See the Unseen

Next-Generation Corneal Imaging with the Pentacam® Cornea OCT




Redefining Corneal Tomography: Introducing the Pentacam® Cornea OCT

By Renato Ambrósio Jr., MD, PhD (Rio de Janeiro, Brazil)

The convergence of high-resolution imaging and clinically proven tomographic analysis has now become a reality! The Pentacam® Cornea OCT establishes a new standard in anterior segment imaging by combining ultra-high-resolution spectral-domain OCT with the proven precision of Scheimpflug tomography. This unique hybrid technology enables detailed visualization of corneal microstructures and supports precise diagnostics, surgical planning, and postoperative monitoring.[1]

A NEW BENCHMARK IN RESOLUTION

For over two decades, the Pentacam® platform has established itself as the gold standard in anterior segment tomography. With the introduction of the Pentacam® Cornea OCT, OCULUS bridges the gap between depth-resolved tomography and fine-structure visualization. This hybrid system combines Scheimpflug imaging for wide-area tomographic capture with a spectral-domain OCT in the 800 nm wavelength band. The device achieves an axial resolution of 1.9 µm and a lateral resolution of 10 µm, making it possible to visualize individual corneal layers, including the Epithelium, Bowman's layer, and the Endothelium.[1] The "Wide Angle Pericentric Scanning" technology allows full corneal scans with maximum image fidelity, both centrally and peripherally, which previously was achievable only in ex vivo histological sections.[1]

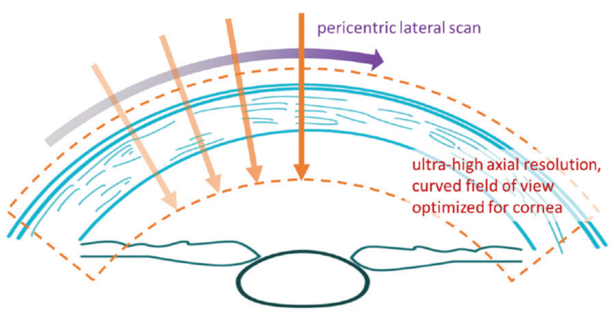

Figure 1: Wide-angle pericentric scanning system of the Pentacam® Cornea OCT keeps the probing beam near-perpendicular to the corneal surface. By creating a measurement window adapted to the corneal curvature, the Pentacam® Cornea OCT's ultra-high resolution is optimally exploited to resolve the details of the corneal layer structure.

DUAL-TECHNOLOGY ADVANTAGE: SCHEIMPFLUG + OCT

The Pentacam® Cornea OCT uniquely combines Scheimpflug imaging and spectral-domain OCT in one device. Scheimpflug technology remains the gold standard for anterior segment tomography! It delivers validated software modules based on topographic, tomographic and densitometric data supported by decades of clinical use. Meanwhile, the OCT module provides ultra-high-resolution cross-sections that reveal fine details such as Descemet's membrane ruptures or epithelial irregularities.[1]

This dual-modality approach enables simultaneous imaging at the same corneal location. While Scheimpflug detects scattering structures and supports normative databases, OCT enhances diagnostic precision through ultra-high structural resolution.[1] Together, they provide an unprecedented level of diagnostic completeness in anterior segment imaging.

CLINICALLY VALIDATED APPLICATIONS

The combined imaging modalities support advanced applications such as the Belin/Ambrósio Enhanced Ectasia Display – now in its 4th edition – epithelial thickness mapping, and corneal optical densitometry. These features aid in early ectasia detection, facilitate differential diagnosis for keratoconus, and enable detailed evaluation after refractive or therapeutic procedures.[2,3,4]

The Pentacam® Cornea OCT's intuitive software interface integrates Scheimpflug and OCT data into a single combined workflow. The system captures 25 radial OCT scans matched to Scheimpflug images in less than a second. To fully leverage the ultra-high resolution, the OCT images are presented in the Cornea Zoom mode, enabling enhanced visualization of sub-layers and anomalies by stretching the image of the cornea axially. Beyond, the Real Shape mode allows for corneal analysis based on the true geometry. Enhanced image tools like the Averaging Mode further enhances diagnostic accuracy. It fuses up to 25 scans to create noise-free images that approach the clarity of histological specimens – a concept referred to as "optical biopsy".[1]

The following describes a case of a 65-years-old female patient presenting with unclear reduced uncorrected visual acuity of 20/30 in the right eye and 20/150 in the left

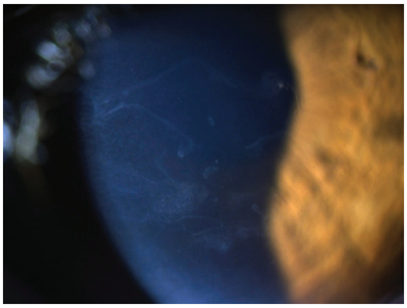

Figure 2: Slit-lamp biomicroscopy showing classical epithelium changes in Cogan dystrophy

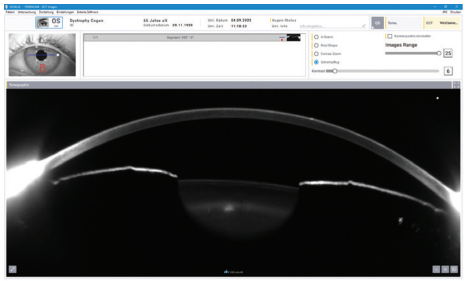

Figure 3: Pentacam Cornea OCT's Scheimpflug image with hyperreflective spot, typical in scattering structures

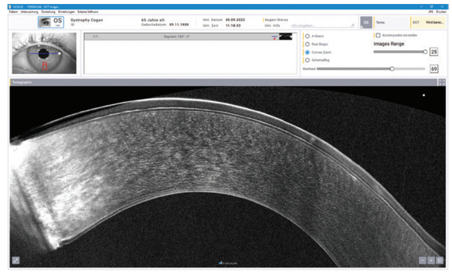

Figure 4: Pentacam Cornea OCT's Cornea Zoom image with stretched corneal thickness to visualize even the finest anatomical details

eye and with distance-corrected visual acuity of 20/25 in the right eye and 20/40 in the left eye. After slit-lamp biomicroscopy, the left eye revealed classical epithelium changes consistent with Cogan dystrophy. Examination with the Pentacam® Cornea OCT confirms the diagnosis with detailed presentation of the abnormal epithelium layer. Scheimpflug images present the abnormality as a bright spot, indicating scattering structures. The OCT Image in the Cornea Zoom mode clearly shows the abnormal epithelium.

FUTURE-PROOF AND BACKWARD COMPATIBLE

The Pentacam® Cornea OCT is compatible with all existing Pentacam® data and integrates seamlessly into existing networks. This is indispensable for smooth follow-up examinations on patients in a familiar environment. Its software modules are floating-license-key enabled and support common EMR and DICOM interfaces. Pentacam users can transfer the licenses of their existing Pentacam® system to the new Pentacam® Cornea OCT. This ensures both clinical continuity and future scalability.

With the Pentacam® Cornea OCT, clinicians can visualize pathology with unprecedented clarity, make more informed decisions, and ultimately improve patient outcomes through next-generation corneal diagnostics.

The Pentacam® Cornea OCT is not just a technological upgrade – it is a platform for future diagnostic solutions. As corneal diagnostics evolve, so must our tools. The Pentacam® Cornea OCT is OCULUS' next step in helping clinicians see more, detect earlier, and treat with confidence.

Layer by Layer: Multi-Zonal Thickness Mapping Unlocks a New Dimension in Corneal Diagnostics

By Pooja Khamar, MD, PhD; Rohit Shetty, MD, PhD; Abhijit Sinha Roy, PhD (Bengaluru, India)

One of the most promising recent advancements in anterior segment diagnostics is the ability to visualize and quantify the thickness of individual corneal layers. With the latest Pentacam® Cornea OCT software extension, clinicians now have access to several multi-layer thickness maps, covering tear film, epithelium, Bowman's layer, and stroma, from a single scan taken in just one second. This level of structural differentiation has not previously been achieved in routine clinical practice.

A TECHNOLOGICAL BREAKTHROUGH

Leveraging its ultra-high axial resolution of 1.9 µm over the entire cornea, the OCT module can now differentiate even the finest anatomical boundaries, converting raw B-scans into segmented layer maps. Subsequent updates will enable mapping of Descemet's membrane and endothelium, further enriching diagnostic depth.

WHY IT MATTERS: EVIDENCE-BASED BENEFITS

▶ Epithelial Thickness Mapping

Epithelial thickness has long been studied as an early biomarker for ectatic changes. Subtle patterns such as the characteristic "doughnut shape" seen in subclinical keratoconus are often detectable even when topographic readings appear normal. In one study, epithelial mapping altered clinical decisions in 16% of preoperative cases, underscoring its value in refractive screening and risk stratification.[5]

▶ Bowman's Layer Thickness

Bowman's layer is emerging as an at least equally important structural indicator. Recent studies have shown that Bowman's thickening may precede epithelial thinning in the fellow eyes of unilateral keratoconus patients.[6]

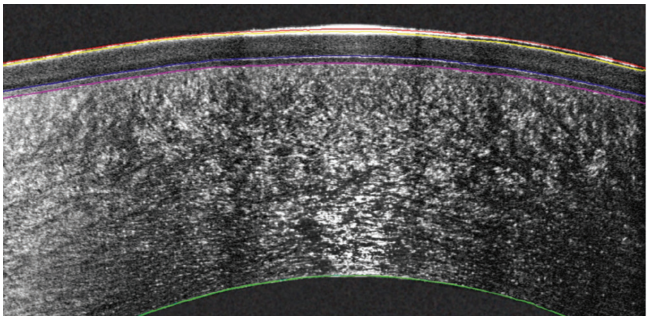

Figure 5: Pentacam Cornea OCT scan with automatically detected layer boundaries

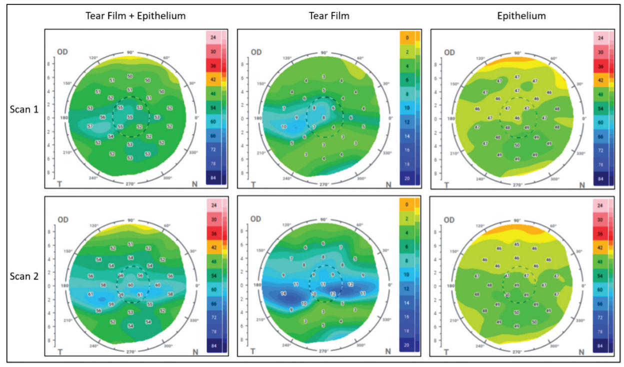

Figure 6: Two consecutive scans of the same patient showing the thickness map of the tear film (middle) and the epithelium (right). On the left side is the combination of both layers, showing that a clear separation of tear film and epithelium avoids misinterpretation of irregularities as epithelial changes.

▶ **Stromal Thickness Mapping**

Stromal thickness profiles support procedural planning and post-surgical evaluation by offering detailed maps of tissue distribution. Data from advanced SD-OCT devices show that stromal thickness follows a centrifugal gradient – thin in the center and thicker peripherally – a pattern that provides valuable foundation for ablation planning and optimizing surgical outcomes.[7]

▶ **Tear Film Differentiation**

Although only a snapshot in time, tear film thickness can affect epithelial measurements. Isolating this layer adds clarity in cases where irregularity could otherwise be attributed to underlying pathology. It is a clinically meaningful addition to accurate epithelial interpretation.

ADDED CLINICAL VALUE

▶ **Early Detection & Risk Stratification:**

Combining epithelial and Bowman's layer maps allows for a more sensitive evaluation of early-stage ectasia, especially in borderline topographies.

▶ **Diagnostic Confidence:**

Layer-by-layer analysis enhances the ability to distinguish epithelial masking effects from true stromal thinning.

▶ **Surgical Planning:**

For refractive surgery, separate tear film, epithelial and stromal thickness maps allow for customized ablation strategies, improved centering, and better prediction of healing response.

▶ **Efficiency and Usability:**

Layer segmentation is performed automatically and fully integrated into the standard workflow. This not only enables users to quickly spot abnormalities, but also provides a detailed and structured dataset for interpretation.

A NEW STRUCTURAL PERSPECTIVE

The ability to isolate and quantify each corneal layer is a long-awaited advancement in anterior segment imaging. In particular, the ability to map Bowman's layer represents a diagnostic breakthrough with broad implications for early detection and clinical confidence. Layer-based diagnostics bring OCT closer to the standard of histological interpretation, bridging the gap between structural imaging and personalized treatment.

The Pentacam® Cornea OCT continues to lead the way – not just through high-resolution imaging, but by delivering actionable clinical insight through intelligent, layer-specific analysis.

Augmented Awareness: Supporting the Review Process with AI-based Anomaly Detection in Corneal OCT

By Renato Ambrósio Jr, MD, PhD (Rio de Janeiro, Brazil)

The increasing resolution of anterior segment imaging has opened new dimensions in diagnostics, but reviewing the vast amount of structural detail remains a challenge in clinical routine. To address this, a novel AI-based support tool is currently being explored for the Pentacam® Cornea OCT. Its purpose: to assist users in detecting suspicious findings within corneal OCT cross-sections without altering diagnostic responsibility.[8]

SUPPORTING THE REVIEW PROCESS

Each Pentacam® Cornea OCT exam captures 25 high-resolution B-scans across the cornea. While these

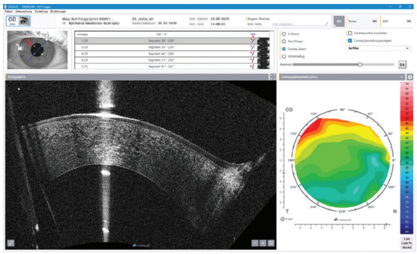

Figure 7: Pentacam Cornea OCT examination looking normal at first sight

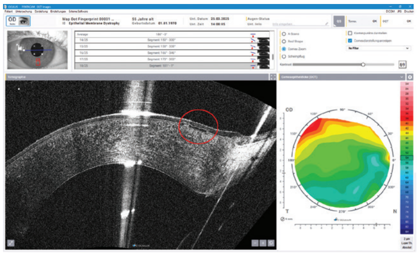

Figure 8: After manual evaluation, segment 18 firstly showed an abnormal epithelium

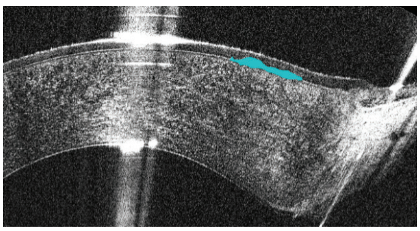

Figure 9: Automatic visual marking of the detected abnormality, using the new AI-based support tool, promises to reduce the image assessment time. Visual representation may differ from the final version.

scans offer exceptional insight into fine structures – including epithelial integrity, Bowman's layer disruptions, or endothelial changes – they can be time-consuming to review thoroughly. In many clinics, this task is left to the interpreting physician, while technicians perform the scan itself.

The new AI-based support system is designed to bridge this workflow gap and reduce the likelihood of missed localized anomalies.[8] After image acquisition, the system automatically analyzes all 25 B-scans and flags potential anomalies. Any image with suspected irregularities is visually marked, drawing attention to regions that may warrant closer review.

The following shows a Pentacam® Cornea OCT examination, which initially appeared normal. Thorough analysis of the 25 cross sectional images reveals epithelial abnormalities in the 18th section, showing classical changes of an epithelial basement membrane dystrophy (EBMD). This abnormality was visually marked by the algorithm, immediately indicating abnormal findings in this case. Otherwise, the EBMD might have remained undetected or only been detected after careful analysis of every single section, which takes several minutes in clinical practice.

FOCUSED ATTENTION, ENHANCED WORKFLOW

This feature offers several practical benefits. First, physicians can prioritize their attention on flagged sections, ensuring that subtle but important changes are not overlooked. Second, it empowers trained technicians to perform targeted follow-up scans before the patient even leaves the exam room. Averaging or Sector Scans of the area of interest provide enhanced noise-free images or imaging of anomalies with increased angular resolution, respectively, ensuring a more comprehensive and efficient imaging assessment.

In doing so, the Pentacam® Cornea OCT can help to prevent delays in care, reduce the need for repeat appointments, and strengthen the communication between technician and physician. In busy practices, where time is limited and diagnostic certainty is essential, such efficiency gains can translate into measurable improvements in patient care.

The goal is not to replace clinical judgment but to augment diagnostic awareness and streamline the transition from data acquisition to diagnostic decision-making.

A CAUTIOUS AND COMPLIANT APPROACH

To train the system, a large dataset of labeled OCT images was used, including both normal and pathological cases, providing the algorithm with a rich foundation for pattern recognition. However, given the evolving regulatory landscape surrounding AI in ophthalmology, this feature is currently under critical evaluation and not yet available for routine clinical use.

No diagnostic decisions are made by the system. It is designed as a supportive tool to highlight image areas for closer inspection. Clinical interpretation and decision-making remain fully under the control of the physician.

BUILDING CONFIDENCE THROUGH INTELLIGENCE

As OCT becomes more detailed and datasets grow larger, tools that help clinicians focus on what matters most are becoming increasingly valuable. With this AI-based assistance, the Pentacam® Cornea OCT continues to evolve – not only as a precision imaging system, but also as an intelligent support platform for diagnostic precision.[9] ■

1. Ambrósio R Jr, Esporcatte LPG, de Carvalho KA, et al. Combined Rotating Ultra-High-Resolution Spectral Domain OCT and Scheimpflug Imaging for In Vivo Corneal Optical Biopsy. Diagnostics (Basel). 2024;14(13):1455. Published 2024 Jul 8. doi:10.3390/diagnostics14131455
2. Villavicencio OF et al. Independent Population Validation of the Belin/Ambrósio Enhanced Ectasia Display: Implications for Keratoconus Studies and Screening. Int J Kerat Ect Cor Dis. 2014;3(1):1–8. doi:10.5005/jp-journals-10025-1069
3. Correia et al. Topometric and Tomographic Indices for the Diagnosis of Keratoconus. Int J Kerat Ect Cor Dis. 2012;1(2):92-99. doi:10.5005/jp-journals-10025-1018
4. Reinstein DZ, Archer TJ, Vida RS. Epithelial thickness mapping for corneal refractive surgery. Curr Opin Ophthalmol. 2022;33(4):258-268. doi:10.1097/ICU.0000000000000867
5. Asroui L, Dupps WJ Jr, Randleman JB. Determining the Utility of Epithelial Thickness Mapping in Refractive Surgery Evaluations. Am J Ophthalmol. 2022;240:125-134. doi:10.1016/j.ajo.2022.02.021
6. Pircher N, Kilian R, Beer F, et al. Diagnostic performance of corneal epithelium- and Bowman's layer thickness mapping in patients with unilateral Keratoconus. Graefes Arch Clin Exp Ophthalmol. 2025;263(5):1383-1389. doi:10.1007/s00417-025-06750-8
7. Abusamak M, Issa SM, Alomari AF, et al. Corneal stromal mapping characteristics in normal corneas using anterior segment SD-OCT. Front Med (Lausanne). 2024;11:1485718. Published 2024 Dec 2. doi:10.3389/fmed.2024.1485718
8. Reisdorf S, Fayaz S; AI-Powered Assistant for Detecting Corneal Pathology in Optical Coherence Tomography Images. Invest. Ophthalmol. Vis. Sci. 2025;66(8):5413.
9. Tey KY, Cheong EZK, Ang M. Potential applications of artificial intelligence in image analysis in cornea diseases: a review. Eye Vis (Lond). 2024;11(1):10. Published 2024 Mar 7. doi:10.1186/s40662-024-00376-3