

TAKING ANTERIOR SEGMENT ANALYSIS TO THE NEXT LEVEL

The Pentacam® AXL Wave offers the surgical eye practice a new peak of efficiency

When it comes to today's surgical eye practice, finding more time to accommodate an increasing population of patients seeking solutions for their cataract and refractive issues is a top priority. Global demand for refractive surgical procedures is expected to grow at a compound annual rate of 9.6 percent from 2020 to 2025.¹ Practices that adopt technology that helps them address this influx of new patients may gain a competitive edge over other practices.

In tandem with this increasing demand, the era of COVID's added health and safety protocols has only intensified the need for the surgical practice to gain efficiencies and streamline operations. Technological advances that increase diagnostic capabilities and reduce the number of surfaces to clean can increase the speed with which practitioners get back to patient care.

From a clinical standpoint, patients undergoing cataract and refractive procedures in 2021 have exceedingly high expectations for their visual outcomes. Achieving great results requires moving beyond simple biometry and collecting axial length and anterior surface keratometry measurements.

For example, surgeons need the ability to measure the posterior corneal surface, anterior chamber depth, and optical

biometry, among other quality of vision functionality. More versatile diagnostic capabilities can accelerate clinical flow and rapidly arm surgeons with data to make the best decisions for their patients.

Helping to meet these demands is a next-generation device that takes anterior segment tomography and optical biometry to the next level. In March 2021, the FDA approved the Pentacam® AXL Wave, the latest member of the Pentacam® family of devices offering Scheimpflug-based anterior segment tomography and optical biometry—but with the added benefits of retroillumination and a Hartman-Shack sensor for total eye wavefront and objective refraction.

The device performs five major functions in one measurement routine on the same measuring axis, using the same alignment navigation. This added functionality means the doctor or technician can reduce the number of times they switch devices, and it also means fewer pieces of equipment need to be sanitized in between patients.

Early feedback from surgeons has been that the Pentacam® AXL Wave offers them clinical and practice advantages, as evidenced by the following discussion among early adopters of the technology.

A CLOSER LOOK AT THE PENTACAM® AXL WAVE

In the latest Pentacam® iteration:

- Scheimpflug-based anterior segment tomography and optical biometry are complemented by retroillumination and a Hartman-Shack sensor for total eye wavefront and objective refraction
- Software enables optical performance analysis of the total cornea, total eye, crystalline lens, and implanted IOL
- Intuitive guidance enables both eyes to be examined in less than 5 minutes
- A comprehensive dashboard shows all parameters for corneal screening, IOL power selection and calculation, ICL selection and calculation, and pupil diameter under mesopic and scotopic or room and dark conditions
- The IOL calculator, with a built-in database, verifies findings in several clinical applications such as corneal refractive surgery, lens refractive surgery, presbyopia management, and standard cataract surgery
- Preoperatively, a surgeon can, for example, perform objective refraction, identify low or higher order aberrations (HOAs), and obtain one wavefront to secure aberration measurements for all eye segments. Two pupil diameters are available (mesopic and scotopic), and the anterior segment tomography function provides data to assist the surgeon in assessment of glaucoma, cornea ectasia and Fuchs' endothelial dystrophy. The Pentacam® AXL Wave also can assess visual disturbances and identify their causes.
- Postoperatively, the surgeon is able to, for example, repeat the objective refraction, recheck for HOAs including spherical aberration and use retroillumination of the pseudophakic eye to depict the multifocal or toric IOL, perform wavefront aberrometry, and assess visual performance.



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ADOPTING NEW TECHNOLOGY

Dr. Waring: When did you start using the Pentacam® AXL Wave and what made you decide to try this latest advancement in anterior-segment imaging technology?

Dr. Gulani: I started using the Pentacam® AXL Wave in 2021, having successfully used the Pentacam® platform for over two decades and having been involved in technological advances with brilliant engineers at OCULUS who promptly adapt and incorporate new ideas.

Dr. Miller: I began using the Pentacam® AXL Wave 6 or 7 months ago. My interest in the device had to do with its ability to determine the Zernike polynomials of the crystalline lens. This is quite unlike other devices that can see “internal aberrations” but cannot separate what arises from the back of the cornea from what arises in the crystalline lens. The newest Pentacam® model, the AXL Wave, can “see” the front and back surfaces of the cornea and subtract their combined wavefront from the wavefront of the entire eye to arrive at a wavefront for the crystalline lens all by itself (or a lens implant, for that matter).

Dr. Greenstein: We started using the Pentacam® AXL Wave over a year ago. Since then, the software for this device has continued to improve. I was very excited about the opportunity to try the Pentacam® AXL Wave since the idea of having one device to measure tomography with the detail of the Pentacam® HR, obtain axial length, and capture wavefront aberrations all at once was extremely attractive. The continued software updates have further improved on this technology. OCULUS continues to develop extremely detailed and clinically relevant software, and I am looking forward to the software updates that will allow a clinician to separate out the internal aberrations from the total corneal aberrations, not just the aberrations on the anterior corneal surface.

Dr. Waring: Let’s discuss some of the features of this new device and how you use it for your patient population: A. What role does tomography play? B. How do you use axial length? C. What role does aberrometry play? D. How do you use the retroillumination feature?

Dr. Gulani: It is an art that refractive and cataract surgeons should understand how to correlate anatomy with optics and then holistically custom design surgery. In my patient population, I use axial length to not

only decide premium cataract surgery lens power but also to make surgical choices like ICL vs. LASIK in addition to educating patients with extreme lengths of their likely prognosis. I use aberrometry to catch subtle hints of pathologies like forme fruste keratoconus (FFK) and to better understand the complaints of patients who were referred as a result of their dissatisfaction with premium cataract or LASIK surgery. Finally, I use retroillumination to look at optical pathway clarity (cataract, and corneal scars including radial keratotomy [RK]) incisions pre-surgery and toric IOL placement post-surgery.

Dr. Miller: The tomography functionality allows me to see the peaks and valleys of the front and back surfaces of the cornea. It’s especially useful as a screening tool for determining suitability for laser vision correction. When converted to topography data, I like to use the data to calculate total corneal astigmatism for toric lens implant power calculation.

Though I don’t use the optical biometer on the Pentacam® AXL Wave at this point, if a surgeon wanted to calculate lens implant power using the device, the biometer would be indispensable.

I have found the aberrometry function to be especially useful for determining candidacy for laser vision correction. It is also helpful for screening premium cataract surgery patients and for troubleshooting cases in which patients have visual difficulty following otherwise uneventful cataract surgery. The retroillumination feature is useful for documenting abnormalities in the size and shape of the pupil, and as a crude tool for documenting certain types of cataracts.

Dr. Greenstein: Tomography plays a crucial role in any refractive practice. It is the backbone of any refractive workup. When making decisions about the appropriate refractive procedure for an individual patient, it is critical to understand everything about the shape, not just the curvature, of the cornea. It is crucial to be able to locate islands of posterior elevation, which are concerning for a forme fruste or mild keratoconus. And it is important to be able to reliably measure global corneal thickness to determine if there is localized thinning outside of the central cornea. This can be easily missed by devices only measuring the corneal thickness at one point. By imaging the total cornea, front, back, and thickness, this allows for multi-metric evaluation, which is crucial for diagnosing and monitoring progressive corneal disease such as keratoconus and post-refractive ectasia. And we know OCULUS has

some of the most powerful analytic software available for these evaluations.

Axial length is most important for our preoperative cataract evaluation, but we also use it in our keratoconus and refractive workups. Frequently, our keratoconus patients will have moderate or severely myopic refractions, and steeper corneas contributing to this myopia. The axial length measurement is a quick way to determine whether there is an axial component contributing to the patient's myopia, and enables me to set proper refractive expectations when planning corneal procedures to flatten a patient's cone. Before the Pentacam® AXL, we had to bring patients to an additional device for this one measurement. Now it can be done all at once.

Finally, the axial length can be helpful in determining "myopic regression" in patients who had laser vision correction, particularly at a younger age. When a patient arrives with myopia years after LASIK, it is important to determine the cause of this regression before retreating the patient. Any corneal curvature changes or evidence of ectasia can be determined with the tomography analysis, and a change in axial length is easy to identify as well.

Aberrometry plays an important role in objectively understanding the patient's visual quality. However, aberrometry from many devices is not specific and unable to differentiate the source of the aberrations. Though several devices use a Placido ring topographer to attempt to do this, in patients with keratoconus or other forms of ectasia where the first corneal changes are on the posterior cornea, creating posterior corneal aberrations, these aberrations get included in the internal aberrations. Without a separate tomography device, this can lead to flaws in differentiation of corneal or lenticular aberration. Anterior, posterior, and total cornea aberrations play an important role in having a more complete understanding of a patient's visual system. The Pentacam® AXL Wave allows me to measure a wavefront refraction and a patient's higher order aberrations in one sitting so I can quickly assess the source of a patient's visual complaints after refractive surgery and better address them postoperatively. Future software that separates the internal aberrations from the total cornea aberrations—especially those patients with both corneal and lenticular pathology—will be very helpful in diagnosing the source of a patient's pre- and postoperative visual complaints.

The retroillumination feature is useful to see pathol-

ogy that is directly in the visual axis. (It is important to use this feature in a dark room to get the full advantage of this display, which is effective for patient education.) It is a simple way to show a patient pathology in their visual axis before discussing the treatment plan to improve their vision. Combined with the densitometry analysis from the Pentacam®, the retroillumination feature can offer yet another way to understand the visual impact of these pathologies.

DATA TO HELP MAKE THE RIGHT DECISIONS FOR PATIENTS

Dr. Waring: How do you use the information generated from the Pentacam® AXL Wave to discuss IOL selection with your patients? Do you think the device gives doctors an extra edge in making the right decision for patients undergoing cataract surgery? Please explain.

Dr. Gulani: Yes, indeed. Visually, you can look at the entire optical system from cornea to lens and beyond, not only anatomically but also optically, and understand the projected interplay of IOL optics with that particular eye while also ruling out subtle pathologies (Fuchs', FFK, etc.).

Dr. Miller: I don't currently use my Pentacam® devices for IOL power calculation. However, I do obtain a Scheimpflug map on every patient on whom I am planning astigmatism management and/or multifocal IOL implantation. I find the total corneal astigmatism measurement to be indispensable for toric planning. Why guess at the contribution of the posterior corneal surface when you can measure it directly?

Dr. Greenstein: The advantage of the Pentacam® AXL wave for cataract surgery is the ability to generate so much patient data with one exam. Making the right preoperative intraocular lens decision for a patient undergoing cataract surgery is vital to achieving patient satisfaction after cataract surgery. With so many lens options it is important to determine which patients may or may not be good candidates for a particular premium lens. With the Pentacam® AXL Wave, I can make much of that determination with one device. I am able to look at the tomography for evidence of surface pathology or irregular astigmatism that may rule out a toric or presbyopia-correcting lens, or determine the need for a sequential treatment strategy to treat the cornea first. I am able to account for both anterior and posterior astigmatism to make a toric lens choice. The device allows me to separate out corneal higher order

aberrations that may also influence my decision on certain multifocal or extended depth of focus intraocular lenses.

EDUCATING PATIENTS ABOUT THEIR CONDITION

Dr. Waring: Can you discuss the value of the Pentacam® AXL Wave for patient education?

Dr. Gulani: It's tremendous since patients can see the optical input of each element of the eye while also understanding topography, refraction, and a holistic evaluation of the entire ocular visual system.

Dr. Miller: I show every patient the map of their own cornea and explain how their astigmatism affects their vision. The visual graphic is very helpful, especially when I further use my fingers to illustrate the curvatures of the patient's own cornea in the steep and flat orthogonal meridians.

Dr. Greenstein: The retroillumination image can be very helpful in showing a patient the pathology that is affecting their vision. It is a great way to show patients lenticular change and to explain why they might need cataract surgery. Future software in development will show patients their corneal and lenticular aberration profiles separately, making it easier to highlight the source of their visual complaints.

Dr. Waring: How can the Pentacam® AXL Wave help determine the proper axis placement of toric IOLs?

Dr. Gulani: The device can do so by accurate topography and now refraction in this new AXL Wave system and then postoperatively via the retroillumination image on the full report screen.

Dr. Miller: It gives a surgeon the steep axis of the total corneal astigmatism, and not just that of the anterior surface. This information can be plugged into intraoperative guidance devices such as the Zeiss Callisto or the Alcon Verion. In the operating room, the surgeon can further refine the axis of toric placement using an Alcon ORA aberrometer.

Dr. Greenstein: The retroillumination image may enable you to see your toric lens alignment postoperatively. This requires the image to be taken in a complete dark setting to achieve adequate or pharmacologic dilation to see the IOL markings.

Dr. Waring: How do you use the device to monitor post-surgical results?

Dr. Gulani: I use it for refraction, topography, and anatomical and technological assessments to move from "predicted" to "performed" results.

Dr. Miller: I obtain a second Scheimpflug imaging map after every cataract procedure to determine the surgically induced astigmatism for that eye. This information helps me to plan touch-up procedures should they become necessary. It also helps me to build a database of surgically induced astigmatism so I can track my results.

Dr. Greenstein: The device is great for measuring post-surgical results. For corneal refractive surgery, it will measure a postoperative wavefront refraction, a postoperative tomography, an aberration profile to

For me, the ability to see so much data from one device is the greatest advancement of the Pentacam® AXL Wave technology. Before this device was available, we had the ability to measure all of this data, but it required taking a patient to 3 or 4 devices to complete the evaluation. Now with the ability to generate this data on one device, particularly for postoperative evaluations, this can save the clinician and the patient a significant amount of time.

—Dr. Greenstein

DR. GULANI CASE STUDIES USING THE PENTACAM® AXL WAVE

CASE 1. A Complex Nightmare to 20/25 Vision. In this case, we staged the patient’s surgery using Pentacam® and the Gulani T-INTACS technique to bring 23.5D to 1.4D of astigmatism, and then planned premium toric cataract surgery.

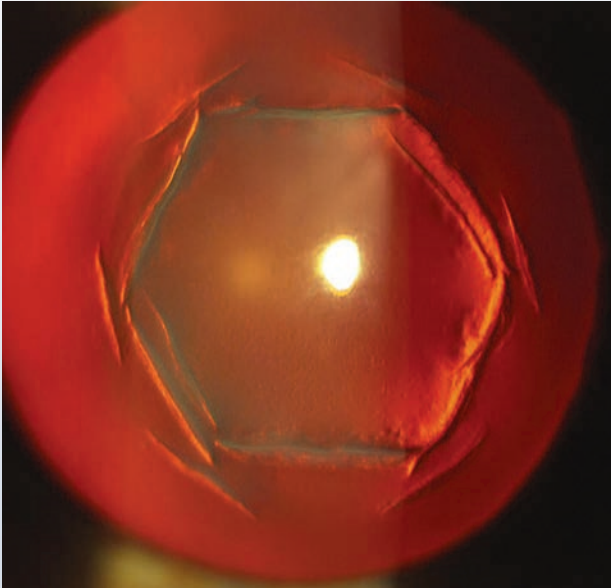
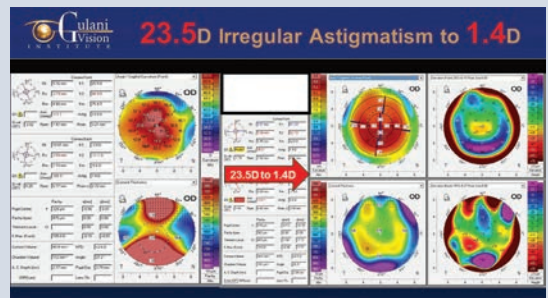
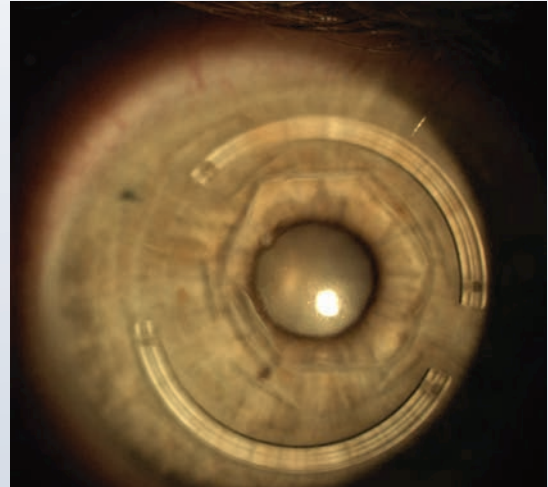
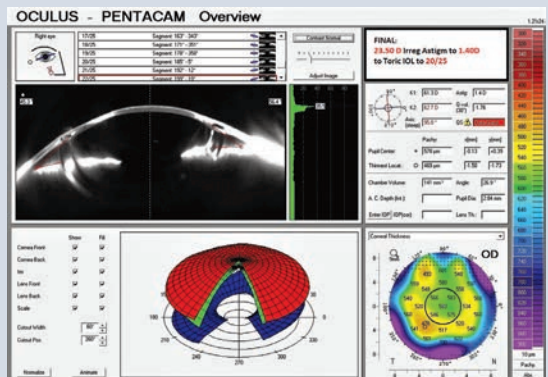
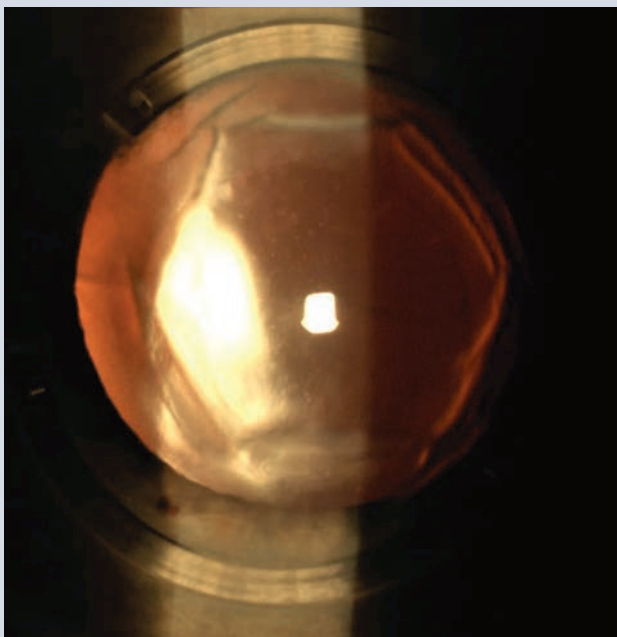


Figure 1. Irregular astigmatism, 90D keratometry, co/ectasia cataract, preoperatively.



Figures 2 and 3. Irregular astigmatism, 90D keratometry co/ectasia cataract, post-INTACS, pre-cataract surgery and topography.



Figures 4 and 5. 23.5D irregular astigmatism, 90D keratometry, co/ectasia cataract, postop 1 and 2.

determine the quality of the patient’s vision, and a retroillumination image that shows corneal or lenticular pathology in the visual axis—all in one device. These metrics can also be followed over time and compared from one exam to another to determine any need for future treatment.

Dr. Waring: Which advancements from the Pentacam® AXL Wave are most useful to you compared to previous models you’ve had in practice?

Dr. Gulani: Refraction, summary view, and isolated optical elements visualization have been invaluable tools to me.

Dr. Miller: It’s helpful to have a device that can show lens aberrations, as this one does. It’s especially useful for patients who have subtle lenticular changes but poor-quality vision and no anatomic correlate on slit lamp examination.

Dr. Greenstein: We were using the Pentacam® HR before changing to the AXL wave. For me, the ability to see so much data from one device is the greatest advancement of the Pentacam® AXL Wave technology. Before this device was available, we had the ability to measure all of this data, but it required taking a patient to 3 or 4 devices to complete the evaluation. Now with the ability to generate this data on one

DR. GULANI CASE STUDIES USING THE PENTACAM® AXL WAVE CONTINUED

CASE 2. Taking a Corneal Scar/Irregular Cornea to 20/20

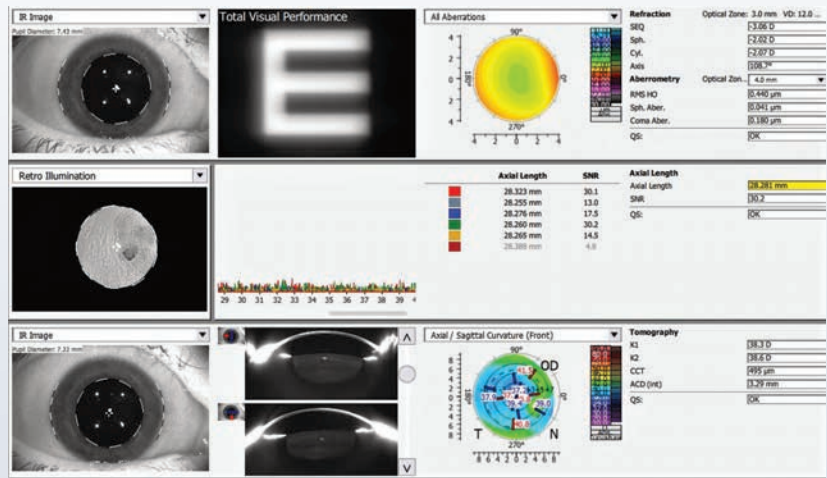
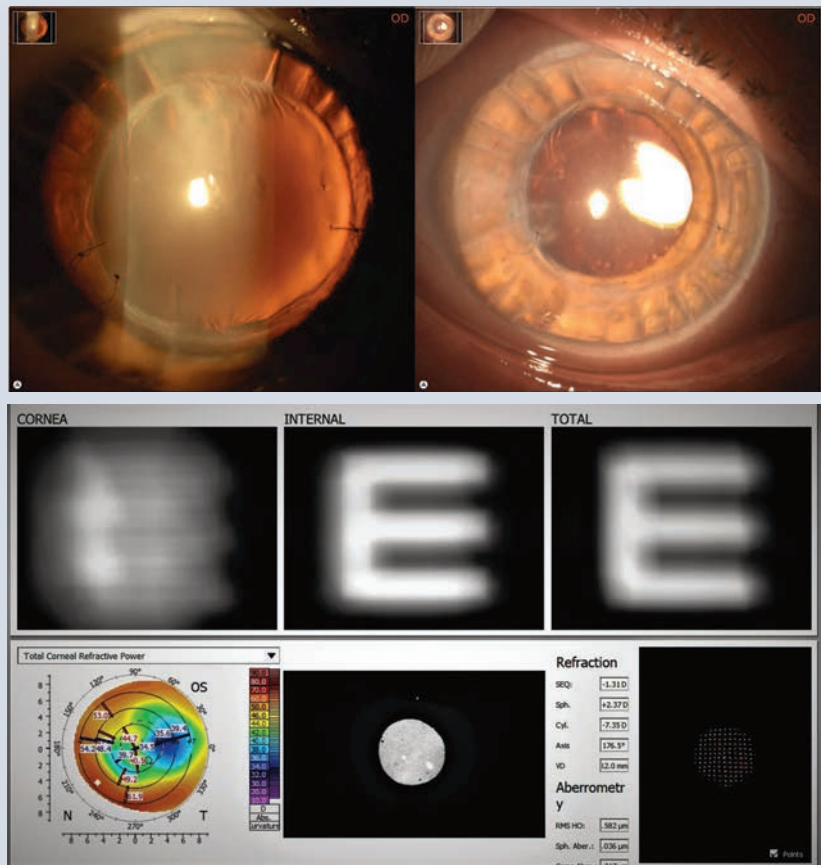


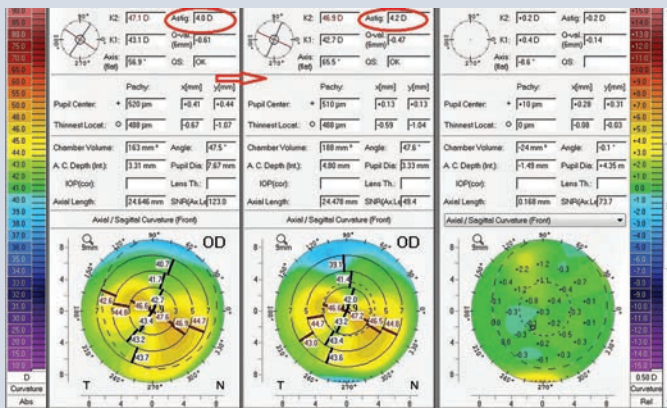
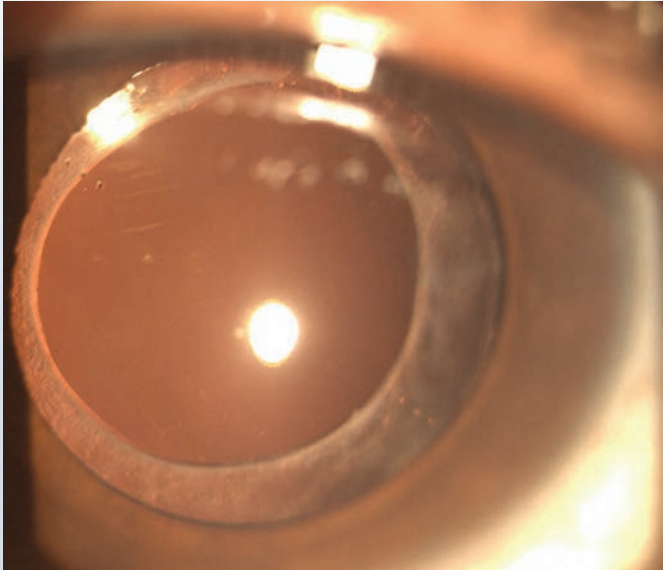
Figure 6. Here, the corneal scar in retroillumination and topography is apparent.

CASE 3. Taking a 20 Cut Radial Keratotomy and Transplant Cornea with Cataract to 20/25 Vision



Figures 7 and 8. The “E” of the cornea is distorted and yet the patient’s final vision “E” is clear.

CASE 4. Keratoconus Cornea to Premium Cataract Surgery



Figures 9 and 10. Keratoconus cornea with the same pre-and postoperative astigmatism, with vision from toric IOL.

device, particularly for postoperative evaluations, this can save the clinician and the patient a significant amount of time.

TECHNOLOGY AIDS MANAGEMENT OF PATIENT CASES

Dr. Waring: Can you discuss specifically how the Pentacam® AXL Wave has been helpful for your patient cases and why?

Dr. Gulani: It helps patients every day at our institute, which has one of the world's largest second opinion and complication management practice profiles. It aids us in safely providing maximum visual outcomes to patients who were told they could not benefit from premium cataract surgery, in performing LazrPlastique™ “no-cut,” “no-blade” laser vision procedures in irregular corneas, in taking keratoconus patients straight to 20/20 vision, and in staging complex surgeries and taking them to 20/20.

Dr. Miller: In many cases, I can show the presence of significant posterior corneal astigmatism with very little corresponding anterior corneal astigmatism. If all I had was a map of the anterior surface, I would be missing much of the total astigmatism of the eye.

Dr. Greenstein: In patients with multiple conditions such as minor corneal irregularity and early cataract where the treatment target is unclear, the Pentacam® AXL Wave has aided us in differentiating the issues, and made it easier to select a treatment or a sequence of treatments necessary to improve patients' vision. For

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instance, a patient in their mid-50s with 20/30 vision had a visible mild cataract but tomography also showed minor corneal changes that were contributing to the visual decrease. By differentiating the pathology, we determined a sequential treatment—first targeting the cornea to improve corneal curvature, followed by cataract surgery—as the best choice to achieve an excellent visual outcome.

A STRATEGY TO SUPPORT EFFICIENT WORKFLOW

Dr. Waring: How has the Pentacam® AXL Wave altered the workflow in your office? How many devices are you finding it can replace in the office?

Dr. Gulani: It can be the heart of a Kerato-Lenticulo-Refractive practice™ with its current features.

Dr. Miller: It has not replaced any devices in my office currently. However, if one wanted to use a Pentacam® AXL Wave instead, it would eliminate the need for other biometers.

Dr. Greenstein: The Pentacam® AXL Wave is as close to an all-in-one device as you can get for a cornea and refractive surgery practice. There is a learning curve for the staff to become comfortable with taking all of the different measurements. Particularly the aberration measurements are not as straightforward as the tomography on the previous Pentacam® devices. However, once the staff gets used to it, it can save a tremendous amount of time. For our preoperative evaluations, we are still using multiple devices, including the Pentacam® AXL Wave, to determine the best refractive procedure or intraocular lens for a patient, but for postoperative evaluations this has really increased our practice efficiency.

Dr. Waring: Given the time constraints and safety protocols that surgical practices are facing in the era of COVID, how does it help efficiency to have a single device that needs to be sanitized, as opposed to three or four?

Dr. Gulani: Of course the efficiency is a given, but also letting patients know that this is a “no-touch” de-

vice goes a long way in today’s COVID environment

Dr. Greenstein: There is no question that our workflow has been significantly altered in the era of COVID. So much of our staff time has been designated to maintaining social distance between our patients, limiting the amount of time the patient spends in the office, and sanitizing all of the rooms and equipment after each use. With the Pentacam® AXL Wave, we can generate so much diagnostic information with one device. This allows us to get patients in and out of the office more efficiently, with less need to wait for additional rooms to become available, and less need to clean multiple devices for every patient.

Dr. Waring: From an ROI perspective, do you feel that the price justifies the practice improvements you have seen in time savings and efficiency?

Dr. Gulani: If we teach surgeons the entire application of this technology, they will look at it as more than just a topographer (that is what they compare prices with), and realize its value comprehensively.

Dr. Miller: I wanted an instrument that could give me wavefront information specific to the lens of the eye, and this is the only device on planet earth that does it currently!

Dr. Greenstein: If you just consider the number of devices that the Pentacam® AXL Wave has the potential to replace—an autorefractor, topographer, aberrometer, and biometer—then the ROI of this one device is clearly evident. With the ability to do so much testing with one device, I can see more patients in a shorter amount of time, which is critical for practice efficiency. There is less patient traffic in the office, less square footage needed for multiple devices, and training of technicians becomes simpler as they need to learn to use fewer devices. Additionally, I work with an optometrist specialized in contact lenses and Boston-Sight PROSE™ treatment, and he has found multiple use cases in specialty contact lenses for this device, especially scleral lenses.

1. Market Scope. 2020 Refractive Surgery Market Report: A Global Analysis for 2019 to 2025. December 2020.

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