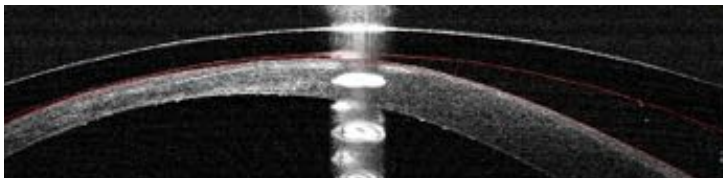

ANTERIOR SEGMENT OCT:

DIAGNOSTIK UND KONTAKTLINSEN-ANPASSUNG

Markus Ritzmann, MSc. Optometrist, FAAO, FSLS

linsen centrum

Teil I

OCT Theorie & Technologie

Funktion von OCT

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- Optische Kohärenz Tomographie = OCT
- Ähnliches Prinzip wie Ultraschall-Technologie
  - Basiert auf Infrarot-Lichtwellen anstelle von Schallwellen
  - Misst die Verzögerung der Lichtwelle im Vergleich zu einer Referenzwelle
  - Zeichnet die Intensität des reflektierten Lichtes auf
  - Benötigt transparente Medien für Lichtpenetration
    - Vorteil von US: kann auch durch nicht transparente Medien gemessen

UBM vs. OCT

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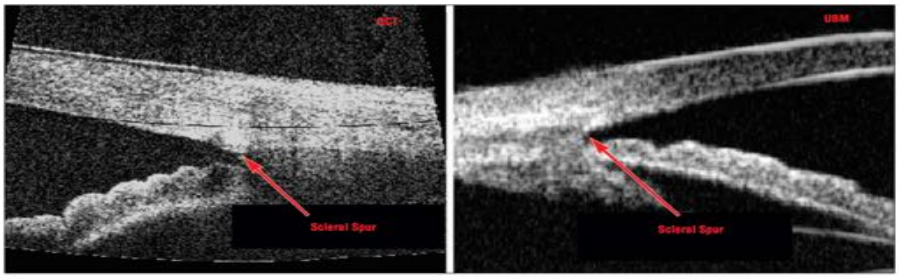
- Vergleich TD-OCT vs. UBM



ARCH OPHTHALMOL/VOL 123, AUG 2005
Sunita Radhakrishnan et al Comparison of Optical Coherence Tomography and Ultrasound Biomicroscopy

OCT Scans

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- A-Scan
  - 1 Axialer Scan mit unterschiedlichen Reflexionen im Gewebe (Tiefe)
  - 1-D Image
- B-Scan
  - Ist die Summe von allen A-Scans und zeigt das Schnittbild des Gewebes
  - 2-D Image
- 3-D Image
  - Ist eine Zusammenstellung von an verschiedenen Stellen augenommenen B-Scans

OCT Scans

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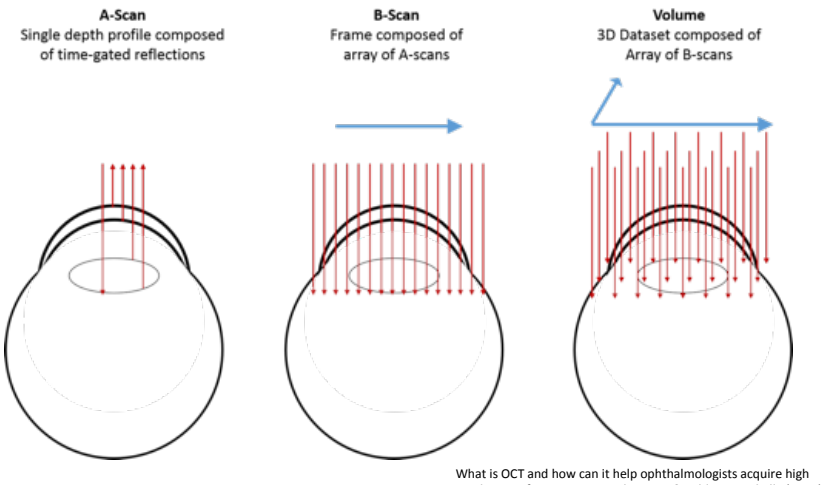

What is OCT and how can it help ophthalmologists acquire high resolution information on ocular tissue? Wildeman, Dhalla (Leica)

Funktion von OCT

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- Scan Breite & Tiefe
  - Bereich in dem die A-Scans aufgenommen werden
- Scan Geschwindigkeit
  - wie viele A-Scans/s aufgenommen werden

Artefakte, Rohscans & Segmentation

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- OCT zeigt kein histologisches Echtbild, sondern gerendertes Schnittbild aus vielen zusammengefügten A-Scans
  - OCT Artefakte von Befunden unterscheiden
- Alle Mappings & Analysen basieren auf „automatischer“ Segmentation von den Schichten durch die Geräte-Software
  - Schlechte Bildqualität kann diese verfälschen
  - In Zweifelsfällen Roh-Scans & Segmentation anschauen

Segmentation

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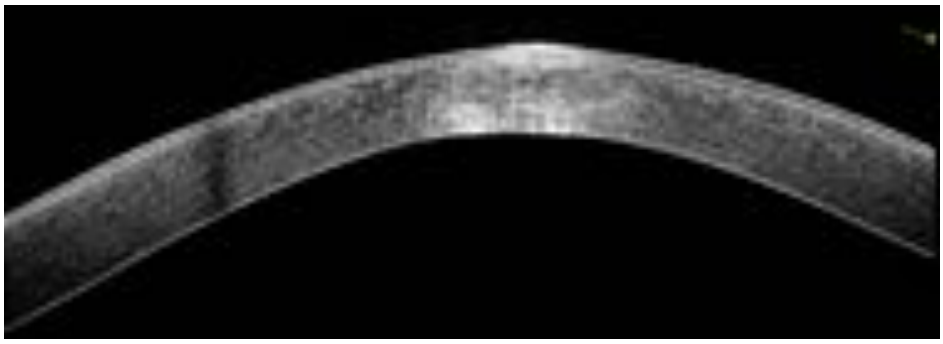
- Narben o.ä. können die automatische Erkennung der Segmentation verfälschen



Normale Artefakte OCT

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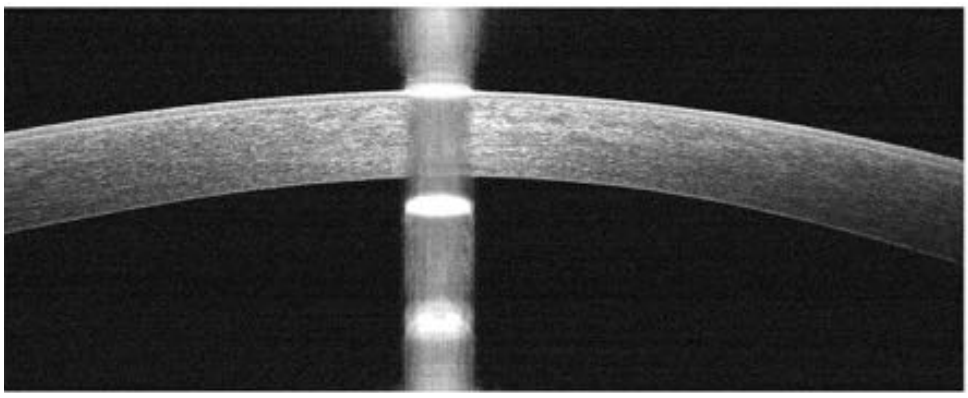
- Reflex von Apex der Cornea



Grau Darstellung

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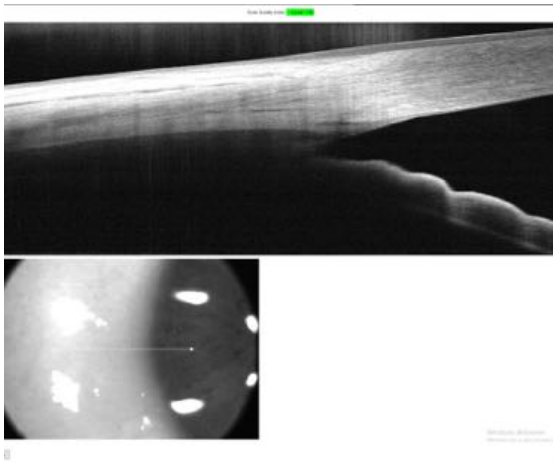
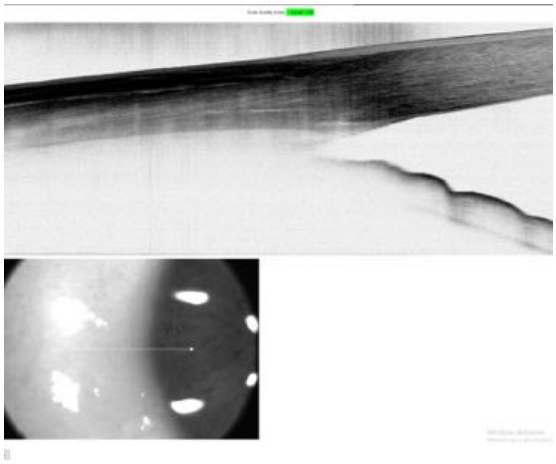


Reflexionsgrad

- Weiss = hoch = opak
- Schwarz = Transparent, keine Reflexion oder oder nicht von Licht erreicht

Invers Darstellung

linsen centrum



Invers zu Grau-Darstellung

Farb-Darstellung

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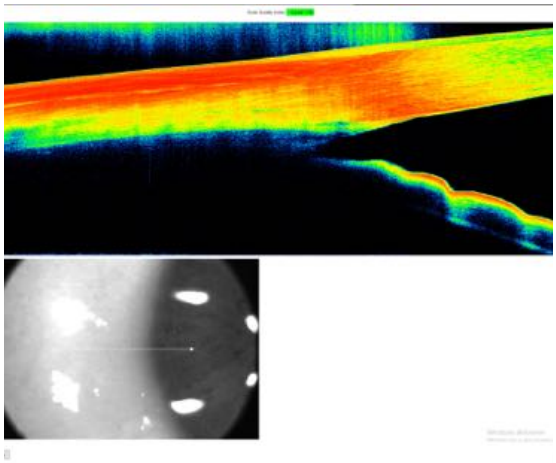

Reflexionsgrad

- Rot = hoch = opak
- Grün = gering = transparent
- Schwarz = Transparent, keine Reflexion oder oder nicht von Licht erreicht

AS-OCT Technologie „Nostalgie“

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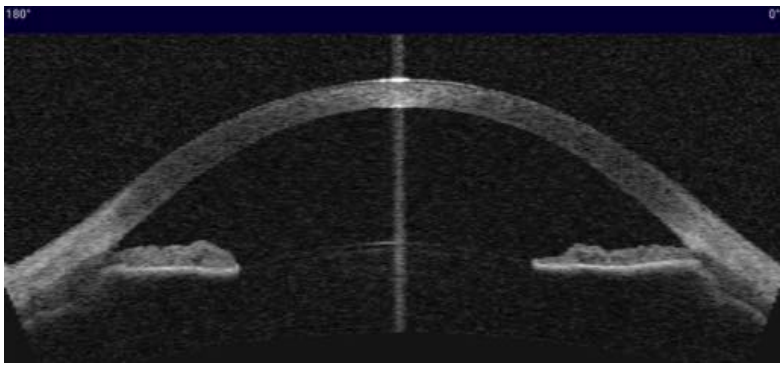
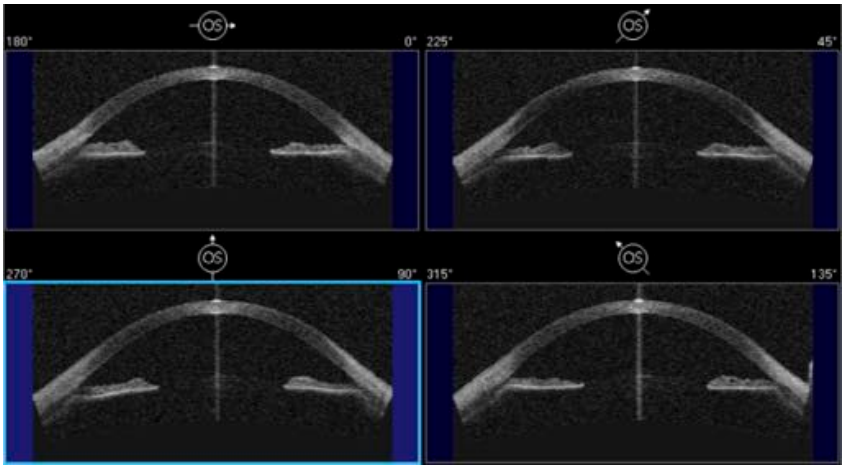


Visante Zeiss

- Release: 10/2005
- Nur AS-OCT
- 16mm weit
- 8mm tief
- 256x1024px
- 2000 A-scan/s
- Discontinued: 2014

AS-OCT Technologie „Nostalgie“

linsen centrum



AS-OCT Technologie „Nostalgie“

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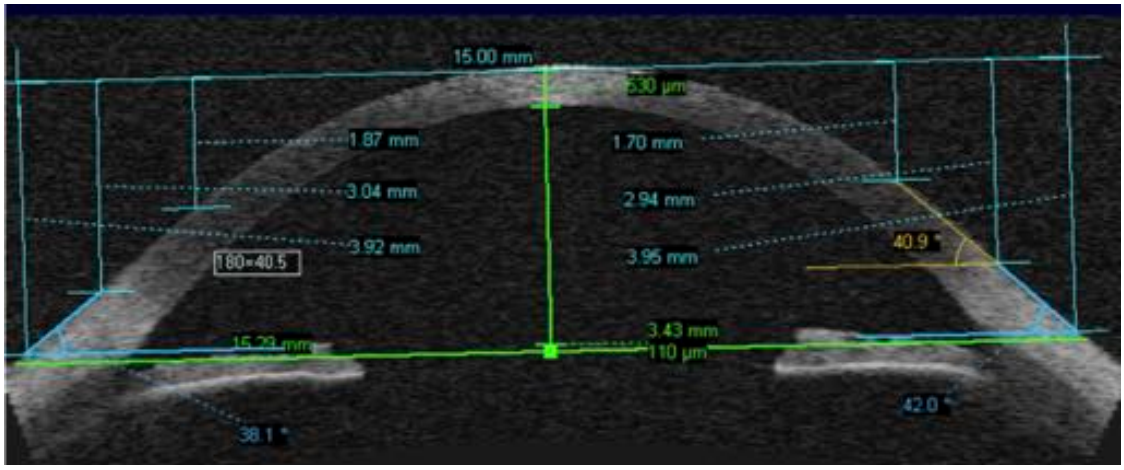

Contact Lens and Anterior Eye 41 (2018) 205–213

Contents lists available at ScienceDirect

Contact Lens and Anterior Eye

journal homepage: www.elsevier.com/locate/clae

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An analysis of anterior scleral shape and its role in the design and fitting of scleral contact lenses

Markus Ritzmann[a,*], Patrick J. Caroline[b], Rainer Börret[c], Emily Korszen[d]

[a] Falco Linsen AG, Tägerwilen, Switzerland
[b] Pacific University, College of Optometry, Forest Grove, OR, USA
[c] Aalen University, Aalen, Germany
[d] Pacific University College of Optometry, Forest Grove, OR, USA

ARTICLE INFO

Keywords:
Anterior scleral shape
Scleral contact lenses
Visante OCT
Sagittal height
Corneo-scleral profile
Scleral angles
Scleral toricity
HVID
VVID
Corneal diameter
Limbal zone

ABSTRACT

Purpose: The purpose of this study was to evaluate the shape of the anterior sclera by measuring the sagittal height and corneoscleral transition angles in the four cardinal and four oblique segments of the eye.
Materials and methods: In this study, 78 normal eyes of 39 subjects were evaluated. The sagittal height, corneoscleral angle and scleral angle were measured at three chord lengths (10.0 mm, 12.8 mm and 15.0 mm) in all eight segments of the anterior eye using optical coherence tomography (Zeiss Visante AS-OCT). Scleral toricity was calculated for each eye, defined as the greatest sagittal height difference found between two perpendicular meridians.
Results: At a 12.8 mm chord length, the shape of the anterior eye was found to be nearly rotationally symmetric, and at a chord of 15.0 mm the shape became more asymmetric. The average sagittal heights of the eight segments at a 12.8 mm chord ranged from 2890 μm to 2940 μm; at a 15.0 mm chord they ranged from 3680 μm to 3790 μm. The average scleral angles at a 15.0 mm chord ranged from 35.17° to 38.82°. Significant differences between opposing segments were found in the sagittal height and scleral angle measurements at a chord of 15.0 mm (sagittal height $p \leq 0.0021$; scleral angle $p \leq 0.0105$). The nasal measurements revealed flatter scleral angles and concave corneoscleral transitions, whereas temporal scleral angles were steeper, with tangential or convex corneoscleral transitions.
Conclusion: These findings are important to consider when designing and fitting contact lenses that rest beyond the boundaries of the limbus, such as scleral lenses.

AS-OCT Technologie „Heute“

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- Kombigeräte für AS- & PS-OCT
  - benötigen Aufsatzlinse oder Veränderung der Distanz für Aufnahme des vorderen Segmentes
- Reine AS-OCT
- Spezifikationen
  - Bis zu 18mm weit
  - Bis zu 10mm tief
  - Bis zu 120‘000 A-scans/s

Heidelberg Anterior Modul

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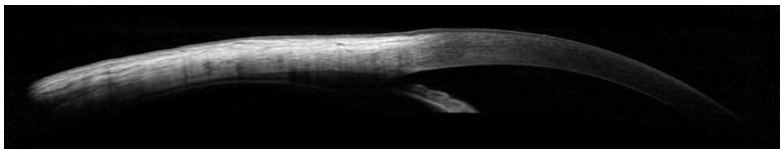

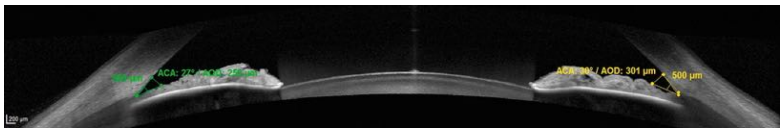

- Aufsatzlinse für Spectralis

Asam J.S., Polzer M., Tafreshi A., Hirnschall N., Findl O. (2019) Anterior Segment OCT. In: Bille J. (eds) High Resolution Imaging in Microscopy and Ophthalmology. Springer, Cham. https://doi.org/10.1007/978-3-030-16638-0_13

Heidelberg Anterion

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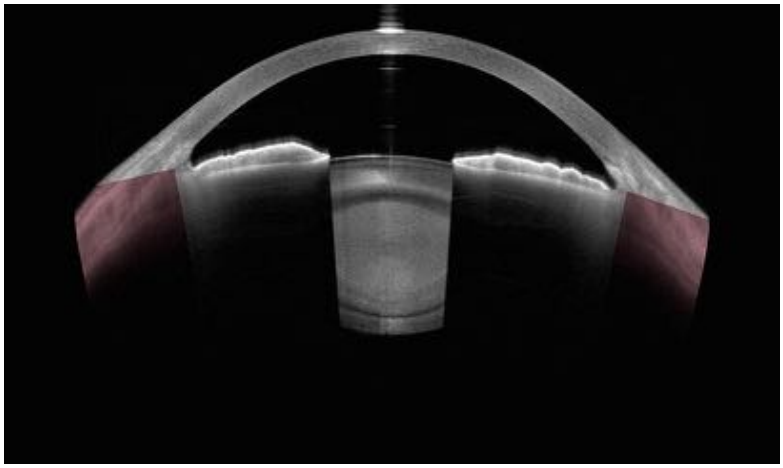

- Nur AS-OCT
- Powermap
- AXL
- Cataract
- 16x8mm?
- Keratokonus

Asam J.S., Polzer M., Tafreshi A., Hirnschall N., Findl O. (2019) Anterior Segment OCT. In: Bille J. (eds) High Resolution Imaging in Microscopy and Ophthalmology. Springer, Cham. https://doi.org/10.1007/978-3-030-16638-0_13

Optovue Solix Anterior Modul

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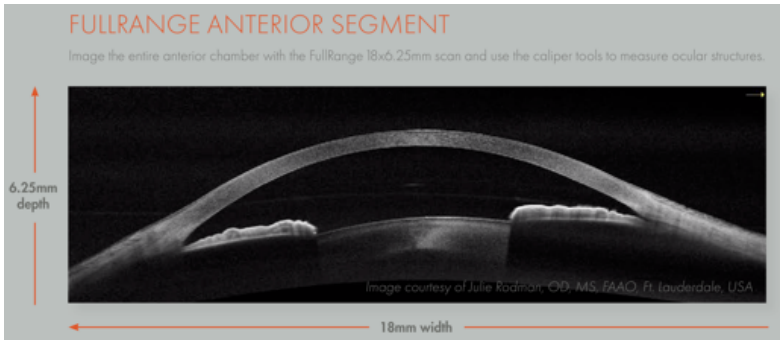

- Aufsatzlinse
- 18x6.25mm Scan
- Powermap
- Meibographie
- Epithelmapping
- Cataract
- Keratokonus
- AXL?

CSO MS-39

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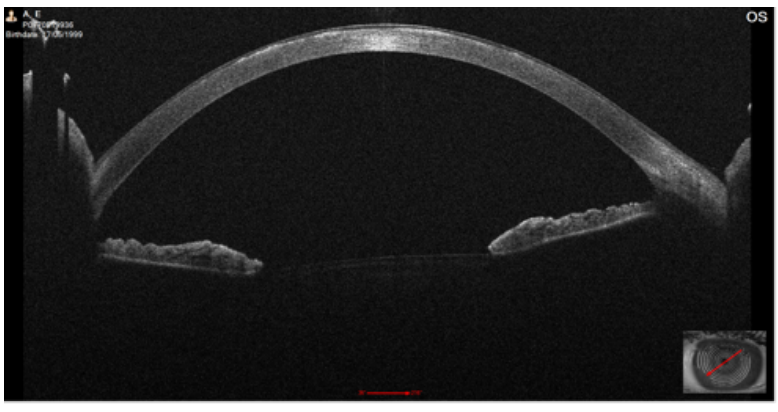
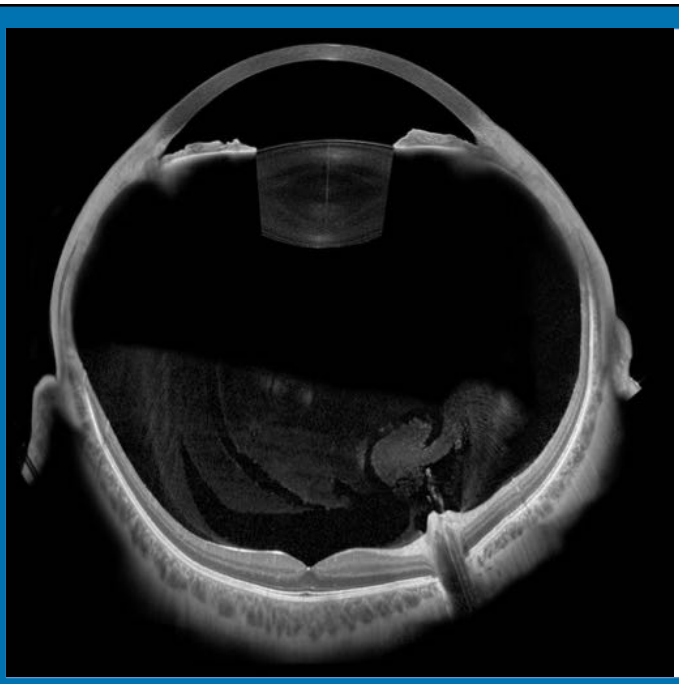


Bild: Elza Institute

CSO MS-39

- Nur AS-OCT
- 16x8mm Scans
- Epithelmapping
- Placido Topography
- Aberometrie
- Keratokonus



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The Future

5 Anterion & 6 Spectralis OCT-Bilder zusammengefügt

https://www.linkedin.com/pulse/story-behind-whole-eye-oct-emily-malbon
A Whole Eye montage created using Adobe Photoshop composed of 5 images acquired using ANTERION for the anterior segment and 6 images acquired using SPECTRALIS for the posterior segment. Composite image deliberately not to scale. An imaging parody for promotional purposes only. Artist: Tim Cole, Clinical Market Development Manager, Heidelberg Engineering UK

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Anatomie Refresher

Histologie Cornea & Kammerwinkel

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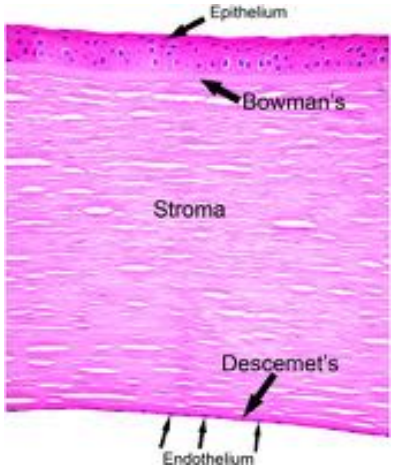
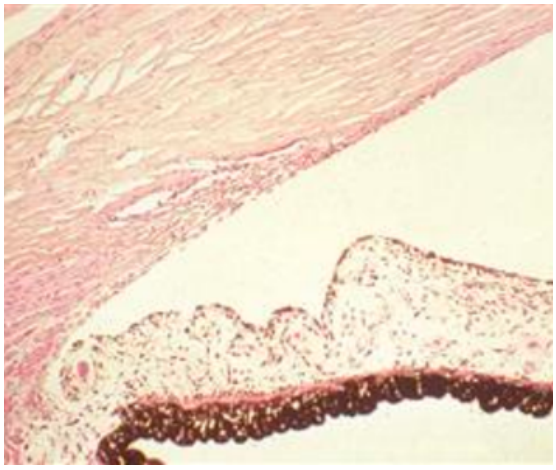


Meeney, A., Mudhar, H. Histopathological reporting of corneal pathology by a biomedical scientist: the Sheffield Experience. *Eye* **27,** 272–276 (2013). https://doi.org



Anatomy of the Angle By: Wallace L M Alward MD, Reid A Longmuir MD Color Atlas of Gonioscopy

OCT Interpretation

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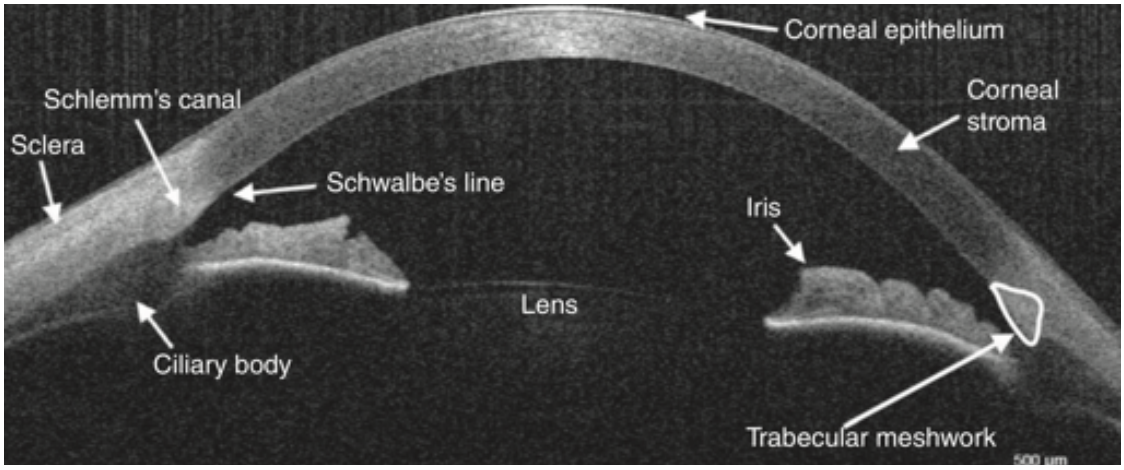

Wang et al. - 2019 - Anterior segment optical coherence tomography

Histologie Kammerwinkel

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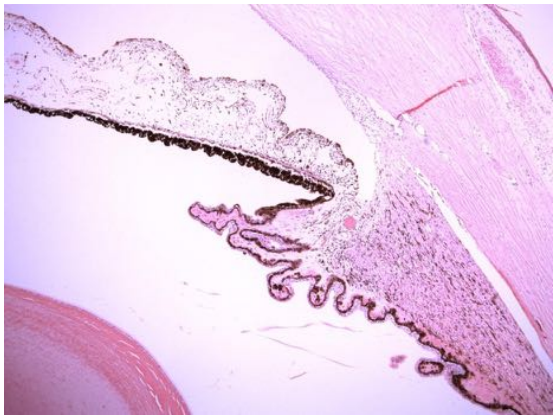

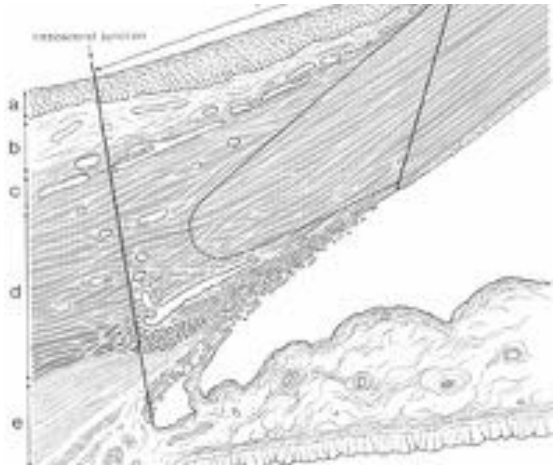

Anatomy of Ciliary Body, Ciliary Processes, Anterior Chamber Angle and Collector Vessels
Adriana Silva Borges- Giampani and Jair Giampani Junior

Strukturen Kammerwinkel

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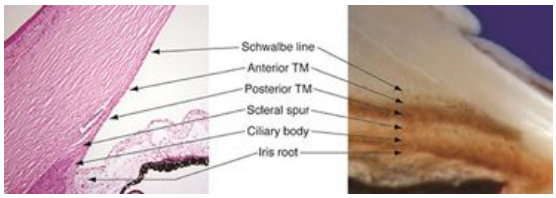

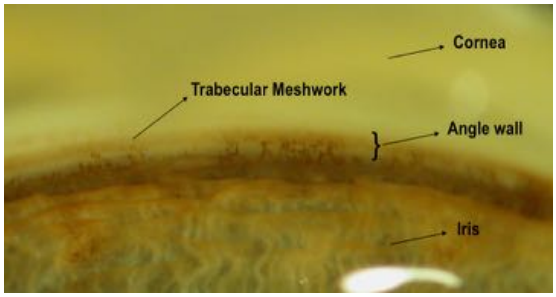

www.aao.org
7 Clinical Pearls for Great Gonioscopy
Written By: Anthony C Gregory, MD

Strukturen Kammerwinkel

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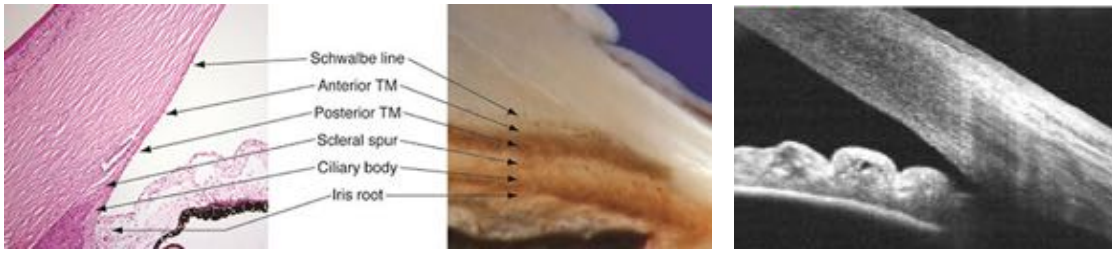

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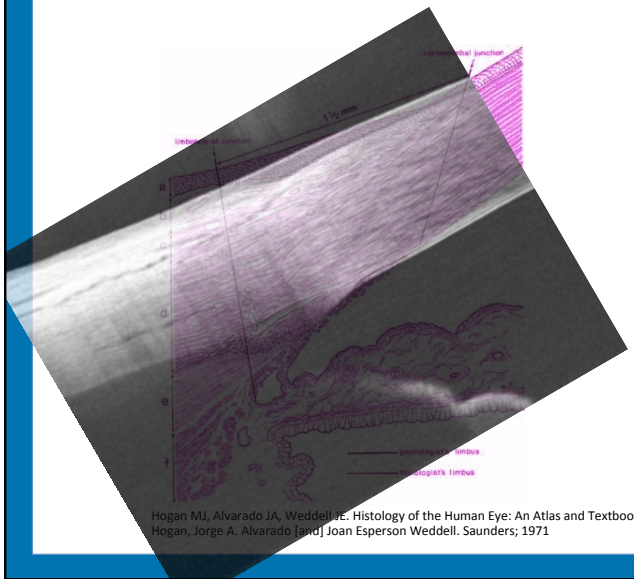
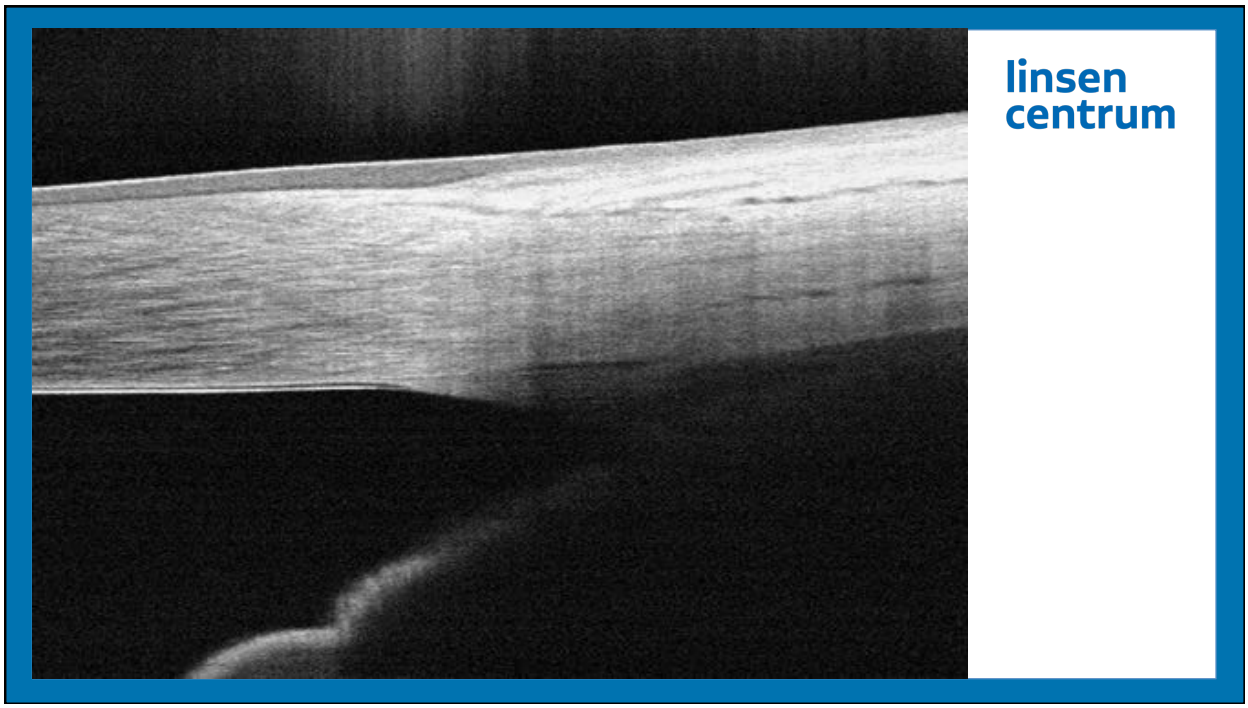


Hogan MJ, Alvarado JA, Weddell JE. Histology of the Human Eye: An Atlas and Textbook [by] Michael J. Hogan, Jorge A. Alvarado [and] Joan Esperson Weddell. Saunders; 1971



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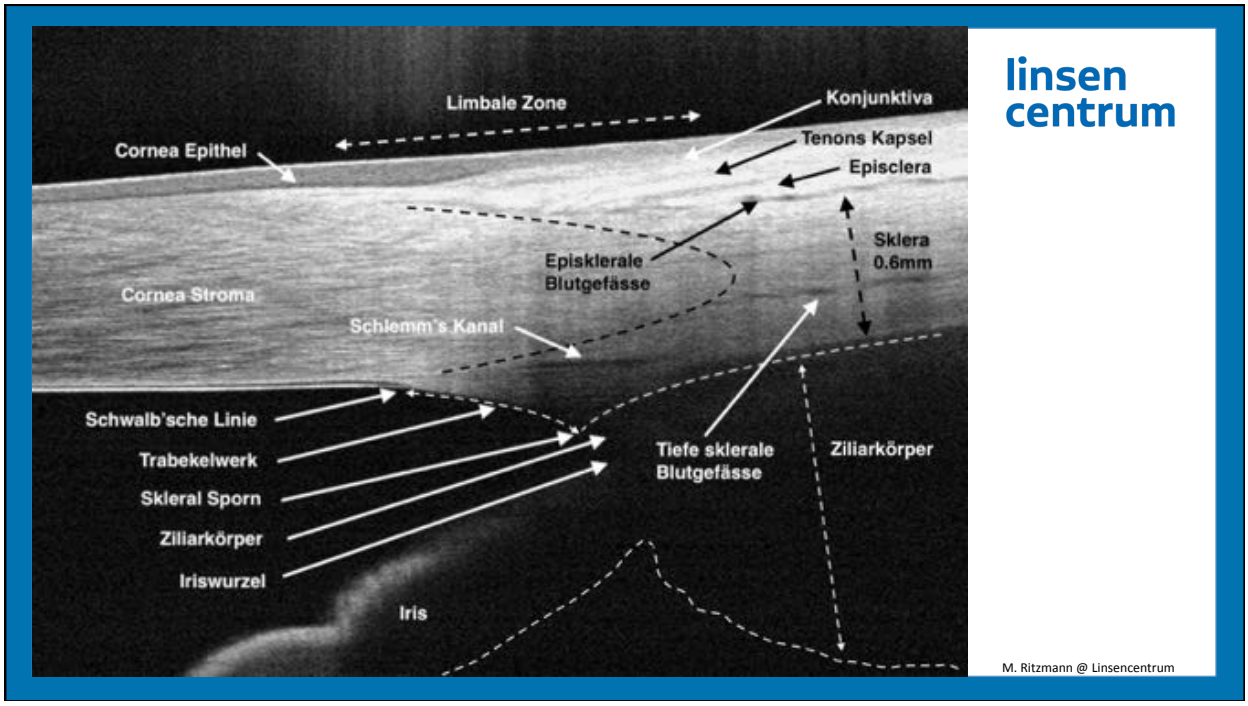

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M. Ritzmann @ Linsencentrum

Histologie Cornea

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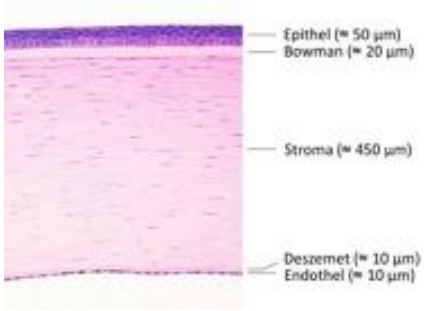

AS-OCT Linsencentrum

https://www.augenklinik-sulzbach.de/behandlungsspektrum/hornhaut-transplantation/die-hornhaut

Corneal Epithelial Imaging with FD-OCT

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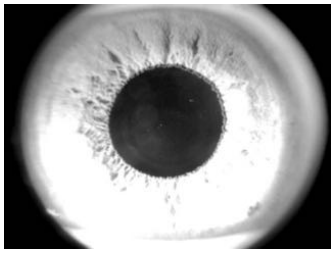

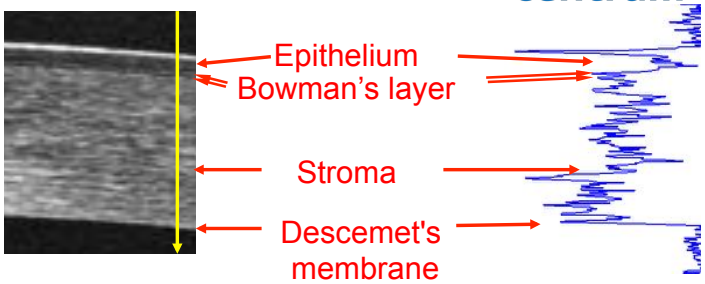

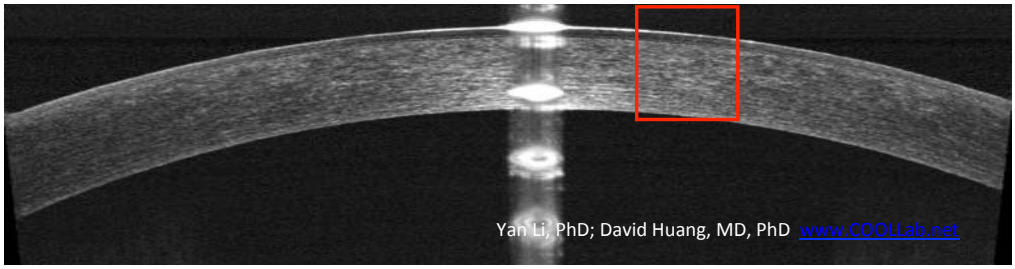

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Diagnostik & Screening

Möglichkeiten mit AS-OCT im optometrischen Alltag

Kammerwinkel

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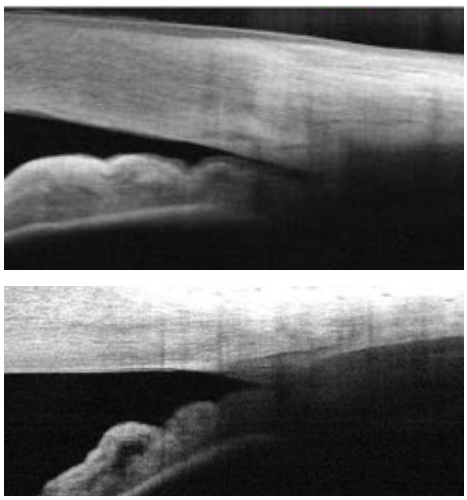
Line-Scan

- Winkel Beurteilung
- Offen, eng, zu?
- Iriswurzel (Winkelblock, Iris Plateau, ...)
- OCT vs. Gonioskopie
  - Pigmente im TM nicht erkennbar
  - „nur“ ein Schnitt vs. Überblick & echt Strukturen mit Gonio
  - Winkel-Deformation (Trauma)
  - ersetzt Gonioskopie nicht vollständig



Kammerwinkel

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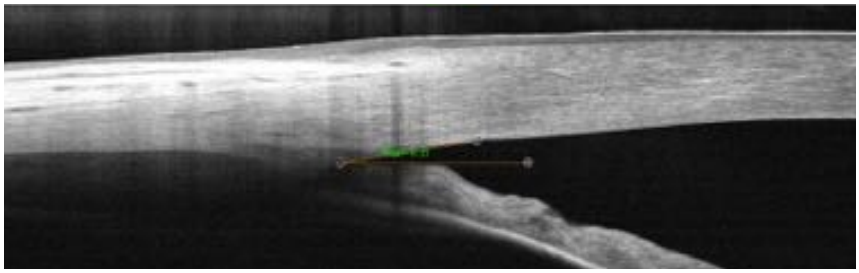
- Kann mit unterschiedlichen Mess-Tools vermessen werden
- In der Beurteilung im Screening sind die sichtbar „freiliegenden“ Strukturen entscheidend
  - Skleralsporn bis Schwalb‘sche Line = Trabekelwerk



Kammerwinkel

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- Bei kritischem Kammerwinkel:
  - Raumbeleuchtung so dunkel wie möglich um maximale Dilatation der Pupille zu erreichen
  - Kammerwinkel zeigt so die engste Konstellation
  - Vorübergehender Winkelblock in dunkler Umgebung (Kino, TV,...) Kopfschmerzen?
  - Mittel dilatierte Pupille höchster Wiederstand von Kammerwasser Pupille + Linse

Akutes Winkelblock Glaukom

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- Subjektive Symptome
  - Übelkeit, Erbrechen, Kopfschmerzen um Auge, verschwommen Sehen, Rötung
- Objektive Symptome
  - IOD >40mmHg
  - Konjunktivale/Limbale Rötung
  - Hornhaut Ödem
  - Mittel dilatierte, nicht reaktive Pupille
  - Flache Vorderkammer

Plateau Iris

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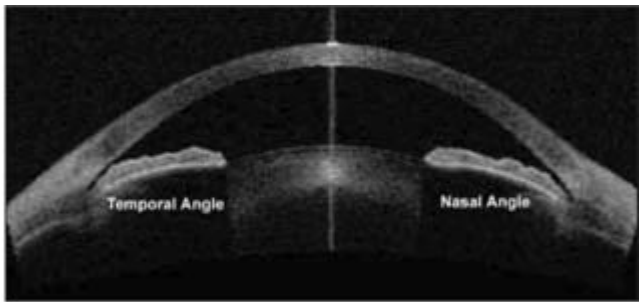

Endocycloplasty A new technique for managing angle-closure glaucoma secondary to plateau iris syndrome
D. Podbielski, D. Varma, I. Ahmed

Risiko für Winkelblock

- Lichtverhältnisse
- Zunehmende Linsendicke
- Diagnostika

Cornea Epithel

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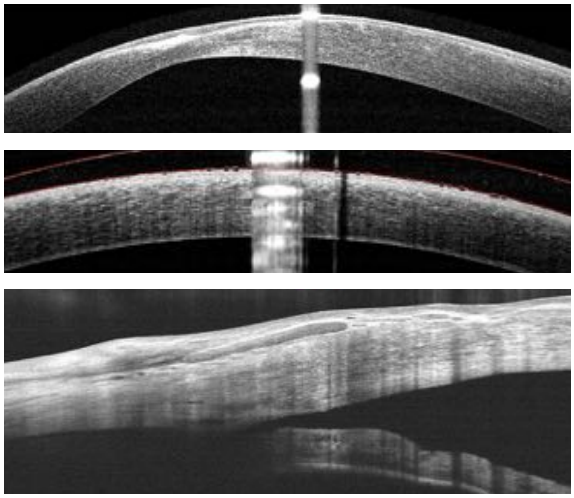
- Line Scan
  - Epithel Auffälligkeiten
    - Vernarbungen
    - Bullosa
    - Pterygium
    - EBD



Cornea Stroma

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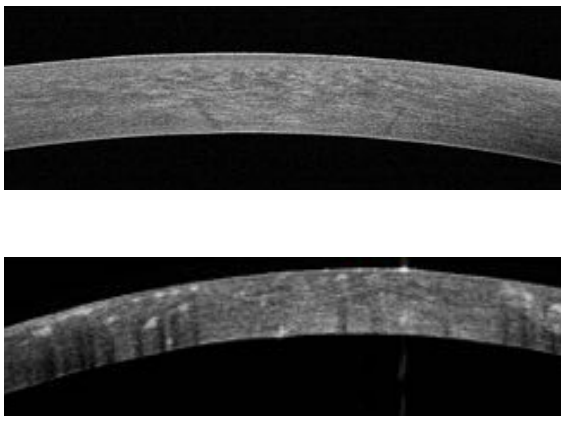
- Line Scan
  - Ödem
    - Vertikal Striae
    - Endothel falten
  - Einlagerungen Cornea
  - Dystrophien



Cornea Endothel

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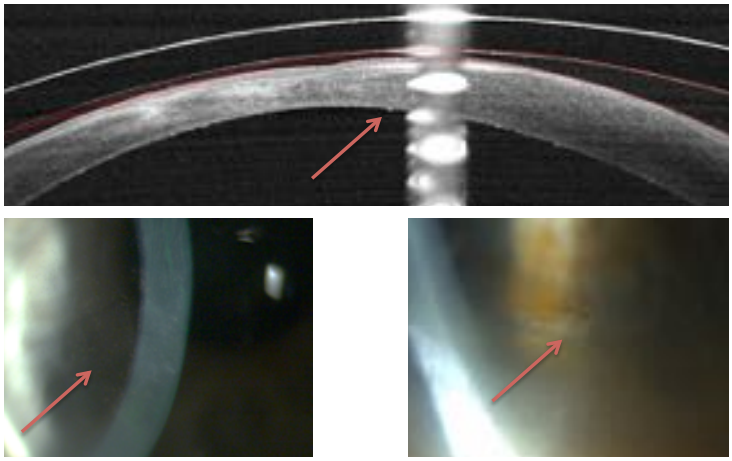
- Line Scan
  - Endothel
  - PDS
  - PEX
  - Fuchs



Pachymetrie

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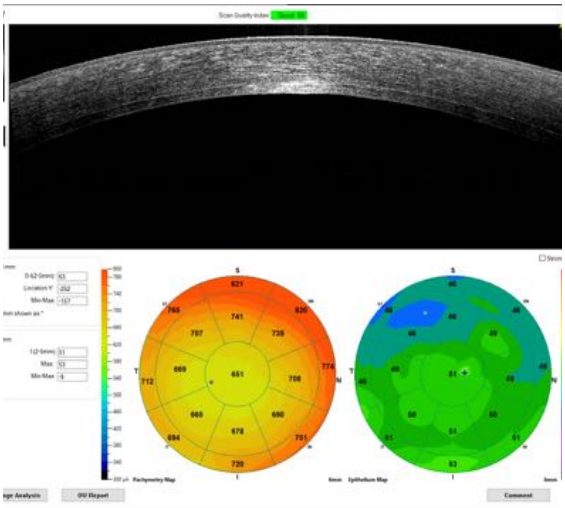
- Pachymetrie
  - IOD Korrektion
  - Glaukom Risiko
- Endothel Veränderungen
  - Fuchsdystrophie
  - PEX (Pseudo Exfoliations Syndrome)
  - pKP



Stärken von OCT-Pachymetrie

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- Stromal-Mapping
  - ohne variabler Faktor von Epithel
  - Keratokonus Progression
  - KL-Träger & Ödeme
  - Ortho-K
- Epithel-Mapping
  - Keratokonus Screening
  - Trockenes Auge Screening

OCT Pachymetrie vs. Scheimpflug

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- OCT-Pachymetrie Messung wird nicht oder kaum durch Hornhauttrübungen beeinflusst
  - Bessere Verlaufskontrolle nach CXL mit Post-OP Haze
  - Vorbereitung von PTK bei Vernarbungen
- Scheimpflug-Pachymetrie misst immer gesamte corneale Dicke Epithel kann nicht segmentiert werden
  - Scheimpflug und Placido Topographie können einen Form frust Keratokonus maskieren
  - im Epithel-Mapping aber wird dieser aufgedeckt

OCT Pachymetrie vs. Scheimpflug

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- Periphere Pachymetrie ist mit OCT genauer als Scheimpflug
  - PMD Progression
    - Placido teils besser als Scheimpflug
- Schnellere Datenerfassung mit OCT
- Höhere räumliche Auflösung gegenüber Scheimpflug

Detecting Keratoconic Thinning with OCT Pachymetric Indices

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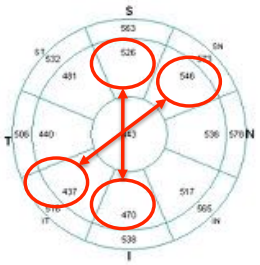
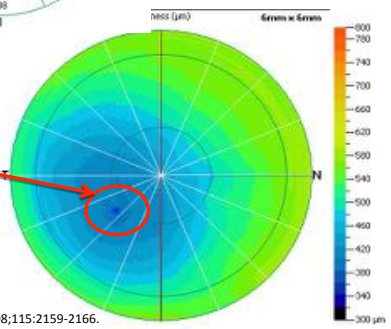
- General thinning
  - Min
- Focal thinning
  - Minimum - median
- Asymmetric thinning
  - I-S
  - IT-SN
  - Y location of the Min





Minimum = 404 µm
Y = -710 µm

Li Y, Meisler M, Tang M, Lu A, Thakrar V, Reiser B, Huang D. Keratoconus diagnosis with OCT pachymetry mapping. *Ophthalmology* 2008;115:2159-2166.

OCT Pachymetry Map-Based Keratoconus Score Table

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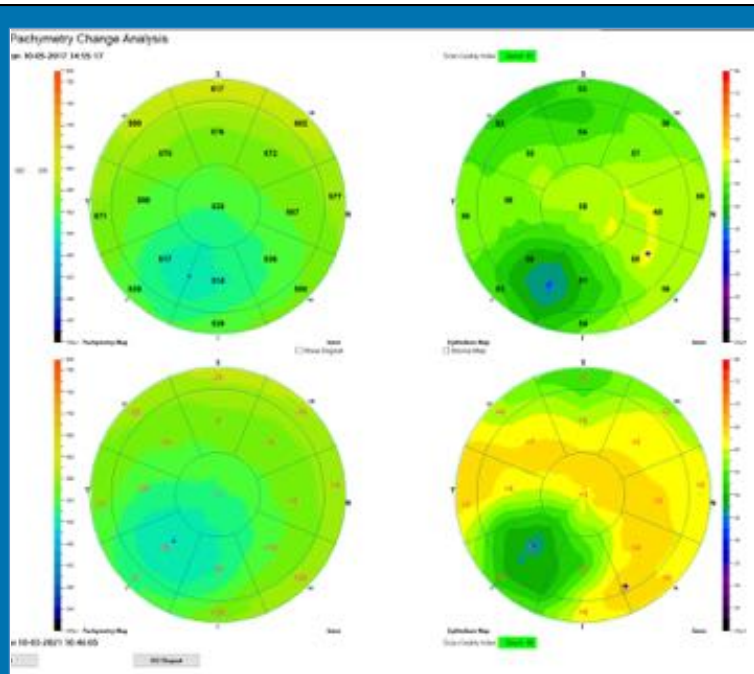
	0	1	2	3	OD	OS
Minimum	>499	499 ~ 476	475 ~ 455	<455		
Minimum- Median	>-21	-22 ~ -25	-26 ~ -29	<-29		
I-S	>-30	-30~-40	-41~-49	<-49		
IT-SN	>-33	-33~42	-43~-51	<-51		
Y location of the min	>-734	-734 ~ -1069	-1070 ~ -1353	<-1353		
Keratoconus Risk Score						

Summation

Each variable will be assigned a score of 1, 2, 3
The keratoconus risk score of the eye is the summation of all scores.

Keratoconus diagnostic criterion: score ≥ 4
Sensitivity = 86%; Specificity = 94%; AROC = 0.951
AROC = area under the receiver operating characteristic curve

Qin B, Chen S, Brass R, et al. Keratoconus diagnosis with an OCT-based pachymetric scoring system, *JCRS*, in press.



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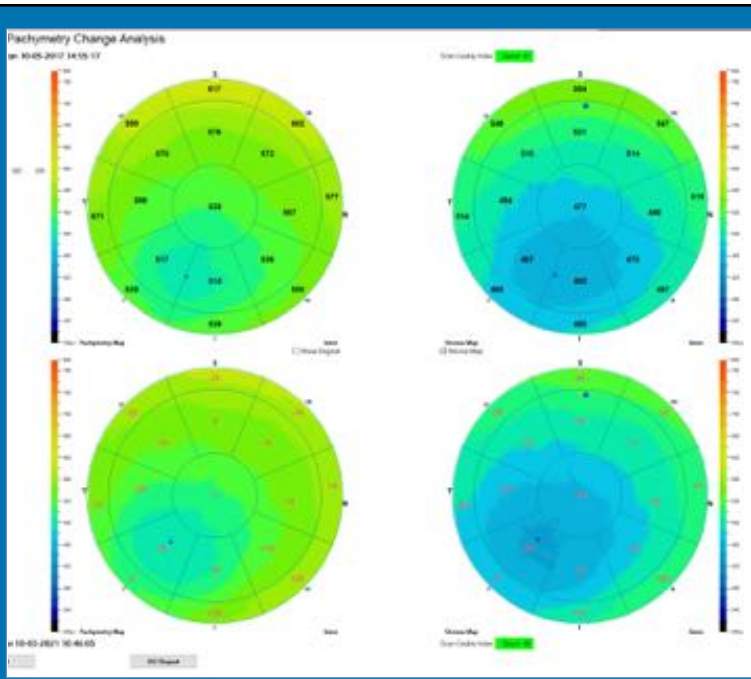
Change Analysis:
4 Jahre

Pachy Total



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Change Analysis:
4 Jahre

Pachy **Stromal**

CXL

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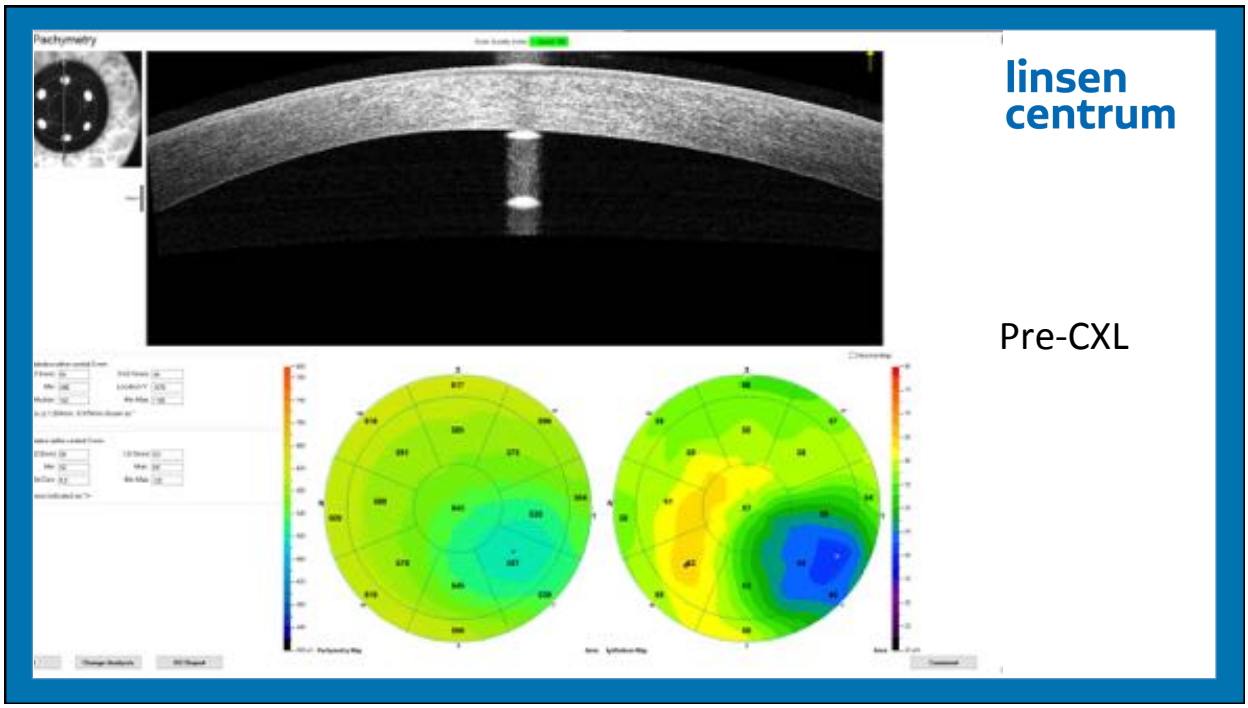
- **Demarkations Linie**
  - **Zeigt bis in welche Tiefe das CXL wirkt**
  - **Ca. 2/3 des Stromas**


Pachymetry
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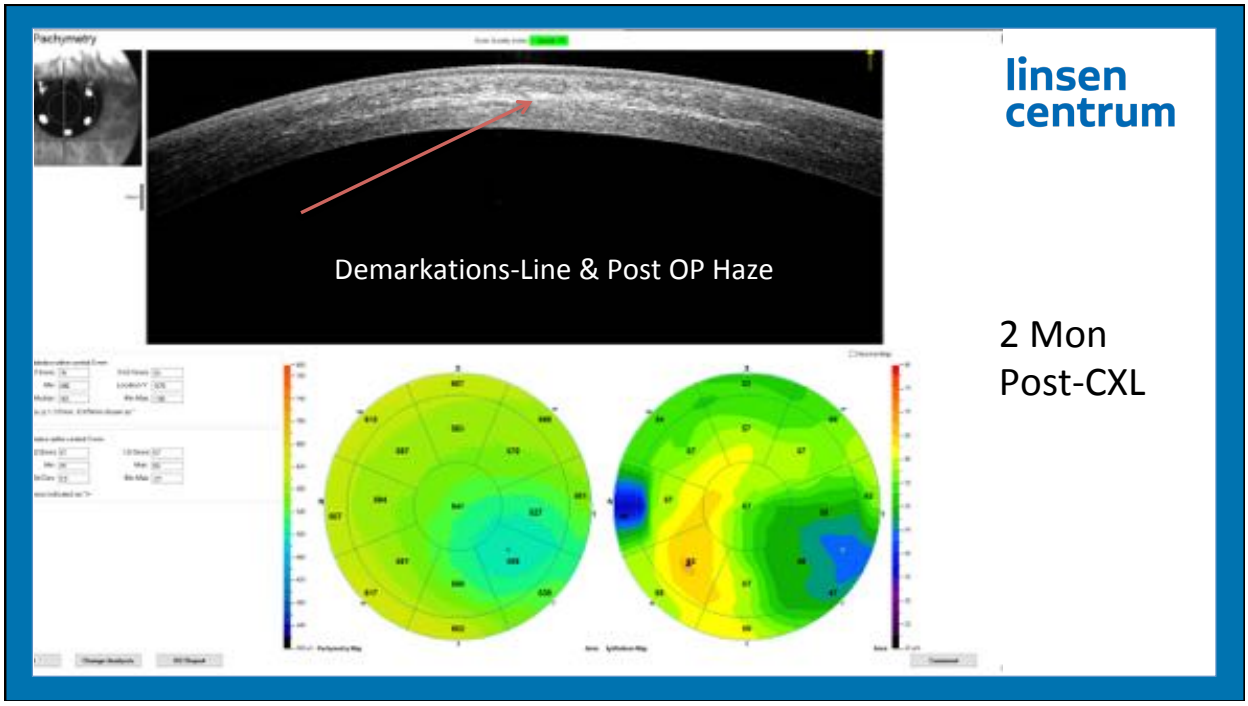
Pre-CXL


Pachymetry
Demarkations-Line & Post OP Haze
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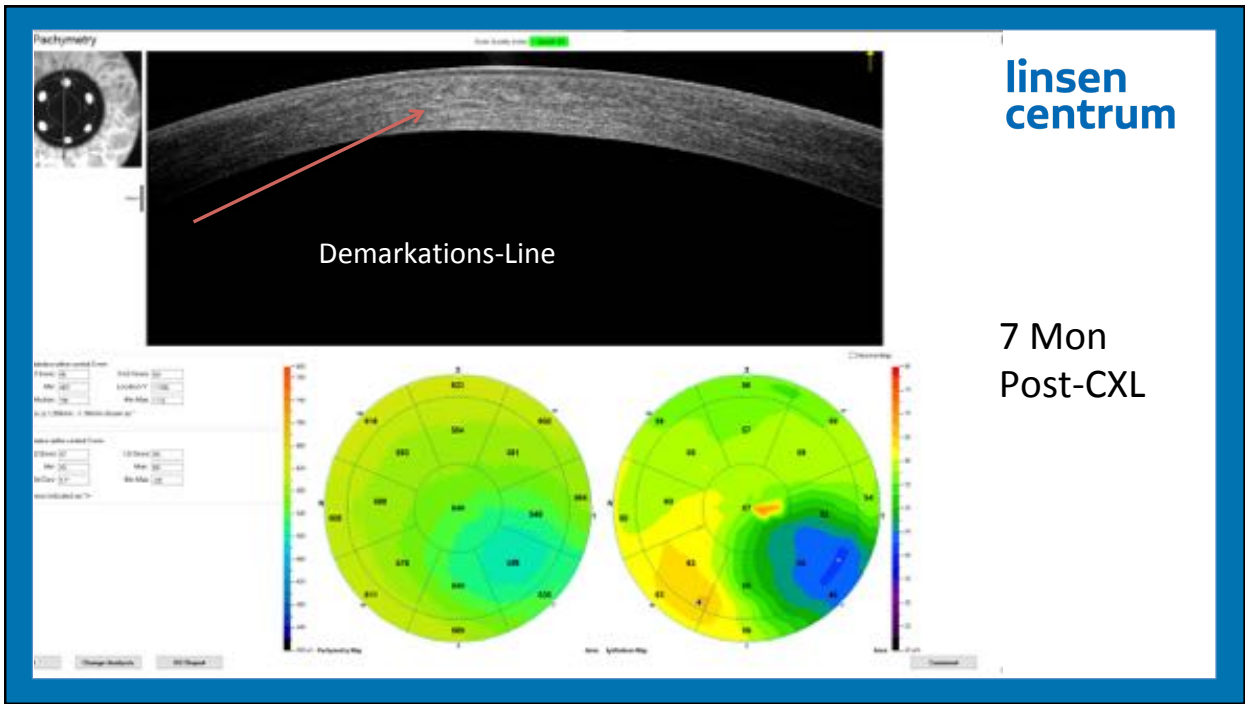
2 Mon Post-CXL


Pachymetry
Demarkations-Line
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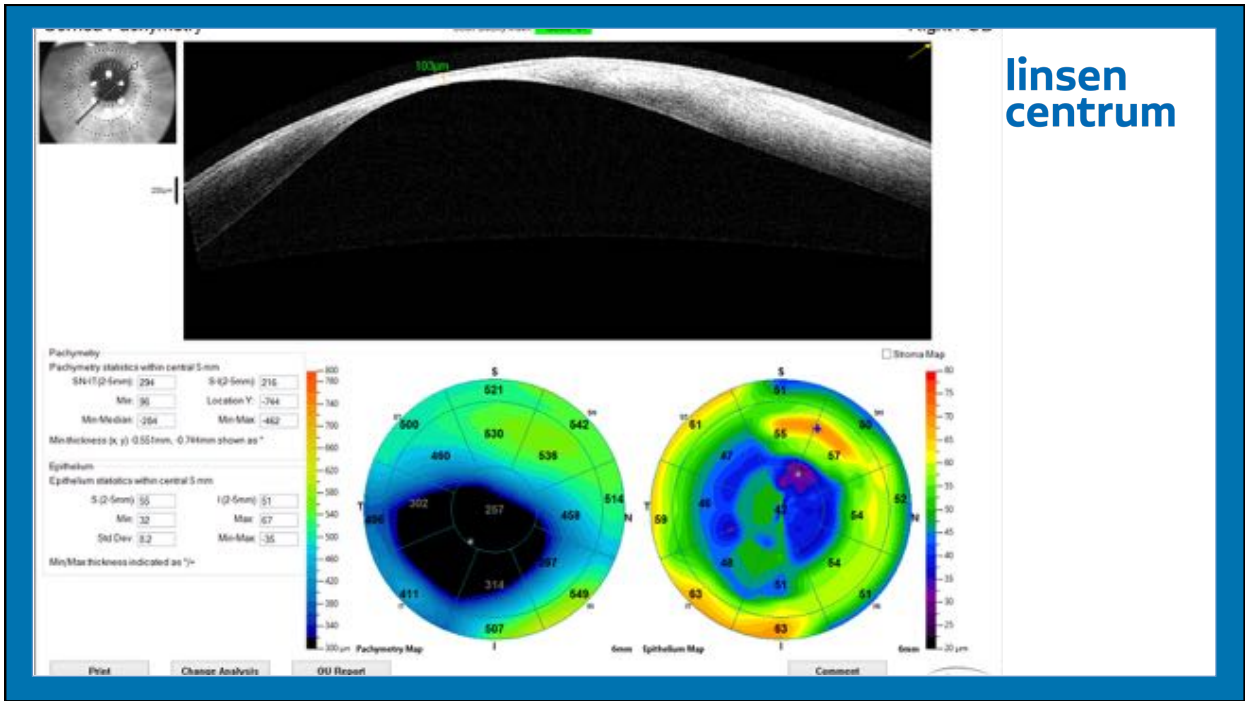
7 Mon Post-CXL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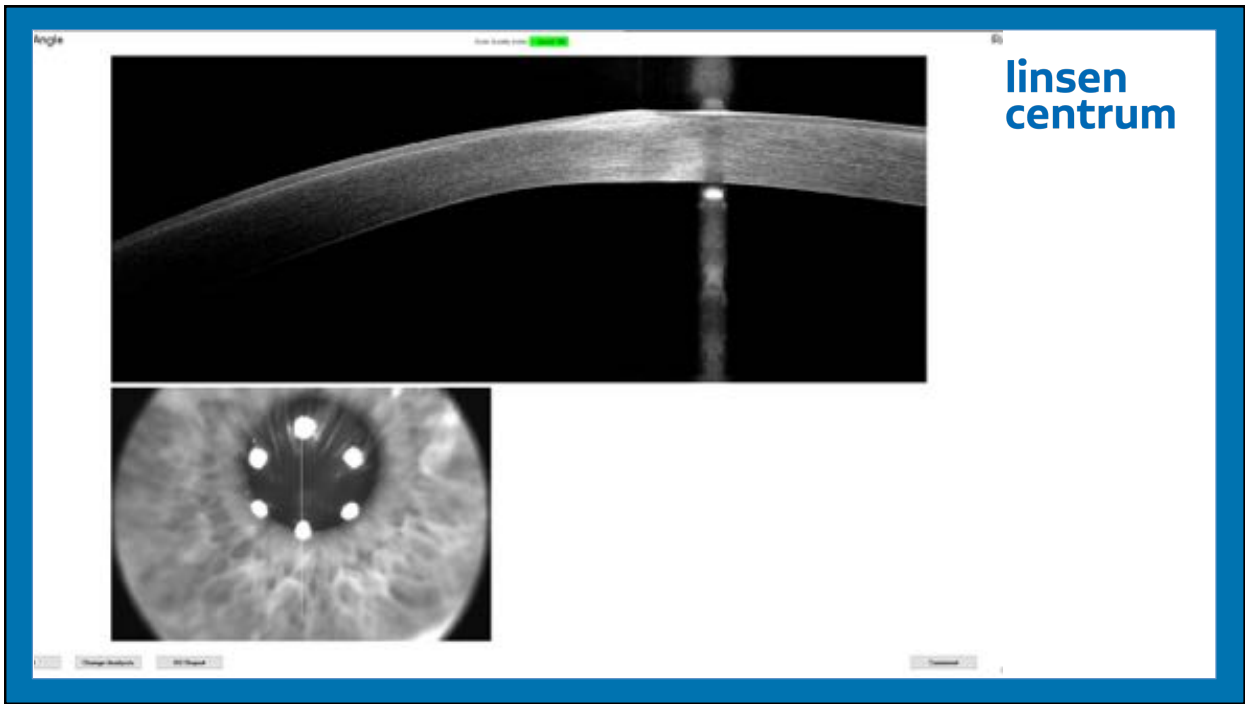
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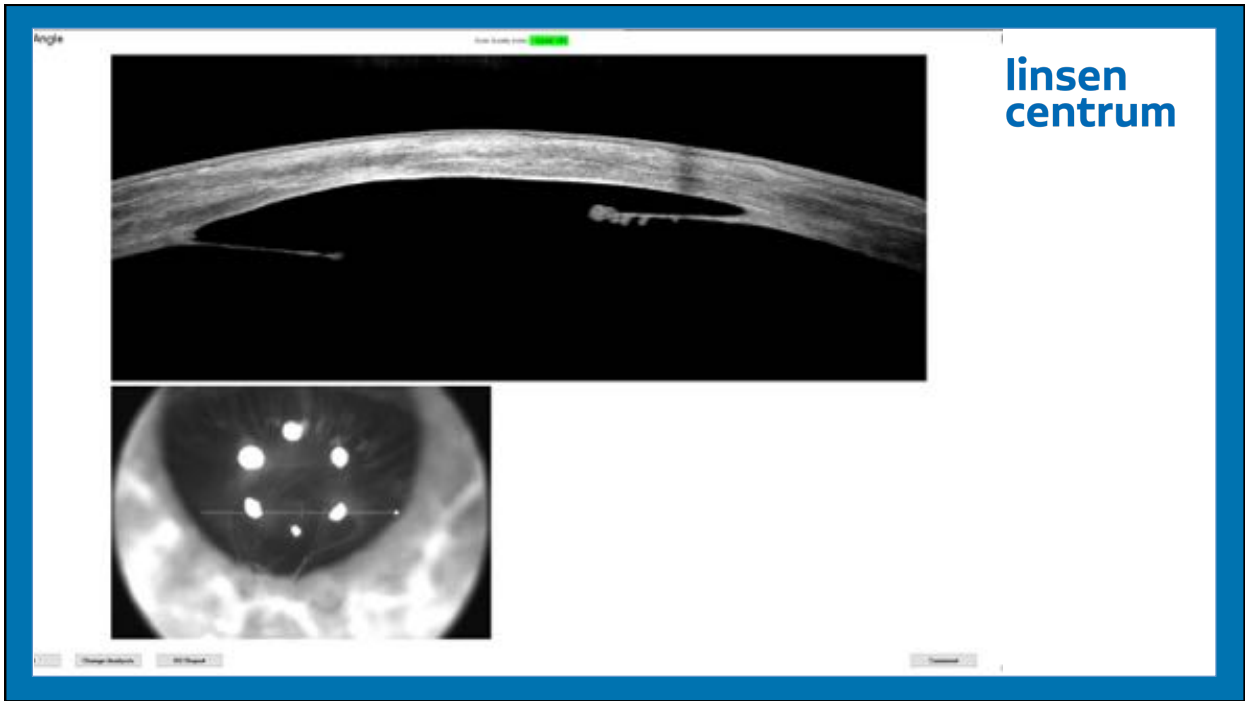
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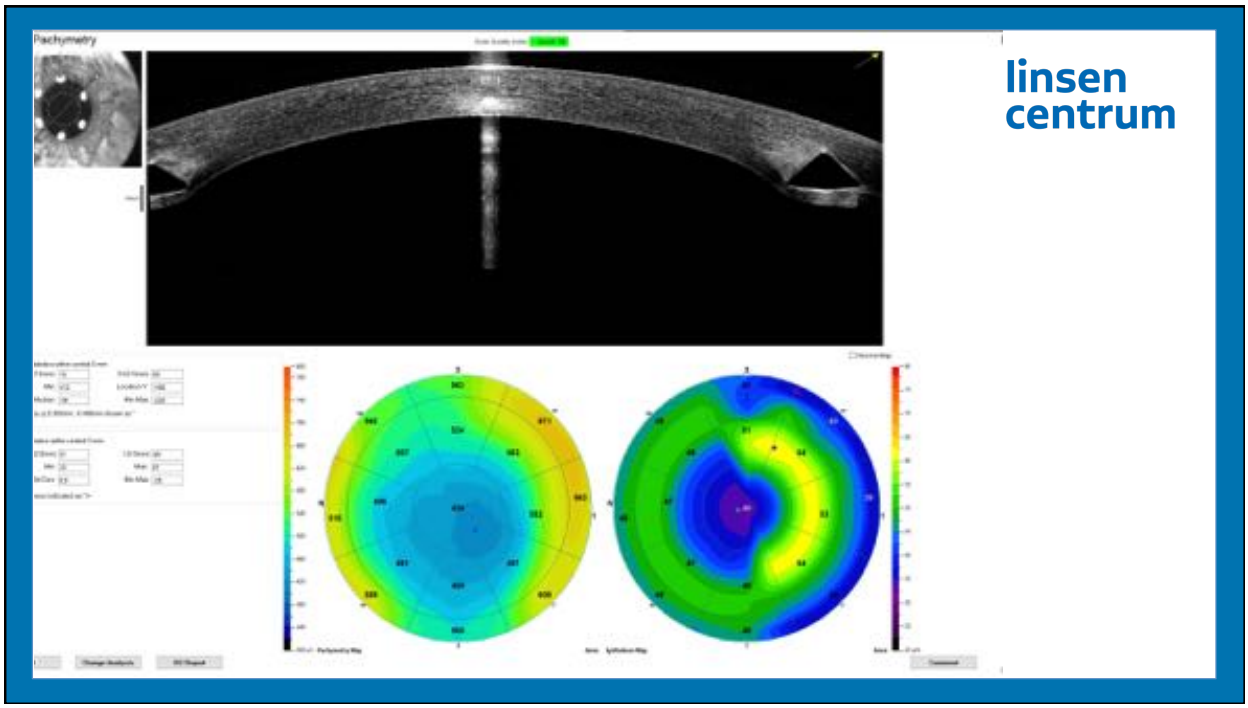

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Epithel-Mapping

Example of Epithelial Thinning over Keratoconic Cone Apex

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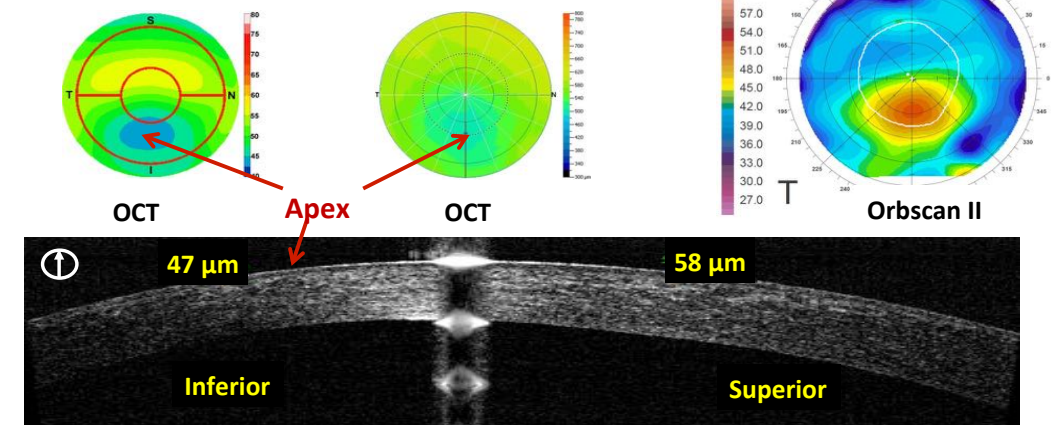
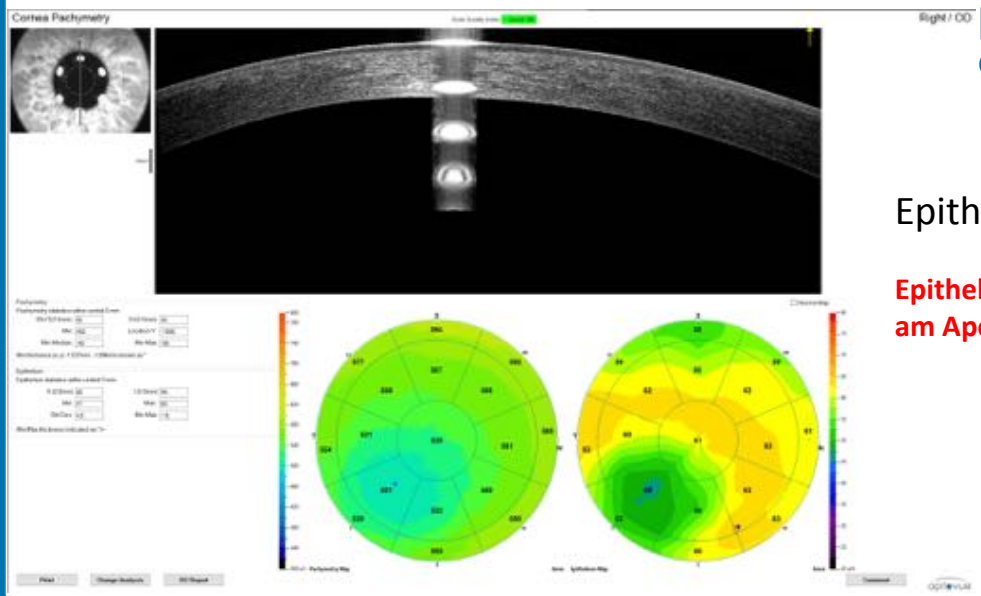
Epithelial Thickness

Pachymetry

Mean Power



David Huang, MD, PhD www.COOLLab.net



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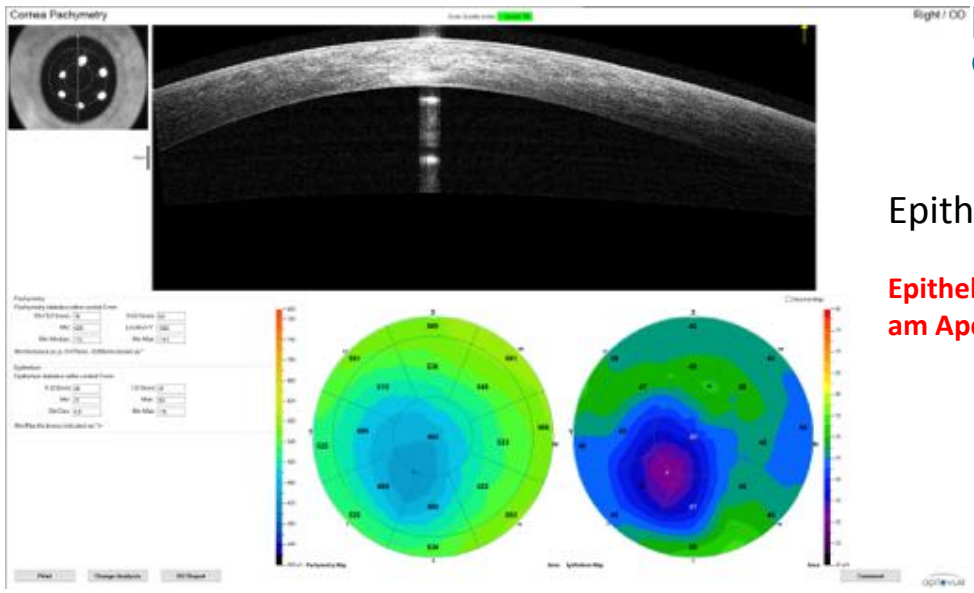
Epithel-Mapping

Epithel Verdünnung am Apex nach



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Epithel-Mapping

Epithel Verdünnung am Apex nach

OCT Pachymetrie vs. Scheimpflug

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- Epithel Modulation vor gegenüber nach Sklerlalinsen tragen:
  - Epithel wird durch Lidscherkräfte moduliert → Oberflächen Regularisation (Topographisch)
  - Scheinbare Progression (steilere K-Werte topographisch) nach Sklerallinsen tragen da die Lidscherkräfte fehlen
  - Wird nur Stroma betrachtet, kann «wahre Progression» in der Pachymetrie beurteilt werden

Epithelmapping & Sklerallinsen

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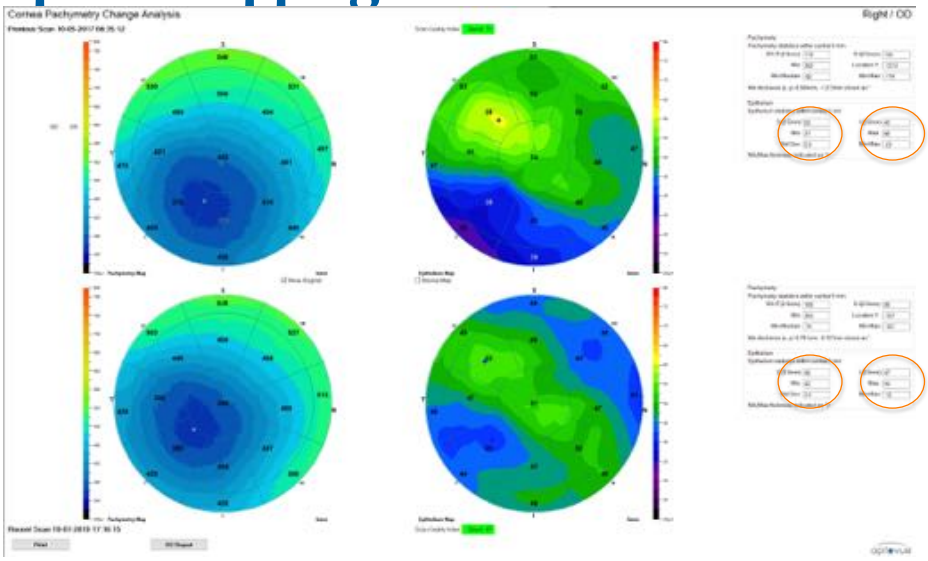

Vor ScCL

Nach ScCL

Pachymetrie Stroma & Sklerallinsen

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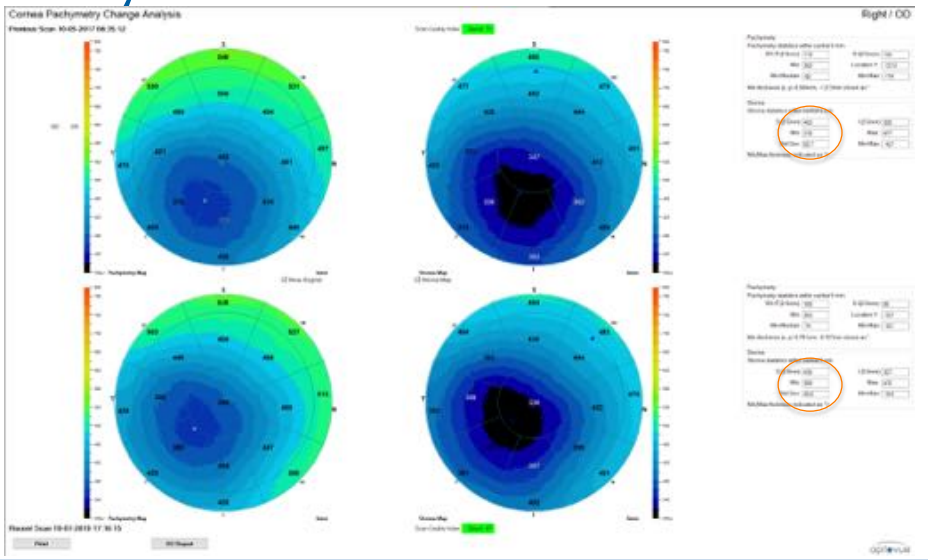

Vor ScCL

Nach ScCL

Ortho-Keratologie

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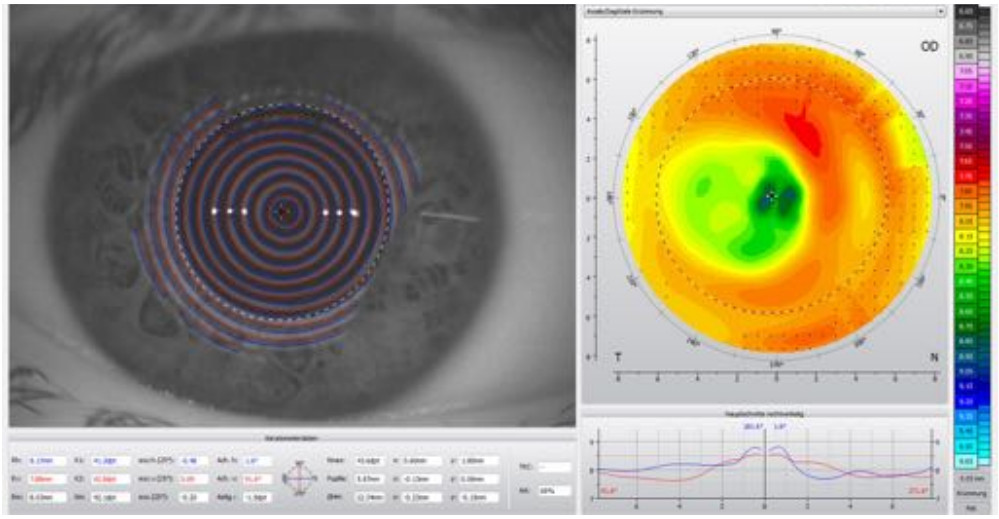

Ortho-Keratologie

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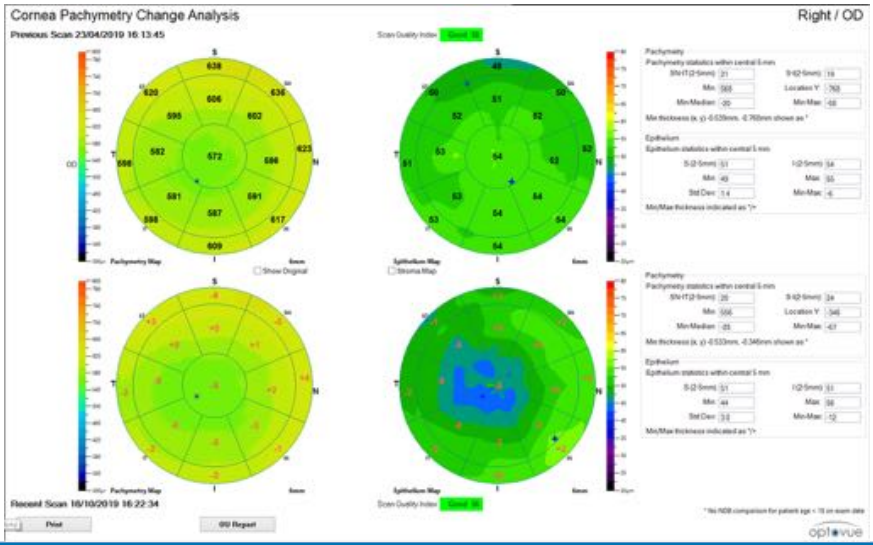

Ortho-Keratologie

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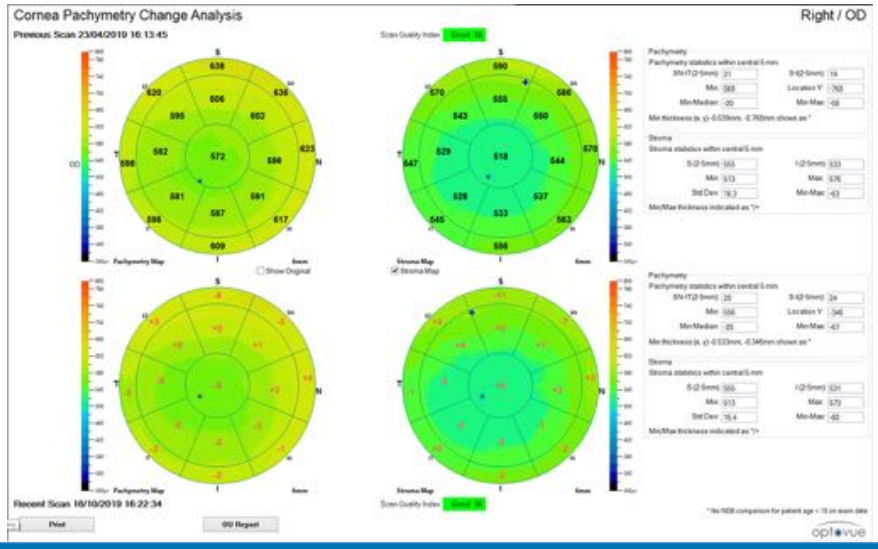

Trockenes Auge Screening

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- Epithelial Thickness Mapping
  - unregelmässigere Epithel-Dicke als beim normalen Auge

In Vivo 3-Dimensional Corneal Epithelial Thickness Mapping as an Indicator of Dry Eye: Preliminary Clinical Assessment

ANASTASIOS JOHN KANELLOPOULOS AND GEORGE ASIMELLIS

• PURPOSE: To evaluate in vivo epithelial thickness in dry eye by anterior segment optical coherence tomography.
• DESIGN: Observational, retrospective case-control study.
• METHODS: Two age-matched groups of female subjects, 70 eyes each, age ≈ 55 years, were studied in clinical practice setting: a control (unoperated, no ocular pathology) and a dry eye group (clinically confirmed dry eye, unoperated and no other ocular pathology). Corneal epithelium over the entire cornea was topographically imaged via a novel anterior segment optical coherence tomography (AS-OCT) system. Average, central, and instability with potential damage to the ocular surface. It is accompanied by increased osmolarity of the tear film and inflammation of the ocular surface.[1]

Dry eye is responsible for significant population morbidity and is a common clinical problem for eye clinicians. Besides the significant symptoms and toll on quality of life, it may present significant challenges in refractive surgery patient assessment.[2] As reported in the peer-review literature,[3–7] its manifestations may range from episodic and mild condition to chronic and severe disease: the disorder can be presented with any or many symptoms of visual

OCT and dry eye syndrome

Adil El Maftouhi[1,2], Christophe Baudouin[2]

Dry eye syndrome is a multifactorial pathology involving tears and the ocular surface, which can cause lesions of the conjunctival and corneal epithelium. Previous studies have indicated several factors responsible for the proliferation and the differentiation of the conjunctival epithelium. However, little is known about the proliferation and other changes that may occur in the corneal epithelium. This study describes the correlation between morphological changes of the corneal epithelium and the different degrees of dry eye syndrome and effectiveness of optical coherence tomography (OCT) in ocular surface evaluation.

Continuous regeneration of the ocular epithelial cells is necessary to ensure their normal cellular function. Several factors are involved in the safeguarding of epithelial function, including tear film production, neuronal innervation and reflex blinking which mediate the maintenance of a favorable environment. Recent advances in spectral domain OCT imaging allow a high axial resolution of the anterior segment, and a rapid, precise, non-invasive imaging of the cornea. Pachymetric epithelial mapping thus enables the display of all of the different interfaces, in particular those of the corneal epithelium. Evaluation of the corneal epithelium including the tear film using OCT allows accurate representation of the status of the ocular surface.

The mechanistic pathways involved in the remodeling of the corneal epithelium and those responsible for the compensatory ability of the cornea necessary for the maintenance of a biomechanical balance are well characterized and play important roles in ensuring high optical quality.

Normal epithelial thickness using OCT

Reinstein et al. first reported the analysis of the corneal epithelium using corneal epithelial mapping over the entire corneal surface using the very-high frequency ultrasound equipment known as Artemis [1]. Their study reported that the average corneal epithelial thickness, excluding tear-film thickness (approximately 4.79 ±0.88 µm), was 53.4±4.6 µm in normal subjects, with greater thickness of the corneal epithelium in the lower part versus the upper part in normal corneas, possibly because of the friction generated by the blinking motion of the eyelids (Figure 1). A more pronounced movement of the upper eyelid causes greater friction on the ocular surface and results in mechanical stress on the epithelial cells, thus causing thinning of the epithelium. Recent advances in OCT, particularly in terms of axial resolution, have enabled the isolation of the corneal epithelial layer using segmentation tools capable of automatically detecting the tear film and the interface between the epithelium and Bowman's layer.

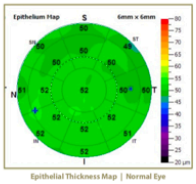

Figure 1. Epithelial mapping in a patient with a normal ocular surface. The corneal epithelium is slightly thinner in the upper regions than in the lower regions, and thicker in the nasal region than in the temporal region.

1. Centre Rabelais, Lyon 2. Centre hospitalier national d'ophtalmologie des Quinze-Vingts, Paris
oemdcentrerabelais@wanadoo.fr

Trockenes Auge Screening

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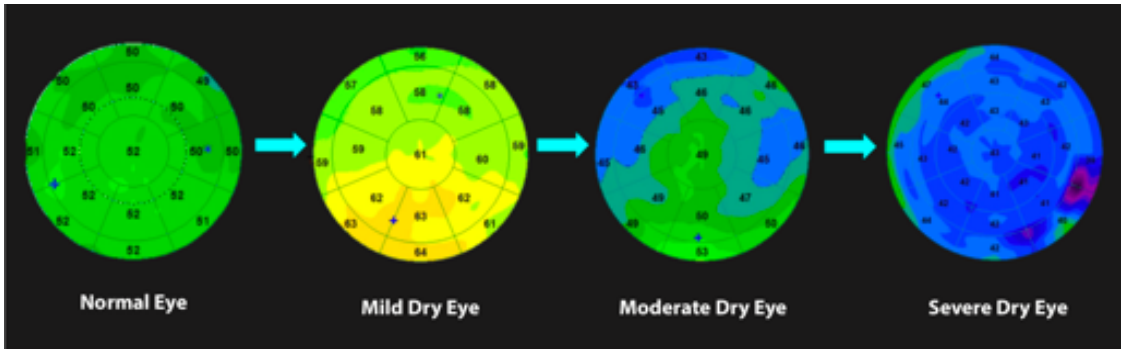

OCT and dry eye syndrome *Adil El Maftouhi, Christophe Baudouin*

Klinische Verwendung Ophthalmologie

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- Advanced Tools in der Ophthalmologie für:
  - Refraktive Eingriffe, PTK, Cataract OP, Keratokonus-Verlauf, Glaukom, Keratoplastik,...
  - Komplette AS Scans ca. 16x8mm
- Angle-to-Angle Scan
- Corneal Power Map
- Pachymetrie
- Vorderkammervermessung
- Kammerwinkel
- Augenlinsen Dicke
- AXL

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Asam J.S., Polzer M., Tafreshi A., Hirnschall N., Findl O. (2019) Anterior Segment OCT. In: Bille J. (eds) High Resolution Imaging in Microscopy and Ophthalmology. Springer, Cham. https://doi.org/10.1007/978-3-030-16638-0_13

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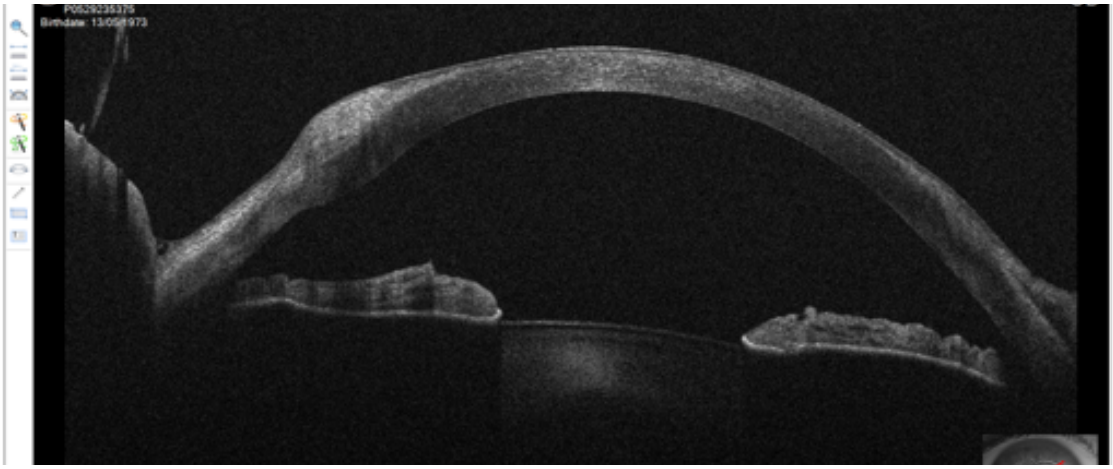

Bild: Elza Institute

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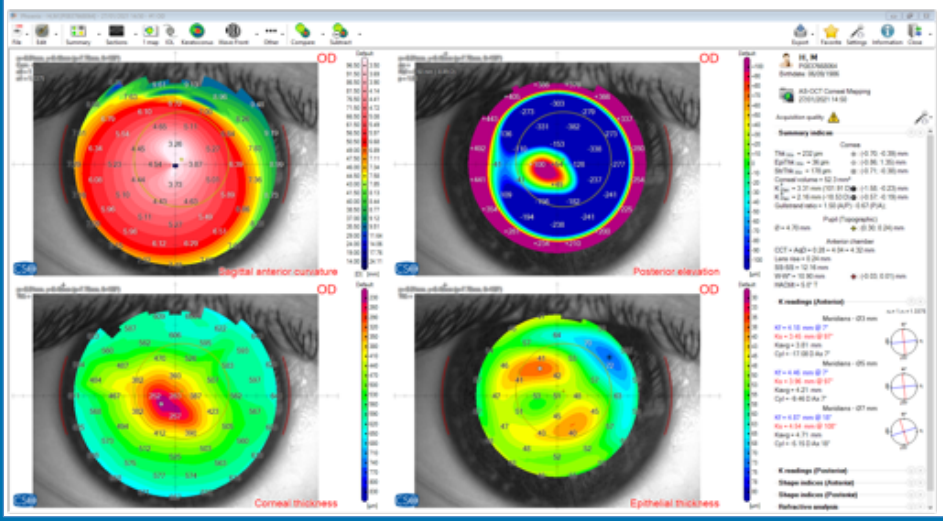

Bild: Elza Institute