AI Anomaly Finder

AI-Assisted Identification of Potential Corneal Abnormalities in OCT Scans

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Executive summary

The Pentacam® Cornea OCT acquires 25 radial spectral-domain OCT scans per examination. This provides detailed cross-sectional information through the full corneal depth, but it also creates a review task in which subtle or localized abnormalities may be present in only a few individual scans. The AI Anomaly Finder is designed to support this review by automatically analyzing the complete OCT examination, highlighting potentially abnormal scans and localizing the image regions that contributed to the AI finding.

The approach combines two complementary AI pathways and highlights an anomaly only when both agree on the presence and spatial location of a potential finding. Development and evaluation used 38,241 corneal OCT images from five countries, including a 12,000-image normal reference library. Performance was assessed in two independent external cohorts. The system is not intended to assign a disease label or replace clinical interpretation; rather, it provides an AI-assisted route from comprehensive imaging to focused review of the original OCT data.

Scope and clinical rationale

High-resolution corneal OCT can reveal structural changes at the epithelial, stromal and posterior corneal levels. In the Pentacam® Cornea OCT, each examination comprises 25 radial OCT scans acquired with an axial resolution of 1.9 µm. The resulting dataset offers detailed visualization from the epithelium to the posterior cornea and can therefore provide substantial diagnostic information. At the same time, the number of cross-sectional images creates a practical challenge: each scan must be reviewed carefully, although a subtle or localized anomaly may be visible in only a small subset of the examination.

The AI Anomaly Finder was developed to support this image-review process. Rather than reducing the examination to a single automated classification, it analyzes all 25 OCT scans and directs the examiner toward images and regions that may warrant closer inspection. The clinical premise is therefore not automated diagnosis, but prioritization and localization within a comprehensive OCT dataset.

AI-assisted review of the complete OCT examination

For each Pentacam® Cornea OCT examination, the AI Anomaly Finder automatically assesses all 25 radial OCT scans. Scans that contain a potential structural anomaly are highlighted in the scan overview, enabling the examiner to move directly to the corresponding cross-sectional image. Within a flagged scan, a colored overlay marks the region that contributed to the AI finding. This connects the scan-level alert with a spatially localized area in the original OCT image.

The overlay can be switched on and off. The examiner can therefore compare the AI-highlighted region directly with the unmodified OCT image and retain the original image data as the basis for clinical interpretation. If a finding warrants closer examination, targeted imaging can be repeated at the same scan position using the available high-resolution acquisition mode. In this way, AI support is embedded in a workflow that leads from broad image review to targeted clinical inspection while keeping the clinician in control of interpretation.

The system is designed to guide attention within the OCT dataset, not to replace the examiner's assessment of the original image data.

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Two complementary AI pathways with spatial confirmation

A central design feature of the AI Anomaly Finder is that a potential anomaly is not highlighted on the basis of a single AI signal. Each OCT scan is evaluated using two complementary AI pathways. A finding is displayed only when both methods independently identify an abnormality in the same spatial region. This requirement combines agreement in detection with agreement in localization.

The first pathway combines supervised image segmentation with anomaly detection. Supervised segmentation is used to recognize structural abnormalities learned from annotated clinical images. In parallel, anomaly detection identifies deviations from normal corneal morphology by comparison with a reference library of normal OCT images. The technology overview identifies PatchCore as the anomaly-detection component used for this comparison.

The second pathway independently evaluates the complete OCT scan at image level. EfficientNet-B3 is used for this classification step, while Grad-CAM localizes the image regions that contribute most strongly to the network assessment. A scan is highlighted only when the first pathway and the independent image-level pathway agree both that a potential anomaly is present and where it is located. This spatial confirmation is intended to provide an additional layer of confidence and to reduce unnecessary flags across the 25 scans of a complete examination.

AI analysis architecture

Pathway 1	Pathway 2	Displayed finding
Supervised segmentation + PatchCore anomaly detection	EfficientNet-B3 + Grad-CAM	Spatial confirmation
Learns annotated structural abnormalities and deviations from normal morphology.	Independently assesses the complete scan and localizes decision-relevant regions.	Highlight only when both pathways agree on detection and location.

Development dataset and evaluation strategy

The AI Anomaly Finder was developed and evaluated using 38,241 corneal OCT images collected across five countries. The dataset included normal corneas as well as morphologically diverse corneal abnormalities. A dedicated reference library of 12,000 normal OCT images supports the anomaly-detection pathway and provides a broad representation of normal corneal morphology against which deviations can be assessed.

The dataset was structured to support robust evaluation. Development and evaluation data were separated at the patient level, and image annotations were reviewed by experts. The strength of the development foundation therefore lies not only in the number of images, but also in the multi-institutional composition of the data, the use of expert-reviewed annotations and the separation of evaluation data from the development process. Performance was subsequently examined in two independent external cohorts.

Performance in two independent external cohorts

The first external cohort evaluated the system at the level of individual OCT images. It included 149 images from different patients. In this cohort, the combined system achieved a sensitivity of 88.2%, a specificity of 100% and an area under the receiver operating characteristic curve (AUROC) of 0.941. No normal image in this cohort was incorrectly flagged by the combined system.

The second external cohort evaluated the system in a setting closer to its intended clinical workflow. It included 42 complete examinations, with all 25 OCT scans analyzed for each patient. An examination was classified as abnormal when at least one of its 25 scans was flagged. The system correctly identified 9 of 10 abnormal examinations and 29 of 32 normal examinations, corresponding to a sensitivity of 90.0% and a specificity of 90.6%.

External evaluation	Sensitivity	Specificity	AUROC
Image level 149 images	88.2%	100%	0.941
Examination level 42 examinations	90.0%	90.6%	—

These results provide evidence for the performance of the combined AI approach in two independent external cohorts, but they should be interpreted in the context of the respective sample sizes. Further prospective and pathology-specific evaluation will be important to characterize performance across additional patient populations, individual disease groups and clinical settings.

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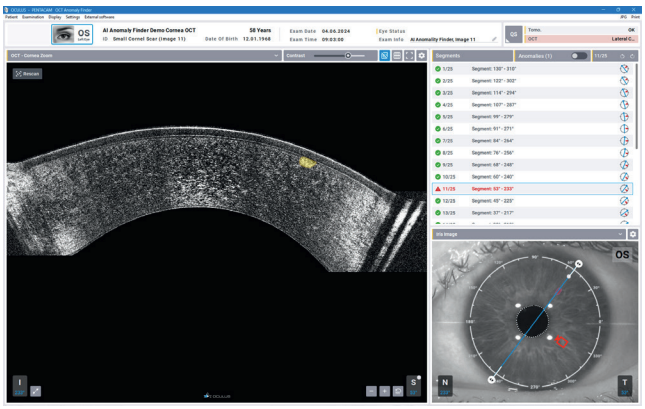
A morphology-based workflow across the full corneal depth

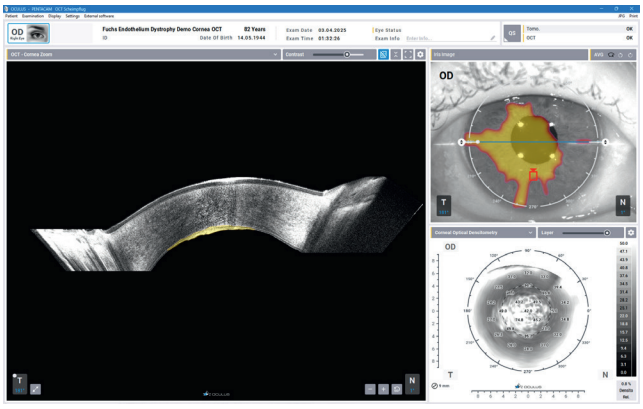
The AI Anomaly Finder is not designed as a disease-specific classifier. Its task is to identify structural deviations within corneal OCT images and indicate their location. During development and evaluation, the system demonstrated the ability to highlight morphologically diverse anomalies involving different corneal layers, including epithelial and subepithelial abnormalities, stromal scars and infiltrates, corneal shape abnormalities and posterior corneal changes.

This morphology-based approach supports one AI-assisted review workflow across the full depth of the cornea. A highlighted region is therefore an invitation to inspect a structural deviation in the OCT data, not an automated disease label. Clinical interpretation remains with the examiner, who integrates the OCT appearance with the complete examination and clinical context.

Examples of morphologically diverse findings



Small corneal scar

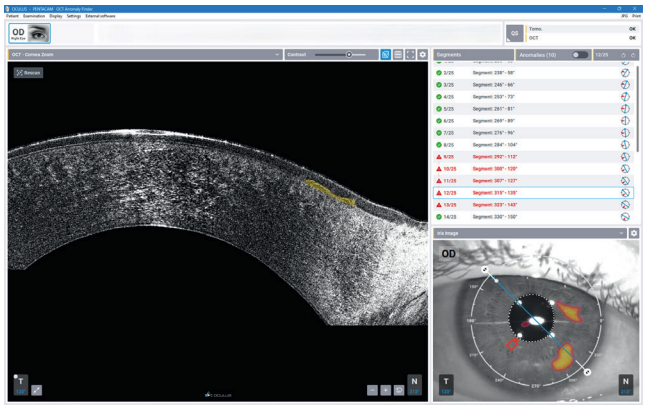


Fuchs' endothelial corneal dystrophy

Clinical case: AI-assisted review of epithelial abnormalities in Map-Dot-Fingerprint Dystrophy

The following case illustrates how the morphology-based approach can be incorporated into the clinical review workflow. The examination was performed in a young female patient with Map-Dot-Fingerprint Dystrophy, also known as epithelial basement membrane dystrophy (EBMD). The condition is characterized by abnormalities of the corneal epithelium and epithelial basement membrane and may present with a map-, dot- or fingerprint-like appearance.

Across the individual OCT cross-sectional images, the AI Anomaly Finder identified and highlighted epithelial abnormalities. Potentially abnormal scans were marked in the scan overview, while color-coded regions indicated the corresponding location in the OCT image and iris image. This enabled the examiner to move from the complete 25-scan examination directly to the cross-sections containing the potential epithelial finding and to inspect its spatial relationship within the cornea.



Clinical case example. A flagged OCT cross-section is shown together with the localized AI overlay and the corresponding position in the iris image. The original OCT image remains available for direct clinical assessment.

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For each flagged cross-sectional image, a Rescan function allows acquisition to be repeated at the same scan position and a high-resolution averaged image to be generated. This provides an additional imaging step when the examiner wants to characterize the highlighted epithelial abnormality more closely. The workflow illustrated by the case is therefore sequential: complete OCT acquisition, AI-assisted prioritization of potentially abnormal scans, localized review of the original OCT data and, when required, targeted high-resolution rescanning.

Importantly, the case should not be interpreted as disease-specific automated diagnosis of EBMD. It demonstrates how the AI Anomaly Finder can draw attention to structural epithelial abnormalities within an examination in which the clinical diagnosis is established by the examiner. This distinction is consistent with the intended morphology-based role of the system.

Clinical relevance and limitations

The practical value of the AI Anomaly Finder lies in connecting a large cross-sectional OCT dataset with focused review. By analyzing all 25 scans, indicating which images may contain a structural deviation and localizing the relevant image region, the system can support a more directed inspection of the examination. The ability to deactivate the overlay preserves direct access to the original data, and the targeted high-resolution rescan provides an additional option when a highlighted area deserves closer assessment.

At the same time, the available evaluation data define the current limits of interpretation. The two external cohorts demonstrate performance at both image and examination level, but their sample sizes are limited. The AI Anomaly Finder is also not a disease-specific classifier, and the available data do not establish pathology-specific diagnostic performance across individual corneal diseases. Prospective studies and further evaluation within defined pathology groups and broader clinical populations will be needed to characterize these aspects in greater detail.

Conclusion

The AI Anomaly Finder provides an AI-assisted review layer for the 25 radial OCT scans acquired during a Pentacam® Cornea OCT examination. Its two complementary analysis pathways combine learned structural recognition, anomaly detection and independent image-level assessment with spatial confirmation. The result is not a diagnostic label, but a localized indication of where a potentially relevant structural deviation may be present.

Development and evaluation across 38,241 corneal OCT images, together with testing in two independent external cohorts, provide the current foundation for this approach. The external validation demonstrated high accuracy at both the image-based and examination-based levels. By linking automated analysis of the complete examination to focused review of original OCT data and optional high-resolution rescanning, the system is designed to support a clinically intuitive workflow while preserving the examiner's responsibility for interpretation and decision-making.

Technology at a glance

- 38,241 corneal OCT images used across development and evaluation
- Multi-institutional data from five countries
- 12,000 normal reference images supporting anomaly detection
- Patient-level separation of development and evaluation data
- Expert-controlled image annotations
- Two complementary AI analysis pathways independently examining each scan
- Supervised segmentation for learned structural abnormalities
- PatchCore anomaly detection for deviations from normal corneal morphology
- EfficientNet-B3 classification for independent image-level assessment
- Grad-CAM localization of decision-relevant image regions
- Spatial confirmation: a finding is highlighted only when both pathways agree in detection and location
- Evaluation in two independent external cohorts

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