22 ANTERION Swept-Source OCT Biometer

Jana Schröpfer, Richard Cornwell, Sandro Gunkel, Melanie Polzer, and Steven Thomson

Background: Swept-Source OCT Imaging for the Anterior Segment of the Eye

Optical coherence tomography (OCT) has become a standard for diagnostic imaging and management of various ocular conditions. Since its introduction, OCT has gained prominence in imaging the posterior segment of the eye and developed into a relevant tool in the clinical evaluation of the cornea and anterior segment. As advances to the technology have improved the acquisition speed and enhanced the resolution of images, the impact of anterior segment OCT imaging on clinical practice has increased [1]. Anterior segment OCT imaging allows for the visualization and assessment of the cornea, conjunctiva, sclera, rectus muscles, iridocorneal angle, lens, and other ocular features [2].

With the commercial introduction of spectral-domain OCT (SD-OCT) technology, imaging of the anterior segment at high speeds with good axial resolution became feasible [1]. However, most commercial SD-OCT devices use relatively short-wavelength light sources (820–880 nm), resulting in limited image depth range and a low penetration of deeper anterior ocular structures [3]. More recently, swept-source OCT (SS-OCT) was introduced with refinements made to the illumination source and detection system. Combining SS-OCT technology with a longer wavelength light source results in an optimized approach for anterior segment image acquisition and analysis. The longer wavelength permits increased penetration depth while the SS-OCT technology ensures minimal sensitivity roll-off at this depth. This combination and the short acquisition time help reduce motion artifacts to generate high-definition images of the entire anterior chamber [1, 2].

The ability to image anterior ocular structures with high clarity and contrast provides the basis for generating clinically relevant data, such as corneal topography, corneal tomography, anterior segment analysis, and biometry. SS-OCT with a long-wavelength light source can further serve as a vital tool to measure the axial length of the human eye and has been shown to have better tissue penetration compared to partial coherence interferometry (PCI) technology [4–7]. The inherent characteristics of long-wavelength SS-OCT thus provide clinicians with the biometric data considered essential to conduct intraocular lens (IOL) power calculations that can result in accurate refractive prediction [8, 9].

J. Schröpfer · R. Cornwell · S. Gunkel · M. Polzer · S. Thomson (✉)
Heidelberg Engineering GmbH, Heidelberg, Germany
e-mail: Jana.Schroepfer@HeidelbergEngineering.com; Richard.Cornwell@HeidelbergEngineering.com; Sandro.Gunkel@HeidelbergEngineering.com; Steven.Thomson@HeidelbergEngineering.com

J. Aramberri et al. (eds.), *Intraocular Lens Calculations*, Essentials in Ophthalmology,
https://doi.org/10.1007/978-3-031-50666-6_22

Clinical Applications of Anterior Segment OCT as Implemented on ANTERION

The ANTERION® from Heidelberg Engineering is a multimodal platform optimized for the anterior segment. It makes use of the technological advantages of long-wavelength SS-OCT and combines it with proprietary features that increase image clarity, thereby enabling the generation of precise measurements needed in cataract and anterior segment surgery. Acquiring high-resolution OCT scans at a relatively long wavelength of 1300 nm, ANTERION is well suited for imaging structural details in the anterior segment as well as performing corneal topography, tomography, anterior segment biometry, axial length measurements, and IOL calculations. By combining these measurements and examinations in one upgradable device, ANTERION caters to multiple clinical applications. The platform is designed to increase patient care by streamlining clinical workflows, saving on space in the examination room and minimizing patient chair time. ANTERION's most common application areas to date include cataract surgery with IOL power calculations, refractive surgery, cornea diagnostics, structural imaging for anterior chamber angle evaluation, and anterior segment imaging for various ocular conditions. To adapt to the workflow needs of each clinical discipline, ANTERION can be configured with different "Apps": Imaging App, Cornea App, Cataract App, and Metrics App.

The **imaging application (Imaging App)** is included in every configuration of the device. It acquires OCT scans with an axial resolution of less than 10 μm, a lateral scan length of up to 16.5 mm, and a scan depth range of 14 ± 0.5 mm. ANTERION's eye tracking technology on the corneal vertex increases the imaging capabilities as it offers geometric alignment of OCT scans along the fixation axis. This also allows for automated quality checks such as eye movement, blinking, and surface segmentation (see Table 22.1 for more technical specifications).

The resulting high-resolution images allow for the evaluation of the anterior segment, with the ability to visualize all structures of interest in one image (see Fig. 22.1). The Imaging App includes customizable scan patterns and can also be used for corneal, scleral, iridocorneal angle, and peripheral imaging, supporting the diagnosis of diseases in these locations.

The imaging capabilities assist clinicians in the diagnosis of anterior segment anomalies and provide visual confirmation of any measured parameters. ANTERION thus provides precise eye measurements as well as additional information for surgical planning and follow-up, such as the visualization of phakic lenses, IOLs, ICLs, or corneal rings.

Table 22.1 Technical specifications for ANTERION

Technical specifications	
Technology	Swept-source OCT with eye tracking
Wavelength	1300 nm
A-scan rate	50,000 Hz
OCT image size (width/depth)	16.5/14 ± 0.5 mm
Axial resolution (in tissue)	<10 μm
Lateral resolution	≥30 μm
Corneal topographic measurement points	16,640 (for both anterior and posterior surface)
Corneal measurement time	<1 s
Corneal diameter	8 mm (for both anterior and posterior surface)
Biometry (technology)	Optical (swept-source OCT; 1300 nm)
Data format	DICOM

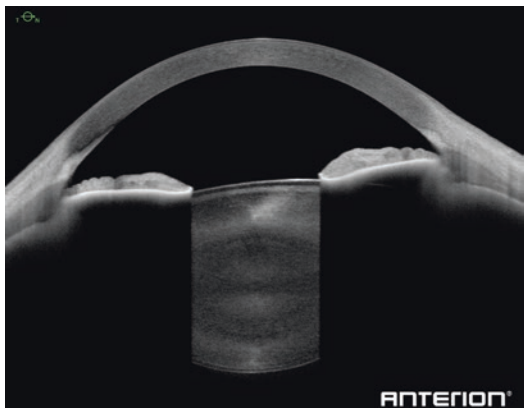

Fig. 22.1 ANTERION image of a healthy eye

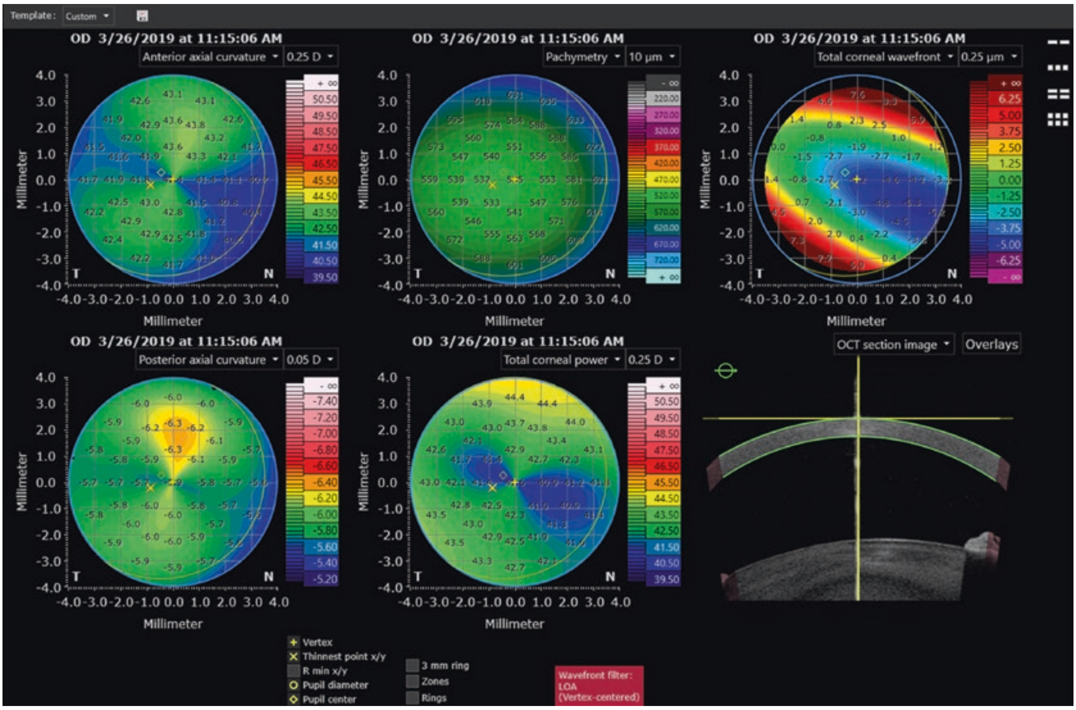

Fig. 22.2 ANTERION Cornea App: Corneal topography and tomography maps as well as corneal imaging for an eye with astigmatism and cataract. **Image Courtesy:** Damien Gatinel, MD, PhD, Paris, France

ANTERION's **cornea application (Cornea App)** scans the cornea in detail, providing a comprehensive analysis that is required in cornea diagnostics, anterior segment surgery, and IOL power calculations. The cornea data is acquired using 65 radial OCT scans (256 A-scans per B-scan), with an acquisition time of <1 s. This provides a total of 16,640 data points that contribute to the calculation of corneal maps and reports within an 8-mm zone. ANTERION's optimized SS-OCT technology considers both the anterior and the posterior corneal surface, providing important corneal topography and tomography data. The maps in the Cornea App include anterior and posterior axial curvature, tangential curvature, elevation, pachymetry, posterior/anterior corneal curvature radii ratio, total corneal power, as well as anterior and total corneal wavefront. Parameters such as pupil diameter, angle kappa, corneal vertex, thinnest point, or minimum radius can be overlaid onto the corneal maps. Due to the high-resolution imaging of the cornea, ANTERION also offers the possibility to verify the segmentation of the corneal surfaces in the accompanying OCT images. The Cornea App templates can be customized to display all clinical information: operators can select their preferred maps and data in a multi-view template, conduct a comparison of both eyes with differential maps, and use a layout for follow-up examinations that automatically calculates progression analysis for selective measurements (see Fig. 22.2 for a customized Cornea App template). This diagnostic tool will support clinicians in the investigation of various keratopathies and ectatic disease along with refractive and other corneo-surgical involvement. Beyond that, ANTERION's comprehensive corneal data is used to augment refractive cataract surgery and populate IOL power calculations.

For assessing **anterior chamber biometry and angle metrics**, ANTERION offers the **Metrics App.** With one acquisition, it provides six OCT images of the anterior chamber in a radial view (each B-scan consisting of 768 A-scans). These high-resolution OCT images provide the basis for freehand measurements and for calculating relevant angle metrics. The segmentation lines for the corneal surfaces, lens surfaces, and the iris are automatically displayed but can also be adjusted by the operator. The ability to acquire high-contrast images of the anterior chamber allows for the qualitative visualization of its architecture and the quantitative assessment of all relevant parameters. Besides iridocorneal angle assessment (anterior chamber angle, angle-opening distance, trabecular-iris space area, and scleral spur angle), the Metris App also provides measurements of the anterior chamber, cornea, and lens. Among these values are anterior chamber volume, spur-to-spur and angle-to-angle distance, central corneal thickness, corneal diameter, lens thickness, and lens vault. The ability to measure these structures while visualizing the anterior chamber at various angles can serve as a complementary tool to gonioscopy considering that the OCT technique offers the additional benefit of being non-contact [10]. The ANTERION Metrics App can therefore support in the assessment and monitoring of anterior chamber and angle closure disease. Furthermore, it can generate information useful in the evaluation of cataract surgery, anterior and posterior chamber phakic lens implantation, and other surgical procedures (see Fig. 22.3).

Finally, ANTERION offers the **Cataract App** for the **streamlined planning of cataract surgery and IOL calculation**. It combines key biometric measurements with a suite of IOL power calculation methods. The optimized SS-OCT technology provides accurate axial and surface measurements and offers visual confirmation with high-resolution images. The ability to identify eyes that have unusual geometry and to integrate total corneal power into the IOL prediction further supports the selection of the most suitable IOL.

The following chapter section presents the Cataract App in detail and summarizes all functionalities that make ANTERION a valuable tool for optical biometry and complex IOL power calculations.

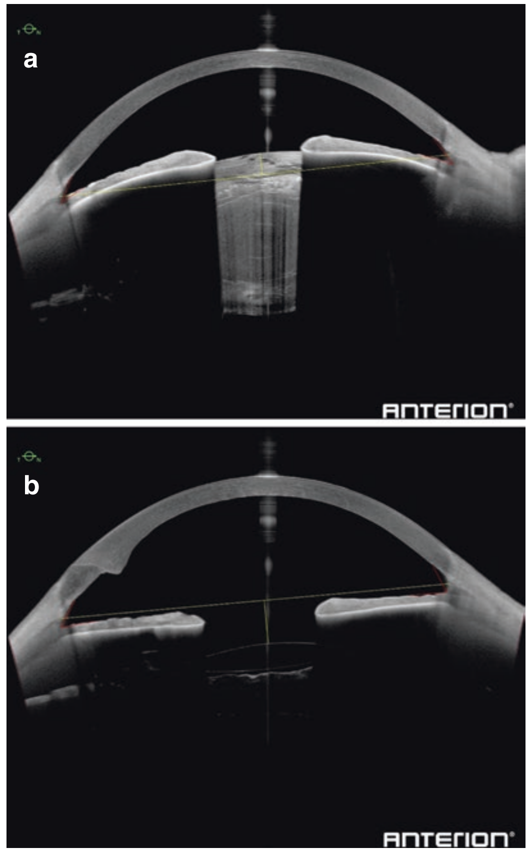

Fig. 22.3 ANTERION Metrics App: Evaluation of the same eye before (**a**) and after (**b**) cataract surgery including selected measurement overlays for anterior chamber angles, spur-to-spur distance, and lens vault. **Image Courtesy:** Damien Gatinel, MD, PhD, Paris, France

Biometry and IOL Power Calculations with ANTERION

ANTERION serves as a relevant tool for optical biometry and IOL power calculations due to its SS-OCT technology combined with high-definition topography and tomography.

Effective IOL power calculations require accurate biometry, with axial length (AL) and keratometry being two of the primary components. Improved refractive prediction accuracy can be achieved when additional variables such as anterior chamber depth (ACD), lens thickness (LT), and corneal indices are considered.

ANTERION calculates ACD from both central corneal thickness (CCT) and aqueous depth (AQD). Clear OCT images of the anterior segment significantly contribute to improved refractive accuracy by facilitating precise preoperative measurements. ANTERION generates all relevant parameters based on its precise SS-OCT imaging and sets itself apart by providing a much more comprehensive corneal analysis. Keratometry measurements, for example, are based on 16,640 data points over an 8-mm zone and detail both anterior and posterior corneal curvature (see Table 22.2 for more ANTERION parameters and features for IOL power calculation).

It is well accepted that postoperative refractive errors in IOL power calculations are typically ascribed to inaccurate preoperative AL measurements [11]. Rozema et al. [12] presented that the threshold of the AL and ACD to change the IOL power by 0.250 D for cataract surgery is 0.074 and 0.6 mm, respectively, when applied to the Haigis calculation. With the Cataract App, ANTERION measures AL with a high number of scans and calculates their standard deviation to provide clinicians with an objective rationale for evaluating the patient's fixation quality and overall reliability. The AL measurement is displayed alongside high-quality OCT section images. This includes an A-scan graph that shows the OCT signal intensity of the cornea, lens, and retina. The retinal pigment epithelium peak reflection is displayed and can be manually adjusted by the user. Furthermore, the software provides a comprehensive data display for both standard and premium IOL selection with additional anterior segment values. This includes corneal diameter, lens thickness, pupil dimeter, pupil center (kappa angle), as well as spherical aberration and higher order aberration summary. Any asymmetry between the right and left eye is automatically displayed, thus can help to identify errors and irregularities (see Fig. 22.4 for data displayed in the Cataract App).

One of the major benefits of ANTERION is the ability to combine essential parameters with an integrated IOL calculator menu. The spherical and toric IOL calculators provide various calculation methods, with IOL constants populated from either *IOL Con* or *ULIB*. Alternatively, this information can be entered manually with the preferred constants of the surgeon. Importantly,

Table 22.2 ANTERION parameters and features for IOL power calculation

Imaging		Infrared camera and swept-source OCT
Essential parameters	Cornea	Anterior and posterior axial and tangential curvature
		Anterior and posterior elevation
		Total corneal power
		Anterior and total corneal wavefront
		Pachymetry
		Kappa angle
		Corneal vertex
		Thinnest point
		Steepest radius
		Posterior/anterior ratio
		Corneal diameter
	Anterior chamber	Anterior chamber depth and volume
		Angle-to-angle distance
		Spur-to-spur distance
		ACA, AOD, TISA, SSA
		Pupil diameter
	Lens	Lens thickness
		Lens vault
	Axial length	Axial length including A-scan profile
Additional features	Viewing	Information for 4 segments and 2 zones
		Both eyes (OU) layout with differential maps
		Follow-up layout with differential maps
		Progression analysis
		Multi-view layout
		360° anterior chamber angle diagram
	IOL calculation	Spheric and toric IOL calculator
		IOL formulas: *Barrett universal II, Barrett true K, Haigis, Hoffer® Q, Holladay 1, SRK/T*
		OKULIX raytracing interface
	IOL databases	*ULIB* and *IOL con* database support
		Personal IOL database

ACA anterior chamber angle; *AOD* angle-opening distance; *TISA* trabecular-iris space area; *SSA* scleral spur angle

Fig. 22.4 ANTERION Cataract App: Both eyes (OU) view showing anterior axial curvature maps, OCT section images and intensity graphs, axial length diagrams, and parameters for cataract surgery planning

the patient's eye status can be edited to consider histories of refractive surgery, previous IOLs, aphakia, or vitreous surgery.

Traditionally, toric IOL calculations were based on keratometry measurements of the anterior surface of the cornea. More recently, estimation algorithms have been introduced that consider the posterior surface curvature, resulting in significant improvements in toric IOL power calculation [13–17]. ANTERION offers a toric IOL calculator, taking the incision location and surgically induced astigmatism (SIA) into account, as well as enabling the surgeon to choose either corneal astigmatism derived from anterior corneal curvature or total corneal power (see Fig. 22.5). Using preoperative crystalline lens measurements to predict potential postoperative tilt of toric IOLs may provide additional refractive improvements [18]. Ray tracing models can also be employed with these measurements to improve the postoperative refractive outcomes of toric IOLs [3]. ANTERION offers various approaches to IOL power calculation in an attempt to provide an interface that can adapt to new developments as they become available. Within its IOL power calculation section, for example, ANTERION provides an interface to the *OKULIX* IOL ray tracing application. The *OKULIX* prediction utilizes both anterior and posterior corneal measurements and considers ACD and LT as important variables when calculating IOL power. Recent studies have suggested that *OKULIX,* populated with ANTERION data, is capable of providing surgical outcomes at a high level [19].

It should be noted that the high-resolution SS-OCT images from ANTERION provide the basis for accurate biometric measurements while aiding in the visualization of the anterior segment (including the crystalline lens). The images can be used to confirm the postoperative IOL location, including posterior chamber phakic lenses. Furthermore, visualizing and documenting cataracts with SS-OCT has been deemed a useful approach to identify those eyes symptomatic of having haze, glare, or haloes. Surgeons performing anterior cortical cataract cases may find this additional information particularly relevant [3].

The combination of ANTERION's multiple tools and apps offers clinicians and surgeons a precise evaluation of the patient's individual eye geometry and a dedicated tool for complex IOL

Fig. 22.5 ANTERION Cataract App: OU toric IOL calculator accounting for corneal astigmatism, incision location, and surgical-induced astigmatism

calculations. Numerous studies (detailed below) have further confirmed the precision of ANTERION and its agreement to established devices.

Study Results

Various studies have reported on the repeatability of ANTERION in both healthy eyes and in eyes undergoing cataract surgery (see Table 22.3). The repeatability of a device to provide precise measurements cannot be overlooked.

Several authors have evaluated the ANTERION in healthy eyes. Montés-Micó et al. [22] measured 69 Caucasian eyes for corneal diameter (CD), angle-to-angle (ATA), spur-to-spur (STS), and lens vault distances. Eyes were measured five times with both horizontal and vertical meridians. Repeatability was good for the variables evaluated. Within-subject standard deviation (Sw) values were low and ranged from 0.01 to 0.07. Coefficient of repeatability (CoR) values showed a similar pattern being larger for those metrics measuring angles. Coefficient of variation (CoV) values were reported as very small for CD, ATA, and STS distances (0.16–0.57%). Intraclass correlation coefficient (ICC) values for all parameters analyzed were >0.97. An ICC < 0.75 indicates a poor correlation, whereas an ICC > 0.90 indicates a high correlation between the measurements obtained [25]. The study found no statistically significant difference in any of the repeated measurements. While

Table 22.3 Repeatability of ANTERION measurements across selected studies

ANTERION measurements		Shetty et al. [20]			Schiano-Lomoriello et al. [21]			Montés-Micó et al. [22] Tañá-Rivero et al. [23] Ruiz-Mesa et al. [24]		
		Sw	CoV %	ICC	Sw	CoV %	ICC	Sw	CoV %	ICC
Keratometry	SimK (D)	0.104 ± 0.094	0.252	0.9967	0.11	0.26	0.998	0.071	0.16	0.999 [23]
	Kmin (D)	0.134 ± 0.157	0.307	0.9947	–	–	–	–	–	–
	Kmax (D)	0.114 ± 0.093	0.258	0.9976	–	–	–	–	–	–
	TCP (D)	–	–	–	0.16	0.36	0.996	0.081	0.19	0.999 [24]
Biometry	AL (mm)	0.015 ± 0.059	0.058	0.9984	0.01	0.04	1.000	0.004	0.02	1.000 [24]
	AQD (mm)	0.004 ± 0.004	0.135	0.9999	0.10	3.48	0.987	0.051	1.78	0.999 [24]
	CD (mm)	0.051 ± 0.092	0.386	0.9839	–	–	–	0.01	0.16	1.000 [22]
	LT (mm)	0.007 ± 0.012	0.156	0.9995	0.01	0.33	0.977	0.049	1.21	0.999 [24]
	CCT (μm)	1.418 ± 1.647	0.311	0.9952	3.89	0.72	0.996	0.688	0.13	1.000 [24]

Sw within-subject standard deviation; *CoR* coefficient of repeatability; **CoV** coefficient of variation; *ICC* intraclass correlation coefficient; *SimK* simulated keratometry; *Kmin* flat axis keratometry; *Kmax* steep axis keratometry; *TCP* total corneal power; *AL* axial length; *AQD* aqueous depth; *CD* corneal diameter; *LT* lens thickness; *CCT* central corneal thickness (in μm)

the authors did find lens vault distance about 10% compared to CD, ATA, or STS distances about 0.5% (CoV), indicating these measurements were more variable, the values were clinically negligible.

Tañá-Rivero et al. [23] prospectively evaluated 74 phakic eyes (74 patients) and considered average, steep and flat keratometry (K), astigmatism for anterior, posterior, and total at 3 mm, average K and astigmatism at 6 mm, anterior and posterior eccentricity, higher order and spherical aberration, and anterior and posterior best fit sphere (BFS) at 8 mm. All eyes had five consecutive measurements taken over the course of the same session. Subjects in this study had a baseline mean spherical equivalent of −0.43 ± 1.43 D (range, 1.50 to −4.50 D). Sw values were <0.09, varying from 0.035 (posterior average K at 6 mm) to 0.0878 (anterior flat K at 3 mm). CoV values were also low and were similar among most parameters (from 0.08% to 0.21%), except for anterior, posterior, and total astigmatism (from 2.25% to 8.46%). The study concluded that corneal measurements with ANTERION are highly repeatable and, in some cases, superior to other devices.

Ruiz-Mesa et al. [24] prospectively evaluated 74 healthy eyes, analyzing corneal thickness (central and at 2, 4, and 6 mm diameters), AQD, LT, anterior chamber volume (ACV), AL, and pupil (diameter and position) in five consecutive measurements taken during one visit. In this evaluation, there were no statistically significant differences between repeated measurements ($P > 0.05$). The mean difference for corneal thickness was between −0.08 and 0.28 μm. For AQD and LT, the difference was 0.004 and −0.004 mm, respectively. The mean ACV difference was −0.03 mm^3, and the mean AL difference was 0.001 mm. Pupil diameter and position mean differences ranged between −0.008 and 0.009 mm. Overall, most measurements had a Sw < 1 and a CoR < 2 in their respective units, and an ICC > 0.92, again indicating good repeatability for different ocular biometric measurements.

Table 22.4 Comparison between ANTERION and other optical biometers

		Schiano-Lomoriello et al. [21]		Fișuș et al. [26]		Shetty et al. [20]
		ANTERION IOLMaster 500		ANTERION IOLMaster 700		ANTERION Lenstar LS 900 IOLMaster 700
		95% LoA	ICC	95% LoA	MAD	ICC
Keratometry	SimK	−0.68 to +0.70 D	0.987	–	–	0.994
	Kmin	–	–	−0.12 to +0.07 mm	0.04 mm	0.993
	Kmax	–	–	−0.14 to +0.10 mm	0.04 mm	0.993
Biometry	AL (mm)	−0.06 to +0.05	1.000	−0.04 to +0.06	0.02	0.997
	ACD (mm)	−0.50 to +0.57	0.888	−0.16 to +0.01	0.07	0.996
	LT (mm)	–	–	−0.17 to +0.05	0.07	0.992
	CD (mm)	–	–	–	–	0.889
	CCT (μm)	–	–	−6.10 to +17.42	6.47	0.995

LoA limits of agreement; *ICC* intraclass correlation coefficient; *MAD* mean absolute difference; *SimK* simulated keratometry; *Kmin* flat axis keratometry; *Kmax* steep axis keratometry; *AL* axial length; *ACD* anterior chamber depth; *LT* lens thickness; *CD* corneal diameter; *CCT* central corneal thickness (in μm)

There are several studies to date that compared ANTERION to other biometers (see Table 22.4).

Schiano-Lomoriello et al. [21] assessed the repeatability of the ANTERION Cataract App to a Placido-disk corneal topography device (MS-39), using the IOLMaster 500 as the control in 96 healthy eyes (96 patients). Parameters analyzed included SimK average, keratometric astigmatism, posterior keratometry average, total corneal power (TCP), TCP astigmatism, central corneal thickness (CCT), corneal diameter, AQD, LT, and AL. Images were acquired three times for both the ANTERION and MS-39, and once for the IOLMaster 500 (or until a good quality measurement could be acquired). In this analysis, ICC was >0.98 for all variables except astigmatism (0.963) and all measurements (excluding astigmatism) showed a CoV < 1%. Repeatability improved significantly when only eyes with astigmatism >1.0 D were considered. This is a key point as keratometric astigmatism measurements are used to calculate toric IOLs that are usually not implanted in patients with low astigmatism. Importantly, it is noted that the only significant difference between measurements with the ANTERION and the IOLMaster 500 was in corneal diameter. These results add to findings that the ANTERION has high repeatability and are among the first to suggest the device also has interchangeability.

Shetty et al. [20] compared the repeatability of the ANTERION to the Lenstar LS 900 and the IOLMaster 700 to determine impact on predicted IOL power calculations. This study evaluated 127 eyes (76 patients) with established cataract. Repeatability of all measurements for a given device were excellent (ICC > 0.9, low CoV and Sw). The agreement of parameters between the biometers was very good (ranging from 0.93 to 0.99). The predicted IOL power differed statistically between the devices ($P < 0.05$), but the difference was clinically insignificant between the three biometers (ICC > 0.99 for repeat calculation of IOL power). The best agreement between the biometers was obtained for AL and least for CD. Shetty et al. further found all scans had good penetration through the lens – even in cases of mature cataracts. The authors concluded that cataract surgery outcomes using ANTERION would be comparable to other commonly used biometers, even though other devices use different wavelengths for AL, different designs for keratometry measurements, and have different axial resolutions.

Fişuş et al. [26] evaluated 389 cataractous eyes (209 subjects) that underwent measurements (keratometry, CCT, ACD, LT, and AL) on the same day with both the ANTERION and the IOLMaster 700. Overall, the study found good agreement, with a minor offset for ACD and LT measurements. However, this group recommended that these two devices could not be used interchangeably, even although these key parameter differences were small. The mean absolute difference between the keratometry data of the two devices was 0.04 ± 0.05 mm (7.80 ± 0.26 mm for the IOLMaster 700 and 7.82 ± 0.26 mm for the ANTERION; $P < 0.0001$) for the steep meridian keratometry readings and 0.04 ± 0.04 mm (7.63 ± 0.26 mm and 7.65 ± 0.25 mm; $P < 0.0001$) for the flat meridian keratometry readings. For ACD and LT, the mean absolute difference was 0.07 ± 0.04 mm and 0.07 ± 0.04 mm. The mean absolute difference for AL was 0.02 ± 0.03 mm (23.55 ± 1.18 mm for the IOLMaster 700 and 23.54 ± 1.18 mm for the ANTERION; $P < 0.0001$). The mean difference in AL found in the Fisus study (0.01 mm) correlates to about 0.03 D refraction error, which is not considered clinically relevant.

Table 22.4 summarizes the findings of Schiano-Lomoriello et al. [21], Shetty et al. [20], and Fişuş et al. [26], who compared ANTERION to other optical biometers. It indicates the agreement between the respective devices for biometric measurements and keratometry data.

Collectively, these studies confirm that ANTERION measurements show a high repeatability and a good agreement with those acquired by established devices. Future studies and publications that incorporate the ANTERION will allow for direct comparison of outcomes.

Summary

SS-OCT technology combined with a longer wavelength light source provides a strong basis for high-resolution anterior segment imaging, optical biometry, and other anterior segment measurements. It is possible that this combination will replace previous technologies and, in the future, further improvements to IOL power prediction and new application areas that enhance diagnostics and support clinical decision-making will emerge and evolve. The SS-OCT device ANTERION will help streamline cataract and refractive surgery and can also assist in the management of corneal diseases and glaucoma. This latest technology provides high-resolution images, precise biometric measurements, and comprehensive corneal data that can be used to augment refractive cataract surgery and populate IOL power calculations. Furthermore, it may prove particularly helpful in the selection of toric and multifocal IOLs and in assessing eyes with previous laser vision correction treatments. ANTERION presents an all-in-one solution which can substantially improve the workflows in busy practices and clinics by reducing the need for multiple devices. The examinations and calculations are performed at high speed and with a small footprint, thus facilitating improvements to efficiency and logistics.

References

1. Ang M, Baskaran M, Wekmeister RM, Chua J, Schmidl D, Aranha Dos Santos V, Garhöfer G, Mehta JS, Schmetterer L. Anterior segment optical coherence tomography. Prog Retin Eye Res. 2018;66:132–56.
2. Venkateswaran N, Galor A, Wang J, Karp CL. Optical coherence tomography for ocular surface and corneal diseases: a review. Eye Vis (Lond). 2018;12(5):13.
3. Sousa Asam J, Polzer M, Tafreshi A, Hirnschall N, Findl O. Anterior segment OCT. In: Bille JF, editor. High resolution imaging in microscopy and ophthalmology: new frontiers in biomedical optics. Springer; 2019. p. 285–99.
4. Hirnschall N, Varsits R, Doeller B, Findl O. Enhanced penetration for axial length measurement of eyes with dense cataracts using swept source optical coherence tomography: a consecutive observational study. Ophthalmol Ther. 2018 Jun;7(1):119–24.
5. Srivannaboon S, Chirapapaisan C, Chonpimai P, Loket S. Clinical comparison of a new swept-source optical coherence tomography-based optical biometer and a time-domain optical coherence tomography-based optical biometer. J Cataract Refract Surg. 2015;41(10):2224–32.
6. Shammas HJ, Ortiz S, Shammas MC, Kim SH, Chong C. Biometry measurements using a new large-coherence-length swept-source optical coherence tomographer. J Cataract Refract Surg. 2016;42(1):50–61.

7. Chirapapaisan C, Srivannaboon S, Chompimai P. Efficacy of swept-source optical coherence tomography in axial length measurement for advanced cataracts. Optom Vis Sci. 2020;97(3):186–91.
8. Whang WJ, Jung BJ, Oh TH, Byun YS, Joo CK. Comparison of postoperative refractive outcomes: IOLMaster versus immersion ultrasound. Ophthalmic Surg Lasers Imaging. 2012;43:496–9.
9. Yeu E. Agreement of ocular biometry measurements between 2 biometers. J Cataract Refract Surg. 2019;45:1130–4.
10. Rigi M, Bell NP, Lee DA, Baker LA, Chuang AZ, Nguyen D, Minnal VR, Feldman RM, Blieden LS. Agreement between gonioscopic examination and swept source fourier domain anterior segment optical coherence tomography imaging. J Ophthalmol. 2016;2016:1727039.
11. Olsen T. Calculation of intraocular lens power: a review. Acta Ophthalmol Scand. 2007 Aug;85(5): 472–85.
12. Rozema JJ, Wouters K, Mathysen DG, Tassignon MJ. Overview of the repeatability, reproducibility, and agreement of the biometry values provided by various ophthalmic devices. Am J Ophthalmol. 2014 Dec;158(6):1111–20.
13. Koch DD, Jenkins RB, Weikert MP, Yeu E, Wang L. Correcting astigmatism with toric intraocular lenses: effect of posterior corneal astigmatism. J Cataract Refract Surg. 2013;39(12):1803–9.
14. Koch DD, Ali SF, Weikert MP, Shirayama M, Jenkins R, Wang L. Contribution of posterior corneal astigmatism to total corneal astigmatism. J Cataract Refract Surg. 2012;38(12):2080–7.
15. Abulafia A, Hill WE, Franchina M, Barrett GD. Comparison of methods to predict residual astigmatism after intraocular lens implantation. J Refract Surg. 2015;31(10):699–707.
16. Abulafia A, Koch DD, Wang L, Hill WE, Assia EI, Franchina M, Barrett GD. New regression formula for toric intraocular lens calculations. J Cataract Refract Surg. 2016;42(5):663–71.
17. Hoffmann PC, Abraham M, Hirnschall N, Findl O. Prediction of residual astigmatism after cataract surgery using swept source Fourier domain optical coherence tomography. Curr Eye Res. 2014;39(12):1178–86.
18. Hirnschall N, Buehren T, Bajramovic F, Trost M, Teuber T, Findl O. Prediction of postoperative intraocular lens tilt using swept-source optical coherence tomography. J Cataract Refract Surg. 2017;43(6):732–6.
19. Gjerdrum B, Gundersen KG, Lundmark PO, Aakre BM. Refractive precision of ray tracing IOL calculations based on OCT data versus traditional IOL calculation formulas based on reflectometry in patients with a history of laser vision correction for myopia. Clin Ophthalmol. 2021;15:845–57.
20. Shetty N, Kaweri L, Koshy A, Shetty R, Nuijts R, Roy AS. Repeatability of biometry measured by IOLMaster 700, Lenstar LS 900 and Anterion, and its impact on predicted intraocular lens power. J Cataract Refract Surg. 2020 Nov 23.
21. Schiano-Lomoriello D, Hoffer KJ, Abicca I, Savini G. Repeatability of automated measurements by a new anterior segment optical coherence tomographer and biometer and agreement with standard devices. Sci Rep. 2021 Jan 13;11(1):983.
22. Montés-Micó R, Tañá-Rivero P, Aguilar-Córcoles S, Ruiz-Mesa R. Assessment of anterior segment measurements using a high-resolution imaging device. Expert Rev Med Devices. 2020 Sep;17(9):969–79.
23. Tañá-Rivero P, Aguilar-Córcoles S, Ruiz-Mesa R, Montés-Micó R. Repeatability of whole-cornea measurements using a new swept-source optical coherence tomographer. Eur J Ophthalmol. 2020 Jul 18;31(4):1120672120944022.
24. Ruiz-Mesa R, Aguilar-Córcoles S, Montés-Micó R, Tañá-Rivero P. Ocular biometric repeatability using a new high-resolution swept-source optical coherence tomographer. Expert Rev Med Devices. Jun 2020;17(6):591–7.
25. Muller R, Buttner P. A critical discussion of intraclass correlation coefficients. Stat Med. 1994 Dec 15–30;13(23–24):2465–76.
26. Fişuş AD, Hirnschall ND, Findl O. Comparison of two swept-source optical coherence tomography-based biometry devices. J Cataract Refract Surg 2020 Aug 5.