurement and 3-D Scans in One Routine Exam

- IOL power calculations (sphere, toric, postrefractive)
- Scheimpflug imaging
- Iris imaging, showing sclears blood vessels for toric IOL positioning
- Keratometry overlay
- 3-D anterior chamber analyzer
- Pachymetry maps (absolute, relative)
- Elevation maps (anterior, posterior)
- Topography maps (anterior, posterior)
- 3-D cataract analyzer
- 3-D phakic IOL simulation and aging prediction
- Belin/Ambrósio Enhanced Ectasia Display III
- Holladay Report and EKR Detail Report
- Tomography
- Corneal optical density
- Cataract Pre-OP Display
- Corneal wavefront
- Fast Screening Report
- Intrastromal corneal rings display
- Various comparative displays

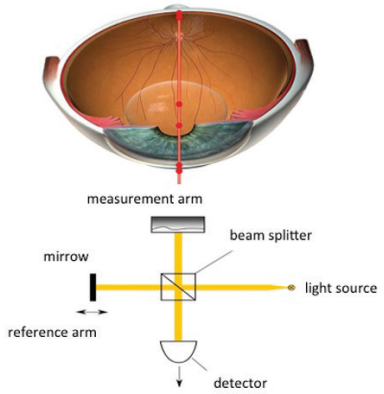

Figure 2. Schematic of partial coherence interferometry to measure axial length.

TABLE 1. COMPARISON OF MEASUREMENTS WITH THE IOL MASTER 500 AND PENTACAM AXL

	IOL Master 500				Pentacam AXL			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Axial length (n=136)	23.81	1.33	21.25	31.20	23.81	1.34	21.14	31.01
Rs (n=136)	7.70	0.29	6.99	8.75	7.73	0.28	7.10	8.79
Rf (n=136)	7.88	0.29	7.26	8.97	7.85	0.29	7.31	8.95
Rm (n=136)	7.79	0.28	7.13	8.86	7.82	0.27	7.20	8.86
ACD (n=136)	3.13	0.40	2.10	4.01	3.21	0.41	2.14	4.34
WTW (n=107)	11.96	0.42	11.10	12.70	11.81	0.40	10.81	12.69

In mean axial length, measurements were identical.

TABLE 2. MEAN DIFFERENCE IN COMPARED VALUES

	Mean Difference	COR	ULOA	LLOA	P
Axial length (n=136)	-0.04	0.09	0.09	-0.09	0.15
Rs (n=136)	0.03	0.16	0.19	-0.13	0.09
Rf (n=136)	-0.03	0.25	0.22	-0.28	0.77
Rm (n=136)	0.03	0.14	0.17	-0.12	0.31
ACD (n=136)	0.08	0.39	0.47	-0.31	0.51
WTW (n=107)	-0.16	0.27	0.12	-0.43	0.97

No significant difference in any of the compared variables was found.

COMPARATIVE STUDY

Study design. My colleagues and I conducted the first study in the world to evaluate axial length measurements with the Pentacam AXL. The purpose of our study was to determine if this device could safely and reliably be used to create IOL power calculations. In our analysis, we compared the measurement of axial length, corneal curvature, corneal radius, and anterior chamber depth—all of which are required for IOL power calculation—taken with the Pentacam AXL to those taken with the IOL Master 500 (Carl Zeiss Meditec).

This retrospective study enrolled 136 eyes of patients aged 66 ±12 years who were scheduled for cataract surgery. The type and stage of cataract were not considered. All eyes were measured with both devices, first with the IOL Master 500 and then with the Pentacam AXL. We did not include patients with

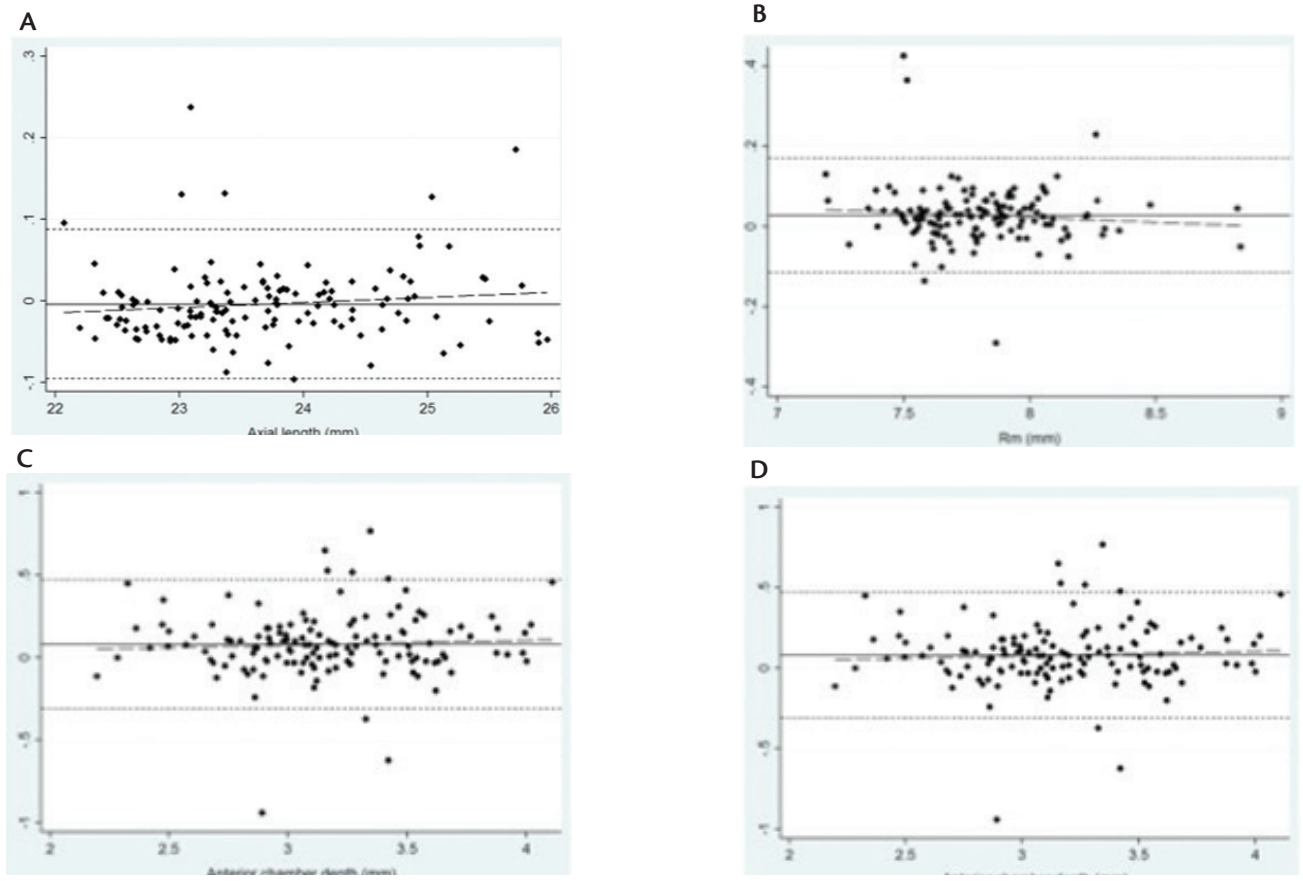

Figure 3. Favorable limits of agreement in axial length (A), radius (B), anterior chamber depth (C), and white-to-white (D) measurements between the Pentacam AXL and IOL Master 500.

known macular pathologies or axial length measurements of less than 22 mm or greater than 26 mm (as measured with the IOL Master 500) in our analysis. In the event that the automatic Pentacam AXL quality measurement did not mark the scan as "OK," the measurement was also excluded.

Results. Table 1 shows the mean, standard deviation, and minimum and maximum measurements of axial length, corneal curvature, anterior chamber depth, and corneal radius taken with the Pentacam AXL and with the IOL Master 500. On average, the axial length measurements were nearly identical between the two devices, and there was no significant difference in any of the compared variables (Table 2).

Due to the favorable limits of agreement found between measurements made with the Pentacam AXL and the IOL Master 500 (Figure 3), and due to the fact that there were no significant differences in keratometric, anterior chamber depth, or white-to-white measurements between the two devices, we showed for the first time that it could be possible to use the Pentacam AXL for IOL power calculations.

Further study. The Pentacam AXL has been the subject of further studies as well. In another comparison of the Pentacam AXL to the IOL Master 500, again the devices produced nearly identical results. This data set included 600 eyes of 600 patients who had undergone cataract surgery at the University of Bochum (n=305), the University of Frankfurt (n=91), the Augenklinik Bad Rothenfelde (n=147), or the Shammas Eye Center (n=47). Results of this study will be published in a peer-reviewed journal in the near future.

CONCLUSION

The Pentacam AXL produces a 3-D scan of the anterior segment and axial length measurements in one routine exam. It has quickly become the complete screening tool for cataract surgery patients, as patients now only need examination with one device instead of two. ■

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Enhancing Surgical Efficiency With a Two-in-One Device

The Pentacam AXL accurately images all eyes and is a useful tool in toric IOL implantation.

BY H. BURKHARD DICK, MD, PHD; TIM SCHULTZ, MD; AND ALEXANDER FELL, MD

About the same time this past year, Bochum University Eye Hospital began using the Pentacam AXL (OCULUS), alone, to evaluate patients presenting for cataract surgery. Prior to this time, we used both the Pentacam HR and the IOL Master 500 (Carl Zeiss Meditec), the former to image the anterior segment and the latter to determine the correct IOL power. Given the recent additional function of the Pentacam AXL to produce axial length measurement and therefore calculate the IOL power, we no longer routinely use the IOL Master 500.

Since introducing the technology into our practice, we have evaluated more than 400 patients with the Pentacam AXL. Not only have we been happy with the device in all cases, but we are extremely impressed with its ability to provide accurate and detailed Scheimpflug images in abnormal eyes, including post–refractive surgery eyes and those with endothelial irregularities. These images are captured in both the anterior and posterior segments of the eye.

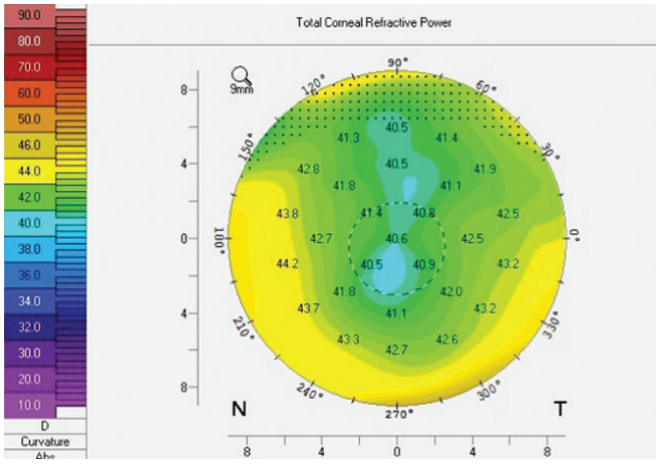

Figure 1. The Total Corneal Refractive Power map calculates the total corneal power of both anterior and posterior astigmatism.

All images courtesy of H. John Shammas, MD

TOTAL CORNEAL REFRACTIVE POWER

Because the topography of the Pentacam AXL so clearly shows irregularities, including astigmatism, we have also found it to be a useful tool in toric IOL implantation. Unlike other devices that only measure keratometry as the radius of curvature of the anterior corneal surface, the Pentacam AXL measures the keratometry of both the anterior and the posterior corneal surface and creates three different maps: Sagittal (axial) Power (SimK), True Net Power, and Total Corneal Refractive Power.

The SimK map is a Placido-style map of the front corneal surface only, whereas the True Net Power map provides the optical power of the cornea by using sagittal curvature values from both the anterior and posterior corneal surfaces. Lastly, the Total Corneal Refractive Power map (Figure 1) uses ray tracing to calculate the total corneal power of both anterior and posterior astigmatism. With each map, the keratometry readings are measured at the 2-, 3-, 4-, and 5-mm rings and at the 2-, 3-, 4-, and 5-mm zones.

Several studies to date have assessed the value of

TABLE 1. PREDICTED VS SUBJECTIVE POSTOPERATIVE REFRACTION

IOL Master 500 / IOL Implanted	Number of patients	Median Absolute Error (SEQ)	< 0.50 D (%) SEQ	< 1.00 D (%) SEQ
SA60AT (Alcon)	39	-0.08	84.62	100
MC6125 Diff (HumanOptics)	88	-0.28	88.64	97.73
CT Spheris 204 (Carl Zeiss Meditec)	33	-0.13	93.94	93.94
Pentacam AXL / IOL Implanted	**Number of patients**	**Median Absolute Error (SEQ)**	**< 0.50 D (%) SEQ**	**< 1.00 D (%) SEQ**
SA60AT (Alcon)	39	0.06	82.05	100
MC6125 Diff (HumanOptics)	88	-0.25	84.09	96.59
CT Spheris 204 (Carl Zeiss Meditec)	33	-0.03	87.88	93.94

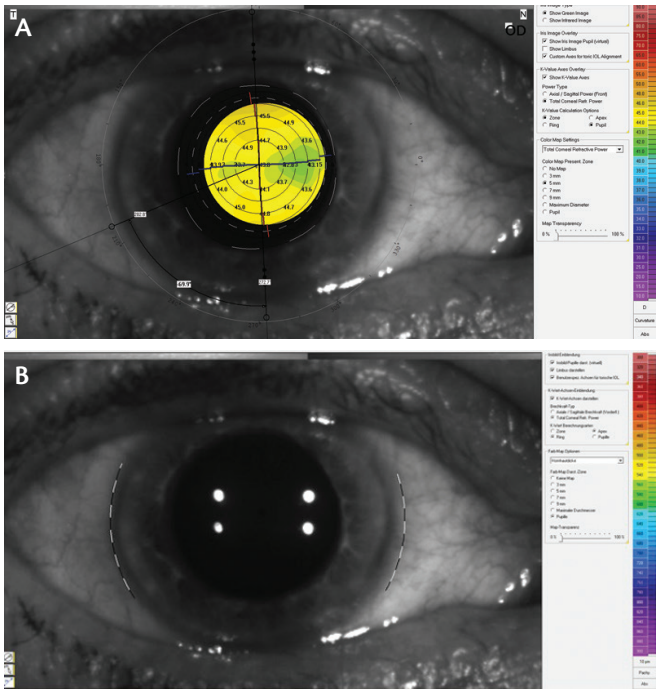

Figure 2. The improved iris image of the Pentacam AXL (A) can aid in toric IOL implantation because it displays a bigger overview of the patient's eye, complete with visible scleral blood vessels (B).

total corneal refractive power in toric IOL calculations.[1-3] Although our experience using total corneal refractive power as a basis for toric IOL implantation is limited to 10 cases thus far, what we have found in our early experience is that it appears to be an excellent way to calculate the total corneal astigmatism. We believe that optimization of our A-constants will further improve our results.

Another nice feature of the Pentacam AXL that can aid in toric IOL implantation is the device's improved iris image (Figure 2A), which displays a bigger overview of the patient's eye, complete with visible scleral blood vessels (Figure 2B). An individual pointer can identify prominent blood vessels in order to compensate for cyclorotation and help in positioning toric IOLs. The iris image can also be superimposed with the Total Corneal Refractive Power map.

OTHER EFFICIENCIES

The Pentacam AXL software is not only good, but it is intuitive. It provides a well-targeted patient screening process with good quality measurements in quite a fast time. Also, there is no need for the patient to move between two devices during the preoperative examination.

Another function of the Pentacam AXL that we have found particularly useful in the evaluation of cataract surgery patients is its densitometric evaluation with Corneal Optical Densitometry and Pentacam Nucleus Staging (Figure 3). These tools provide us with the objective lens density prior to surgery. Furthermore, using the Belin/Ambrósio Enhanced Ectasia Display, the device can be used as a tool for early detection of corneal ectasia.

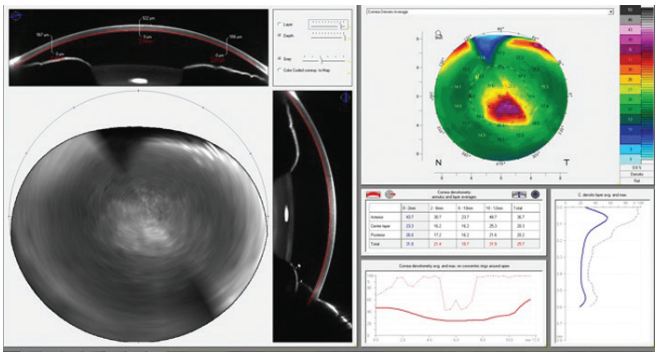

Figure 3. The Pentacam AXL can perform densitometric evaluation with its Corneal Optical Densitometry and Pentacam Nucleus Staging software.

PREDICTED VERSUS SUBJECTIVE POSTOPERATIVE REFRACTION

In a current study we are conducting at University Eye Hospital Bochum and Augenklinik Bad Rothenfelde, we are comparing the predicted postoperative refraction (spherical equivalent; SEQ) with the IOL Master 500 and the Pentacam AXL to patients' subjective postoperative refraction. The preliminary results are promising (Table 1).

CONCLUSION

When practicing refractive cataract surgery, precision is crucial in order to provide patients with perfect postoperative results. As the Pentacam AXL provides us with accurate and detailed information and takes into account both anterior and posterior parameters, we believe that it is the ideal tool for cataract surgery evaluations. All in all, the Pentacam AXL has become a must-have tool in our respective clinics. ■

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