

"Incorporating Technology into Today's Contact Lens Practice"

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International Keratoconus
Academy
Of Eye Care Professionals

General Notes Applicable to All Devices

- Universal metrics will be reviewed
- Comparing metrics of the same technology from different manufacturers is not directly comparable
 - Even within the same instrument may introduce error if not calibrated routinely or simply associated with “test/re-test” variability
- Scan quality matters
 - “Garbage in, garbage out”

Corneal Shape Analysis Systems

- **Corneal Topography** (Curvature Based)



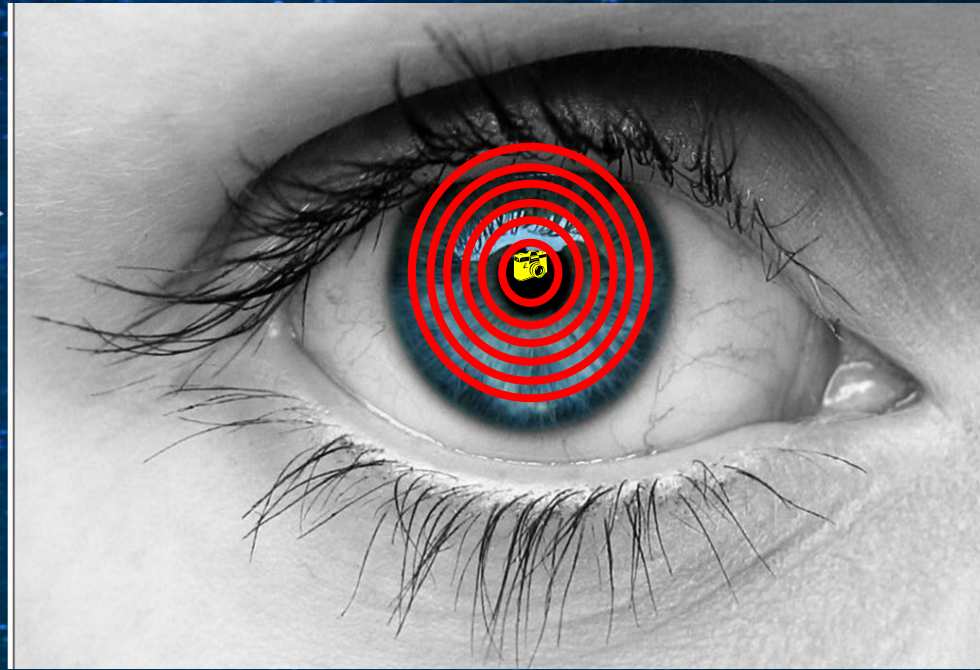
- **Corneal Tomography** (Elevation Based)



- **Anterior Segment Optical Coherence Tomography (ASOCT)**



Placido Topography Systems



Video keratometry

**Curvature based
corneal shape analysis**

Strengths of Placido Topography

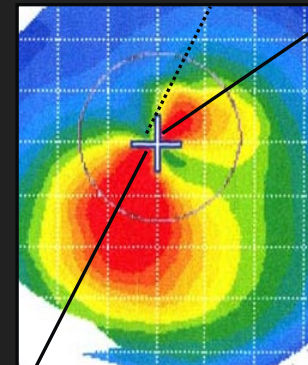
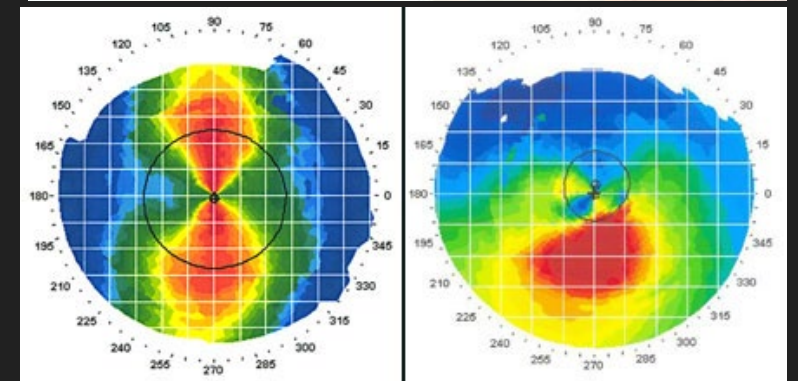
- Curvature (direct measure & most curvature sensitive)
 - Excellent optical performance indicator
- Cost (affordable options)
- Integration with other software (aberrometry, dry eye analysis, etc.)



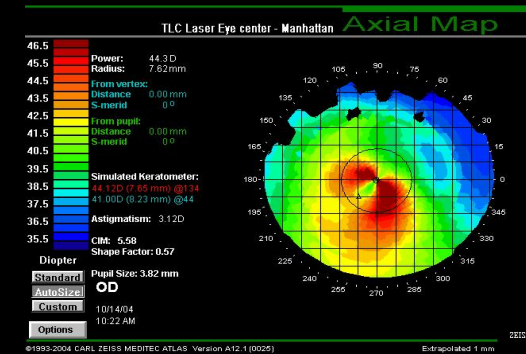
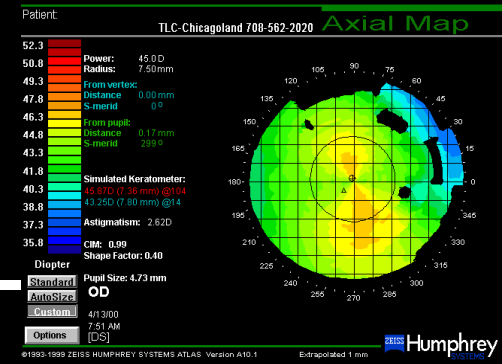
opportunities

Placido Based Corneal Topography

- **Anterior Corneal Surface Curvature**
- **Placido Ring Reflection**
 - Affected by tear film quality - important to view ring image to assess artifacts
 - Mires: Smooth = normal, Broken = tear film
- **Curvature with derived elevation**
- **Symmetry most important**
- Axial = smoothed, Tangential = exact
- **Values of interest**
 - **K >47D**
 - **I-S >1.4D** = top to bottom symmetry
 - **Skew >20 degrees** with >1.5D of Kcyl = axis symmetry



Normal Distribution of Axial Topography Patterns

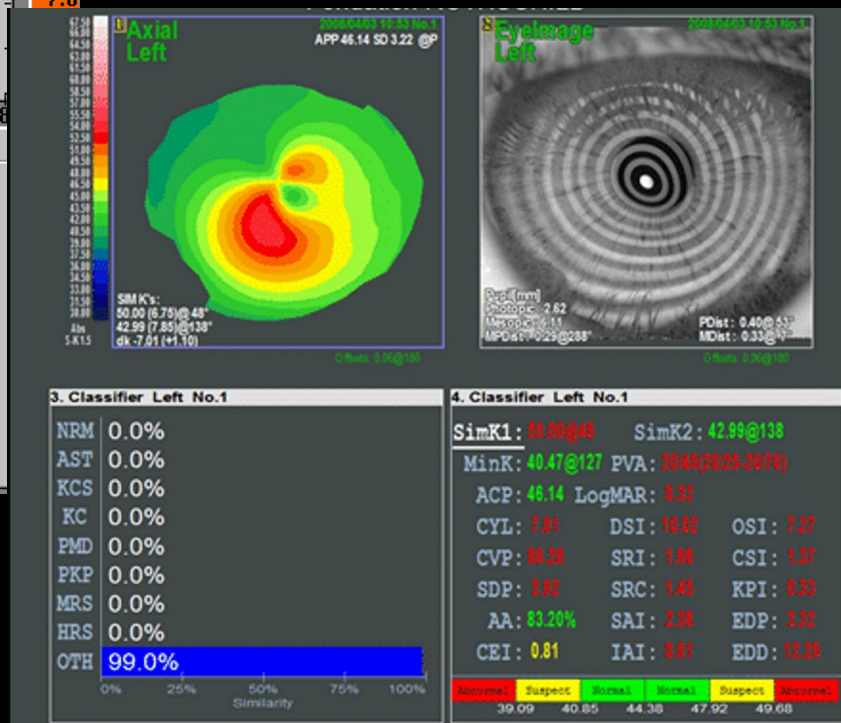
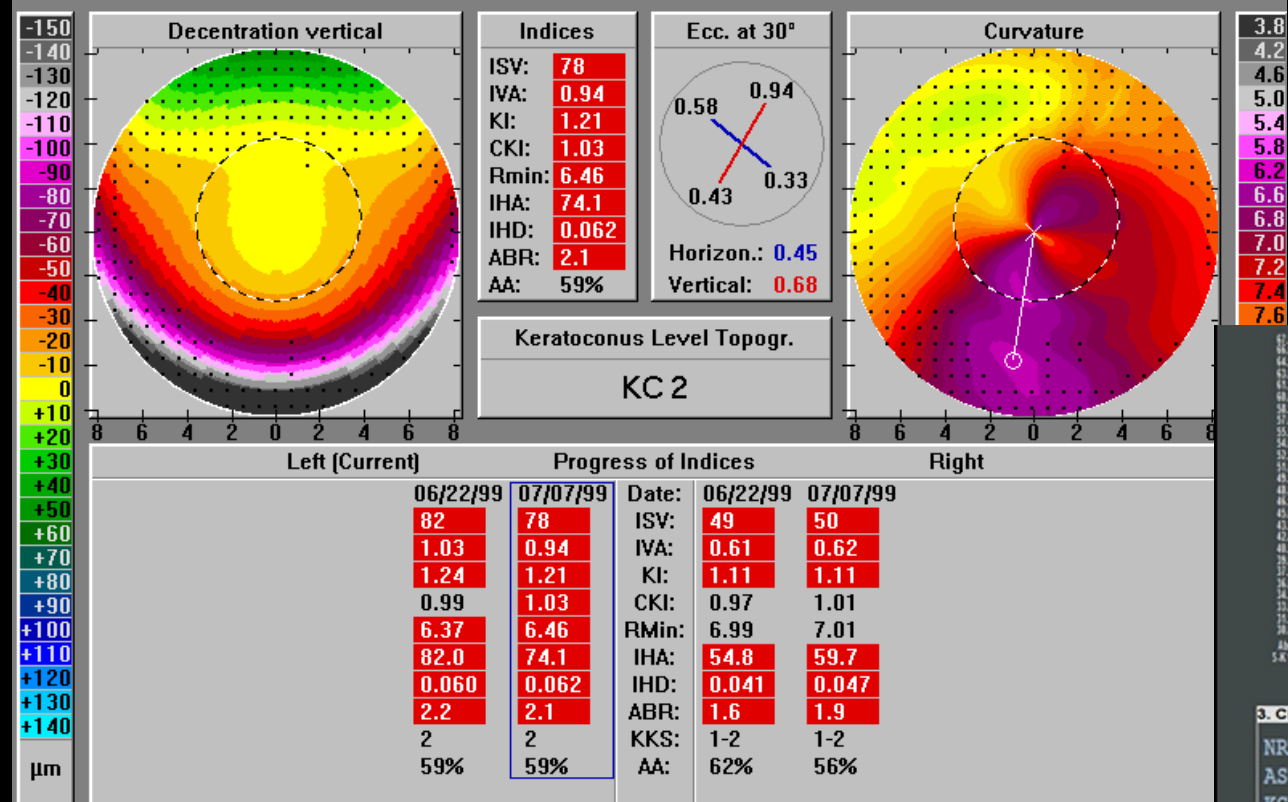


- **Round** [®] = 25.1%
- **Oval (O)** = 20.8%
- **Symmetric Bowtie (SB)** = 20.3%
- **Superior Steep (SS)** = 4.1%
- **Asymmetric Bowtie Superior Steep (AB/SS)** = 2.3%
- **Irregular (I)** = 5.9%
- **Inferior Steep (IS)** = 12.1%
- **Asymmetric Bowtie Inferior Steep (AB/IS)** = 7.4%
- **Symmetric Bowtie – SRAX (SB/SRAX)** = 1.5%
- **Asymmetric Bowtie – SRAX (AB/SRAX)** = 0.5%

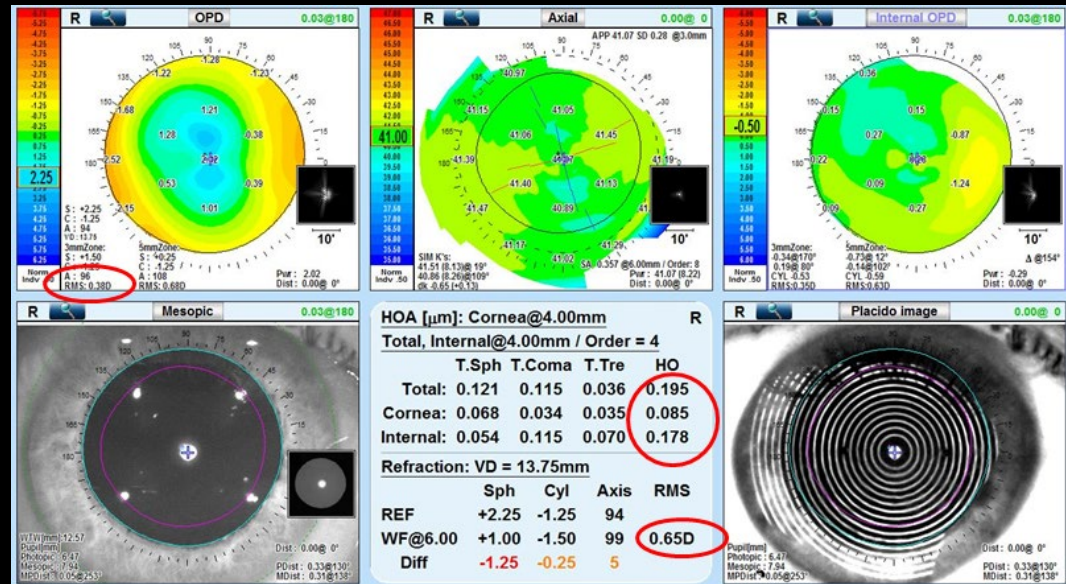
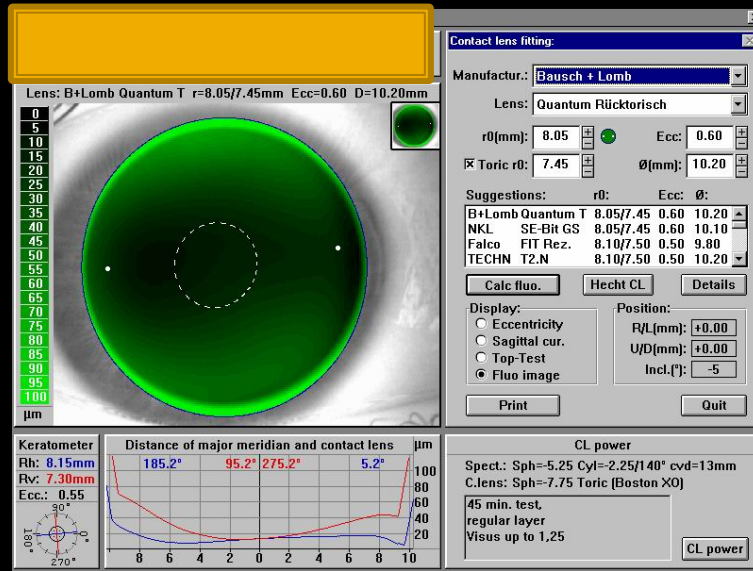
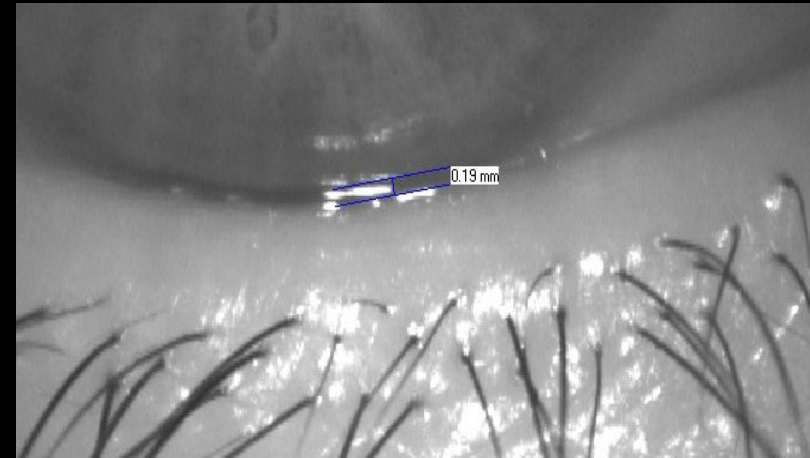
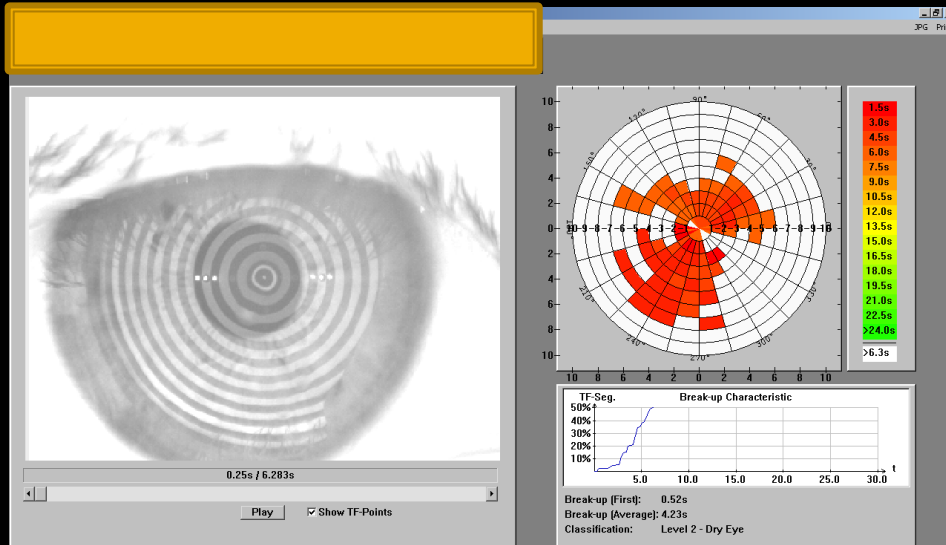
Corneal "Indices"

Automatic classification of the stage of a keratoconus (Amsler & Muckenhirn stages)

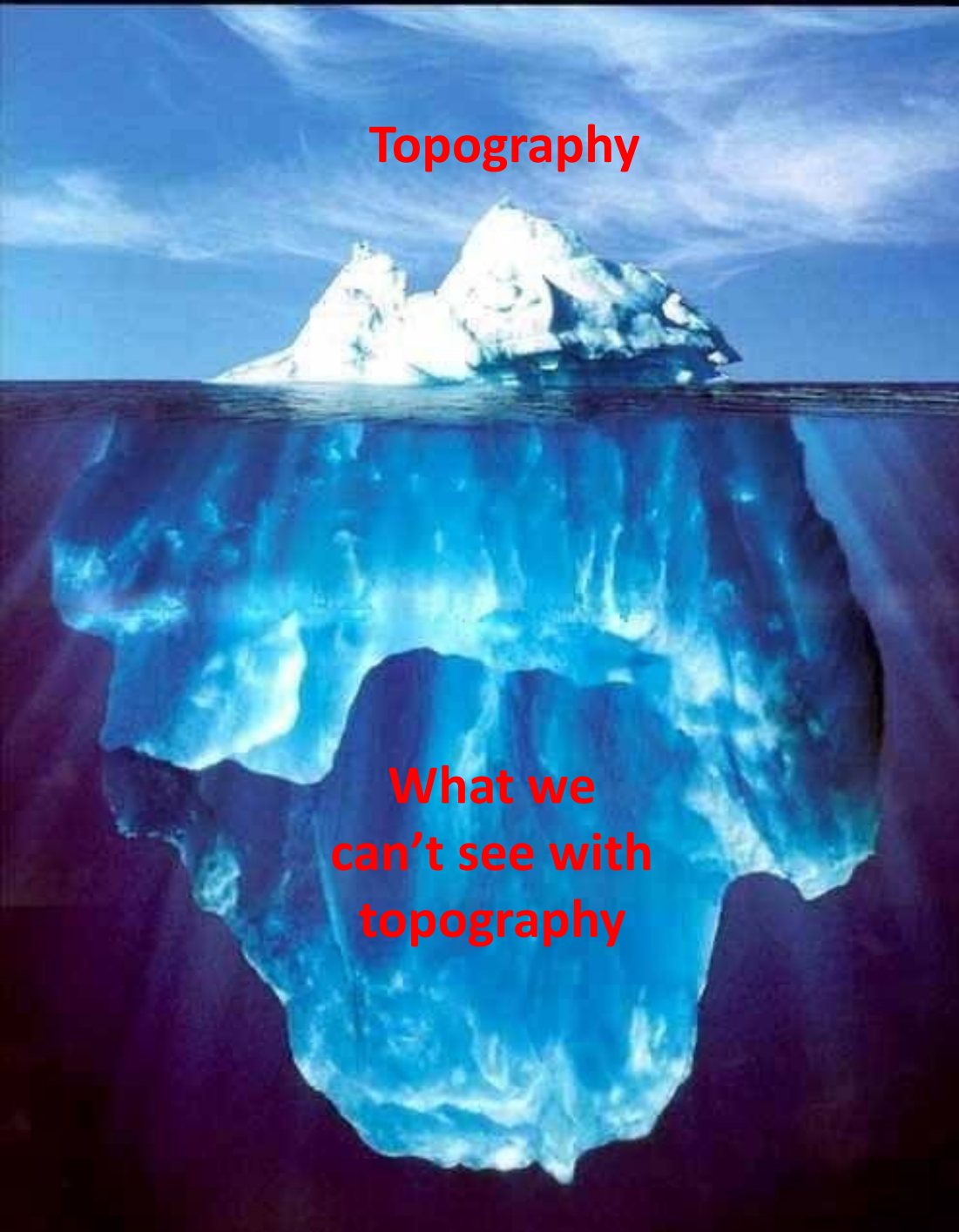
Comparison of the progress of the indices



Integration of Placido topography systems with other diagnostic technologies



Placido Corneal Topography Limitations



- **No** analysis of posterior corneal surface
- **No** representation of corneal thickness
- + There are other issues...
(false + and false -)

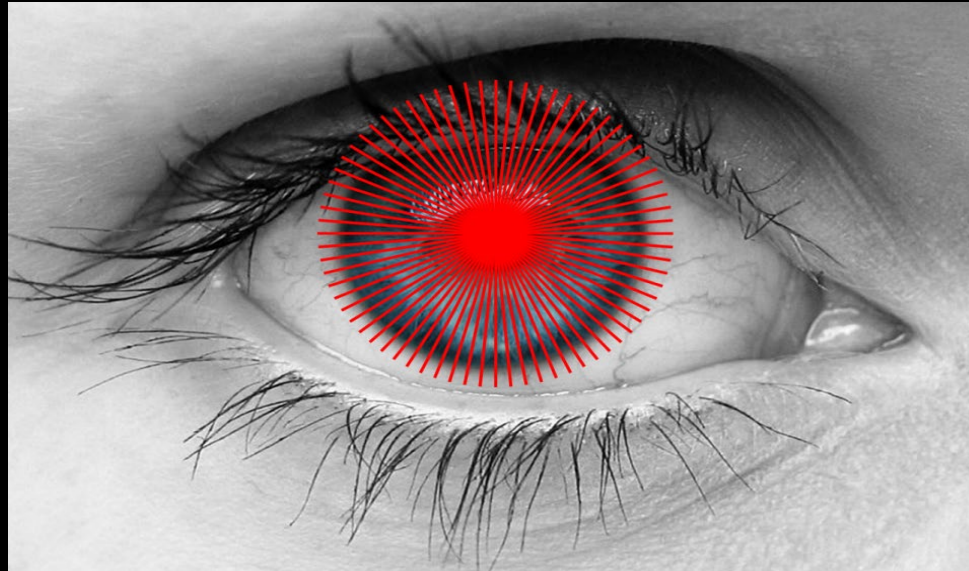
Corneal/Anterior Segment Tomography

Scheimpflug / ASOCT

- **Cross-sectional imaging and reconstruction 2-D to 3-D**
 - Global corneal analysis
- Assess **anterior, posterior corneal shape and global corneal thickness**
 - Multiple derived values
- - Two main imaging technologies
 - **Scheimpflug**
 - **OCT**
- **True Elevation with calculated curvature**
- **Elevation maps: Measures at Thin Point Values of Interest:**
 - Anterior curvature values: same metrics as previous
 - Anterior elevations $>15\mu\text{m}$
 - Posterior elevations $>20\mu\text{m}$
 - Corneal thickness $<500\mu\text{m}$ (thickness “distribution” is impt. In disease dx)
 - Epithelial thickness difference $>10\mu\text{m}$ with donut pattern



Elevation Based "Scheimpflug" Anterior Segment Tomography



Eg. PENTACAM (Oculus) / GALILEI (Ziemer)

Utilizes **Scheimpflug Imaging**

To Achieve **True Elevation Measures**

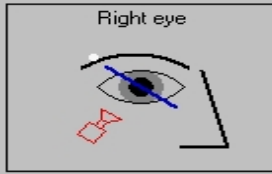


Scheimpflug Imaging Principle



Scheimpflug imaging provides extended depth of focus



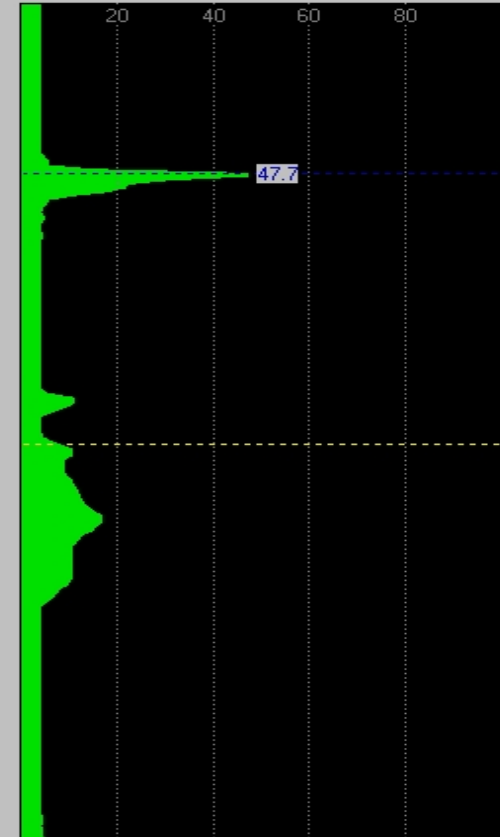


14/25	Segment: 141° - 321°	
15/25	Segment: 148° - 328°	
16/25	Segment: 155° - 335°	
17/25	Segment: 163° - 343°	
18/25	Segment: 170° - 350°	
19/25	Segment: 177° - 357°	

Zoom +
1:1
Zoom -

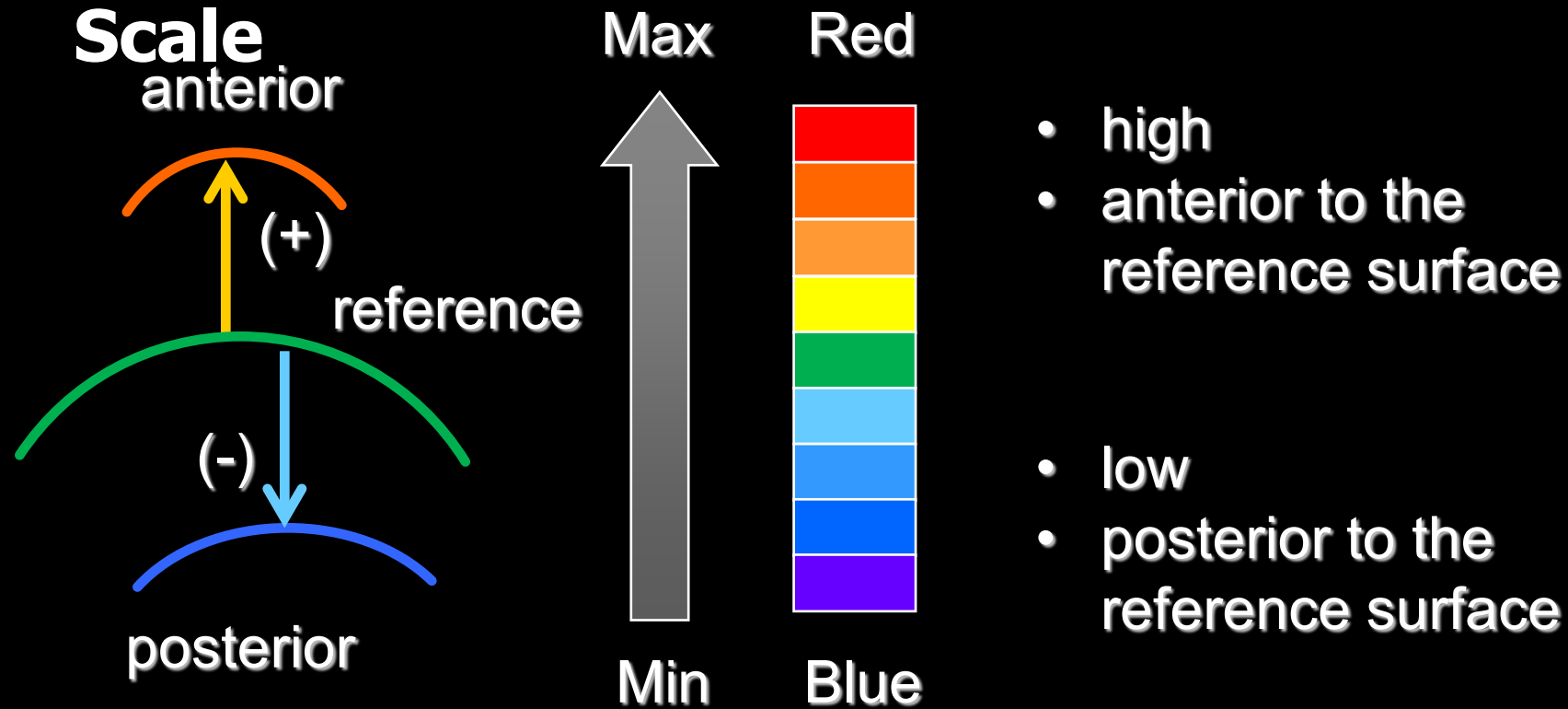
Contrast Normal
Adjust Image

ostenbergerger, Andreas
/02/1957 Right
Exam: 06/29/2009 10:13:23



Scheimpflug Image: keratoconus w/scar

Corneal Elevation Maps : Color

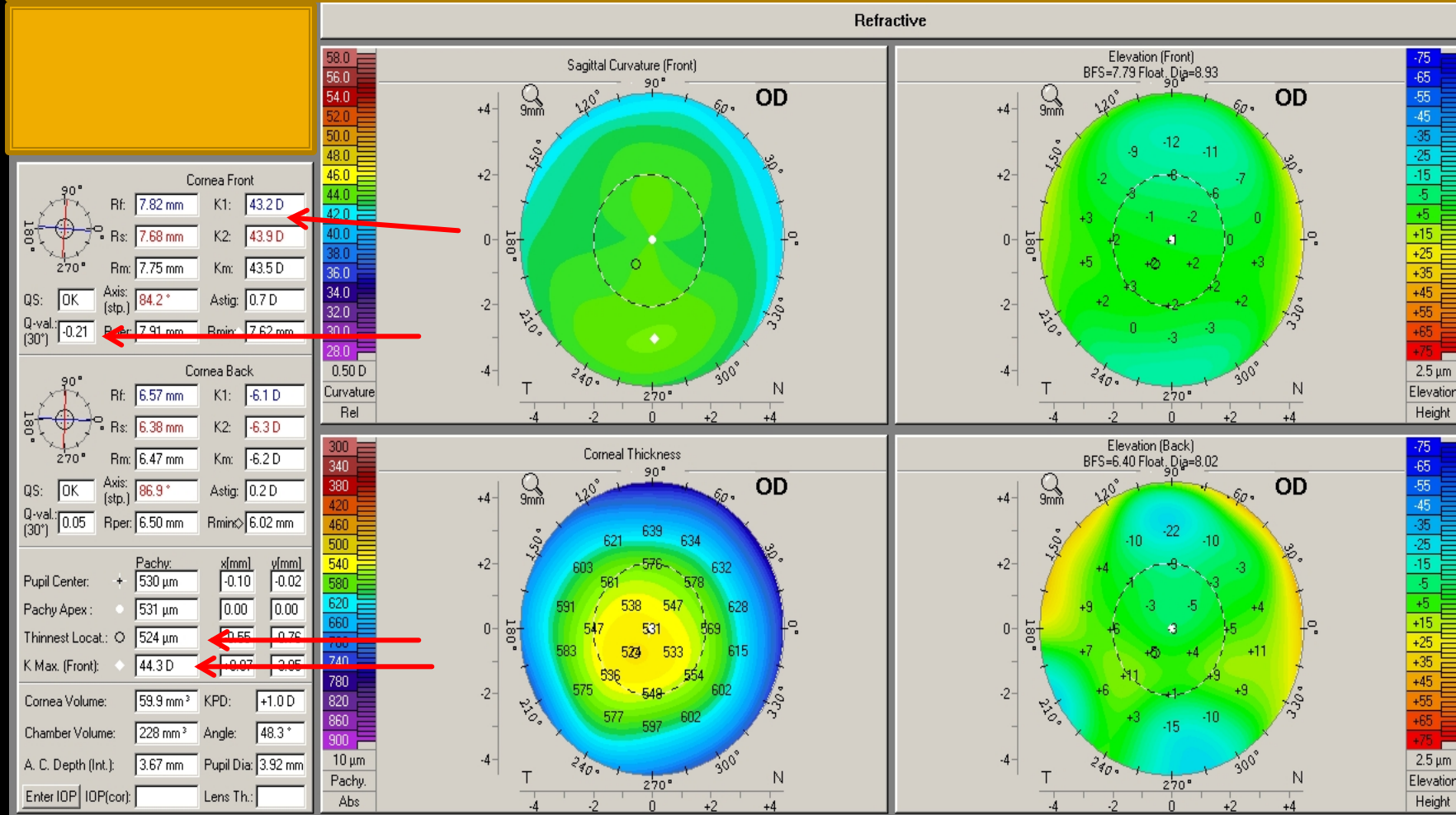


- Relative elevation measures height difference in microns from a best-fitting reference body
- In all elevation maps, **green** is the reference surface or zero level
- **Red** is high and positive, **Blue** is low and negative



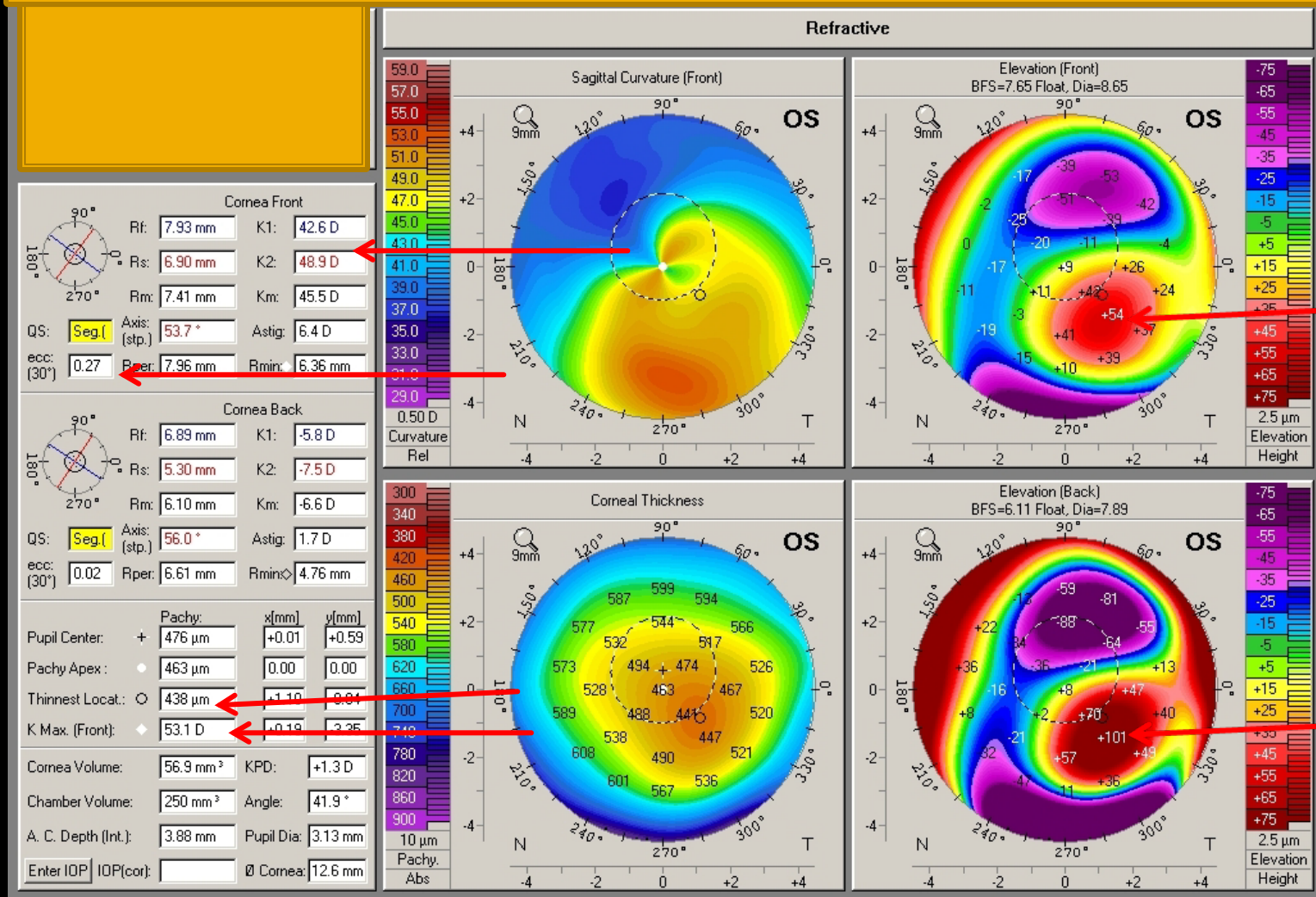
4-maps refractive

Normal



4-maps refractive

Keratoconus

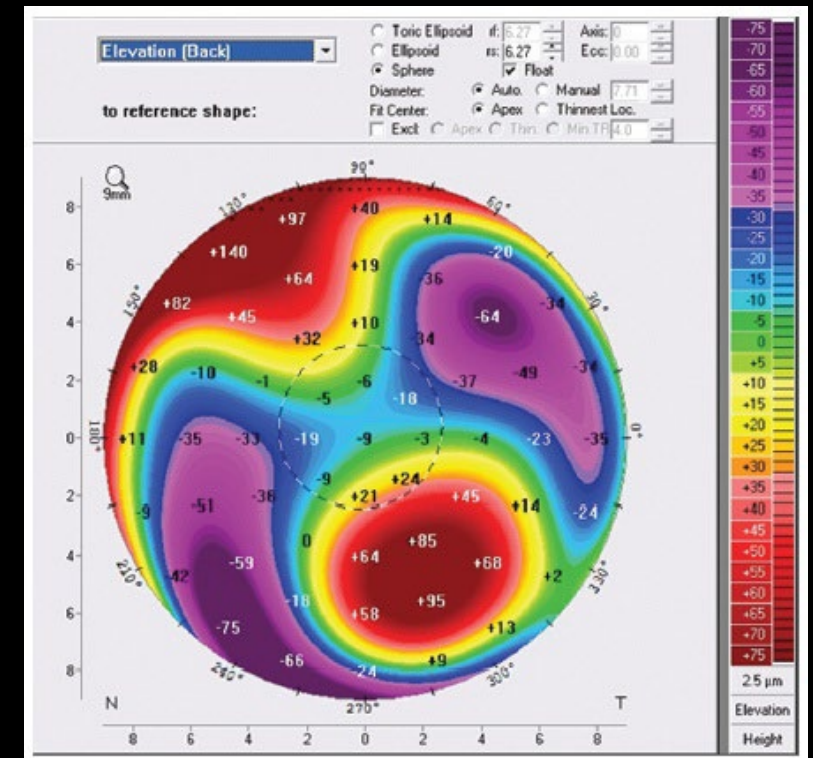


Posterior Corneal Elevation Abnormalities

MUST be present to diagnose mild or sub-clinical keratoconus

- Consensus on Tests to Diagnose Early or Sub-Clinical Keratoconus:

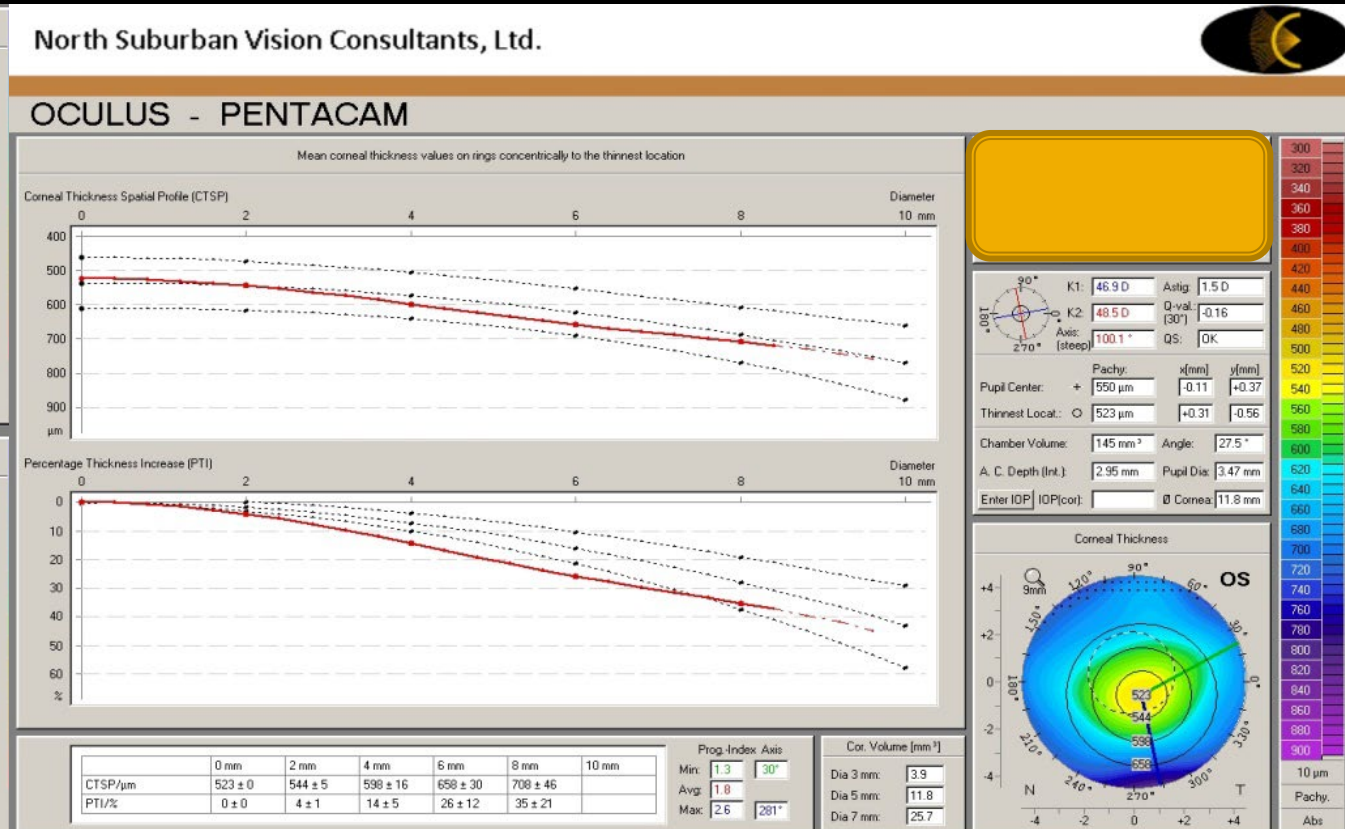
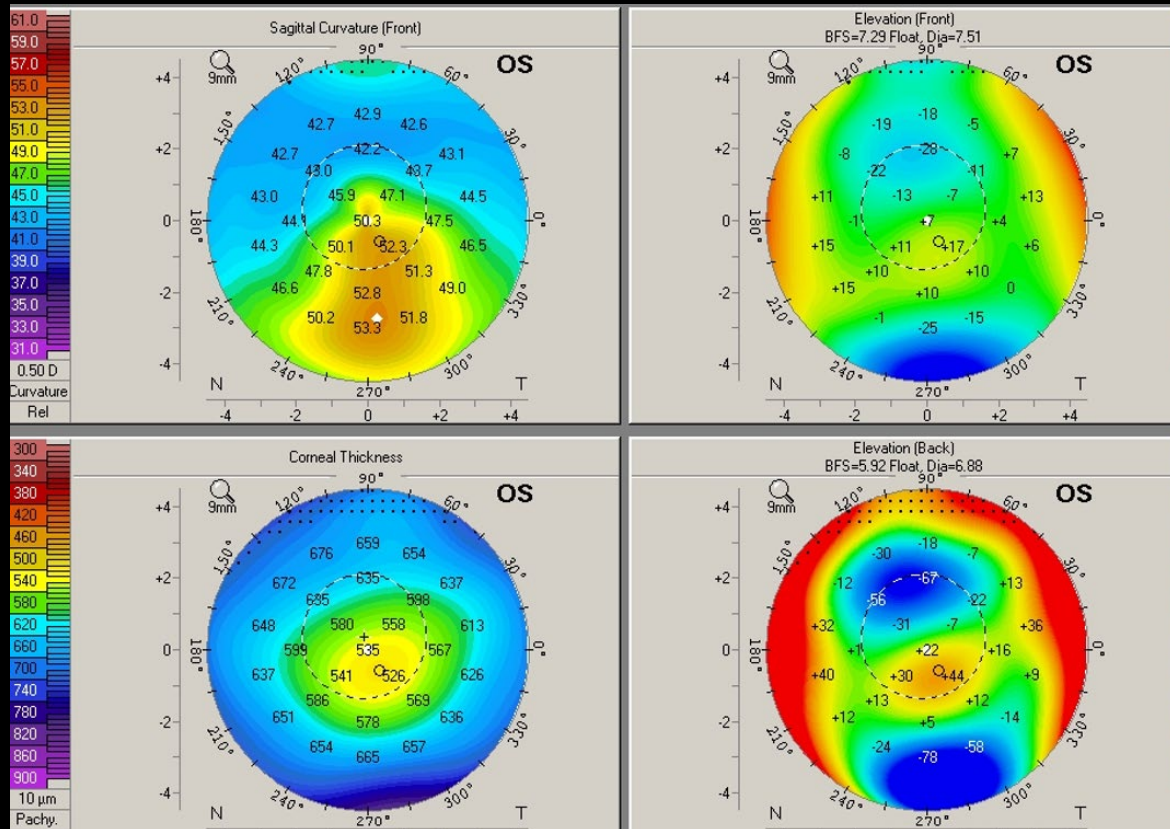
Corneal Tomography (Scheimpflug or AS-OCT)



Central Corneal Pachymetry

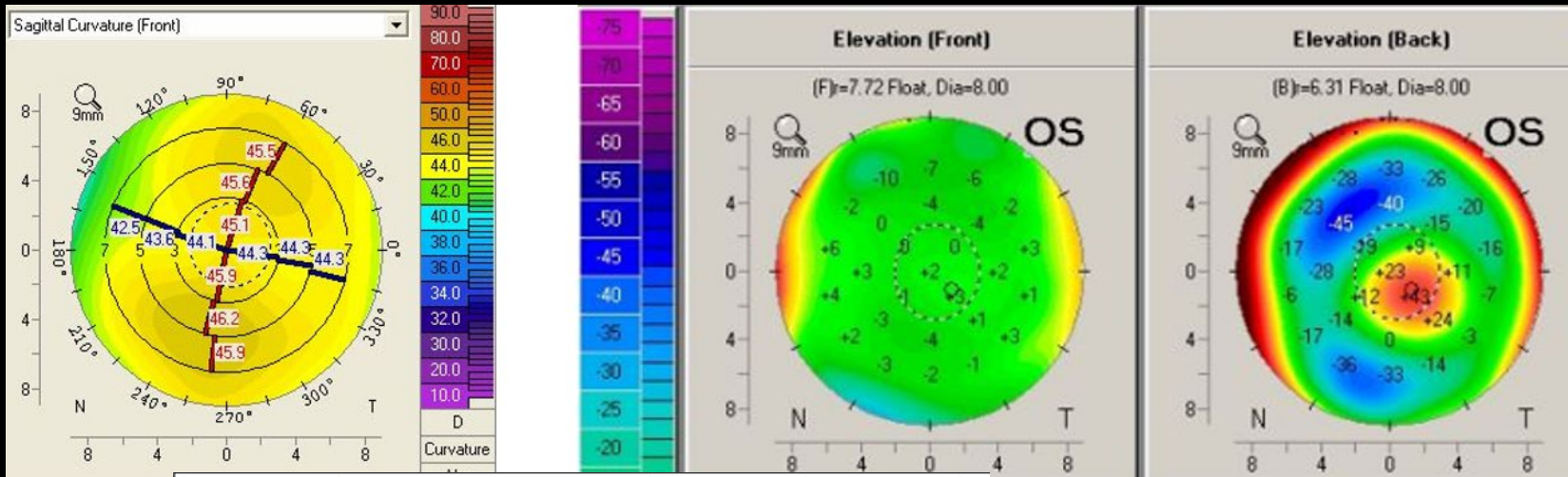
Least Reliable Indicator or Determinant of KC

This is because Keratoconus can be present in a cornea of normal thickness...

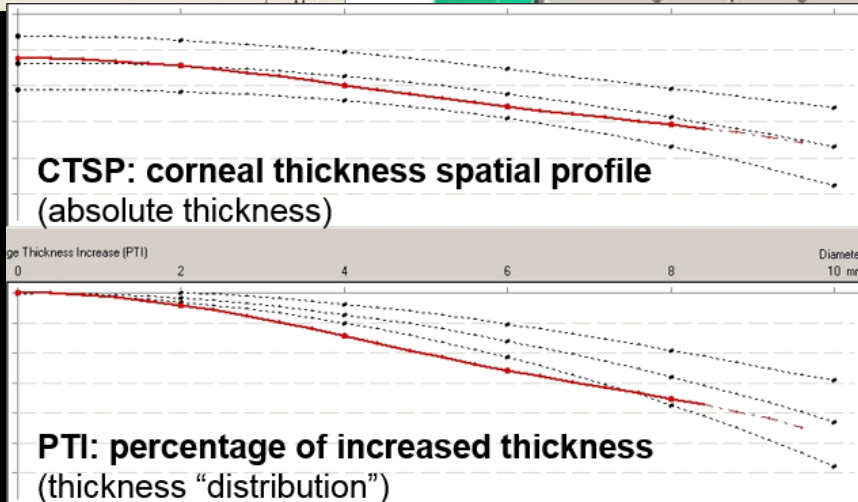
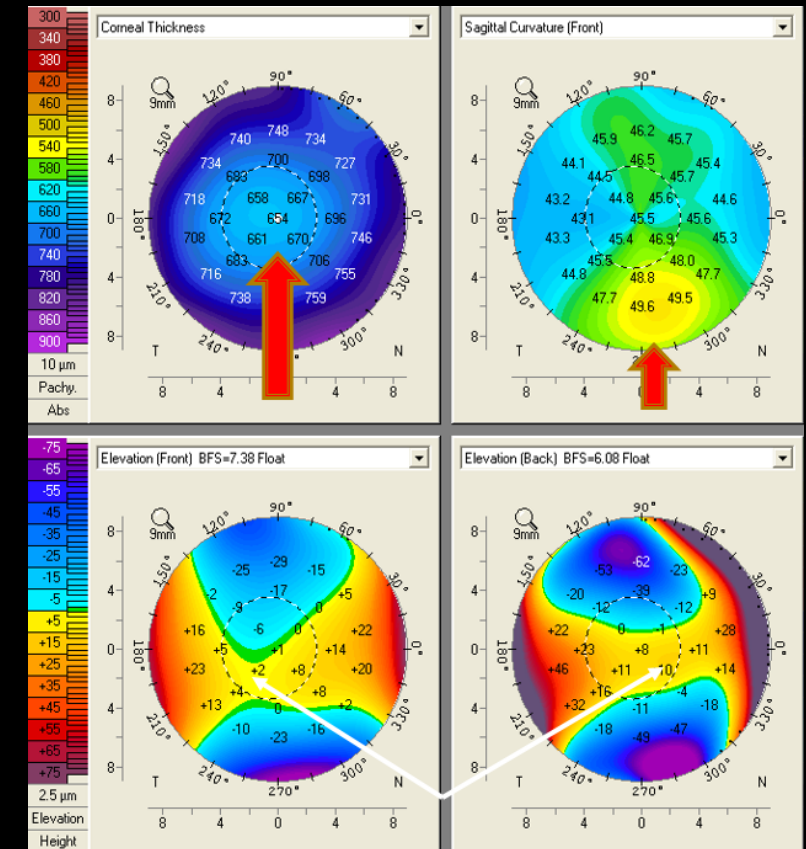


Changes to posterior cornea and corneal thickness occur prior to changes that impact vision

False Negative on Placido Topography

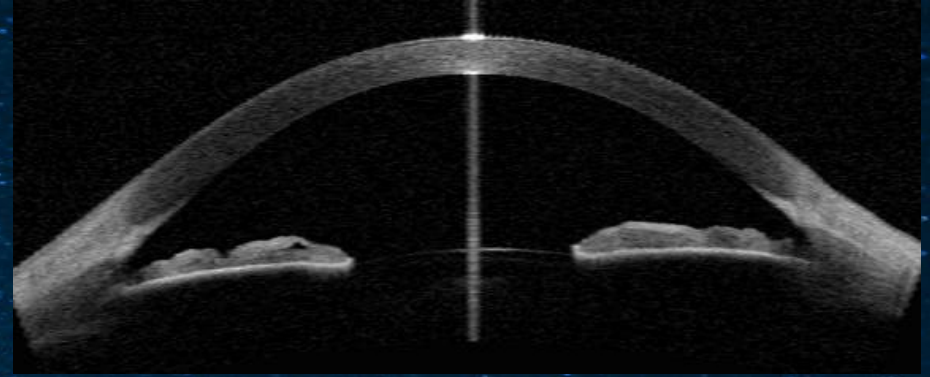


False Positive on Placido Topography



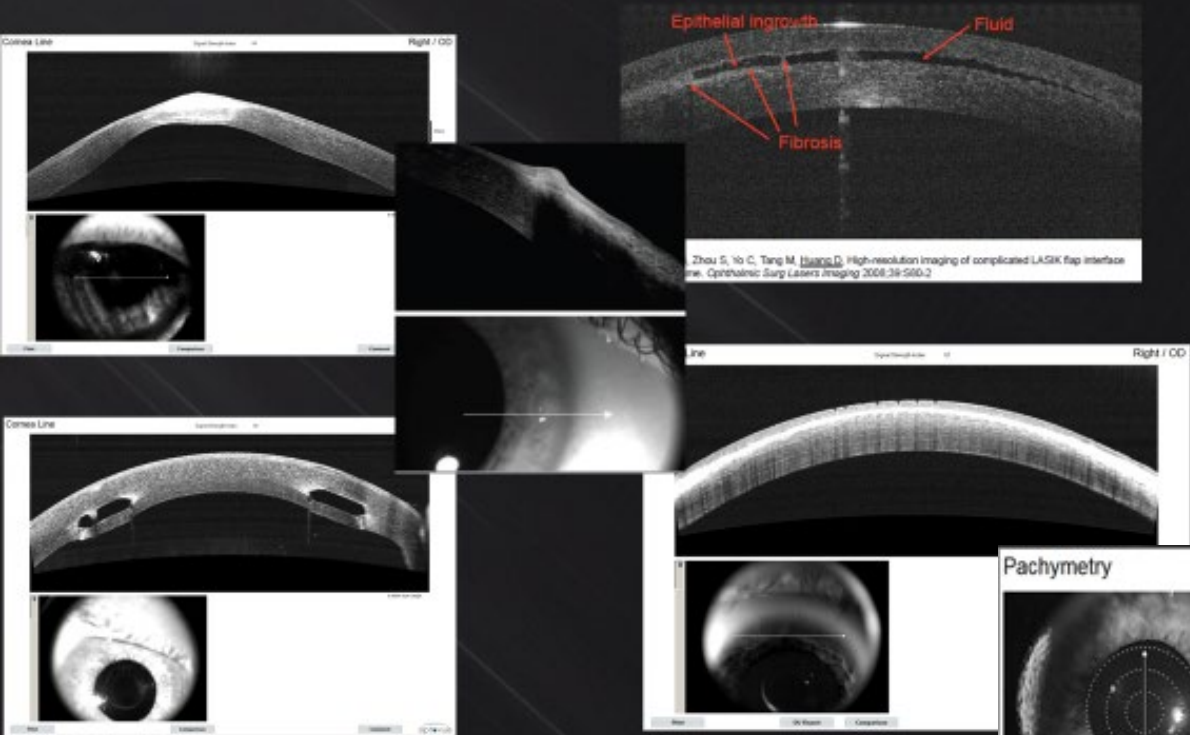
Normal absolute thickness
But,
Abnormal thickness
"Distribution"

Anterior Segment OCT



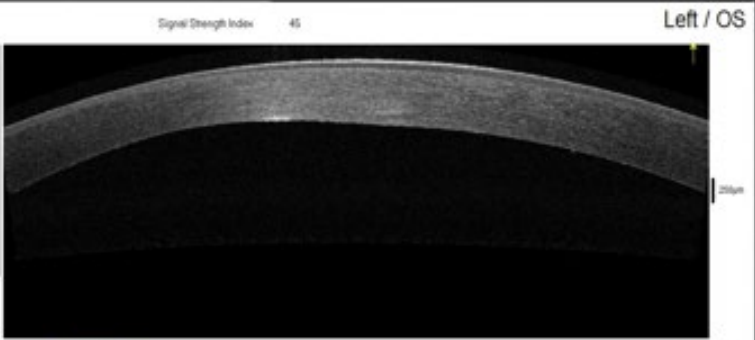
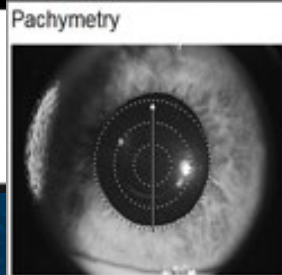
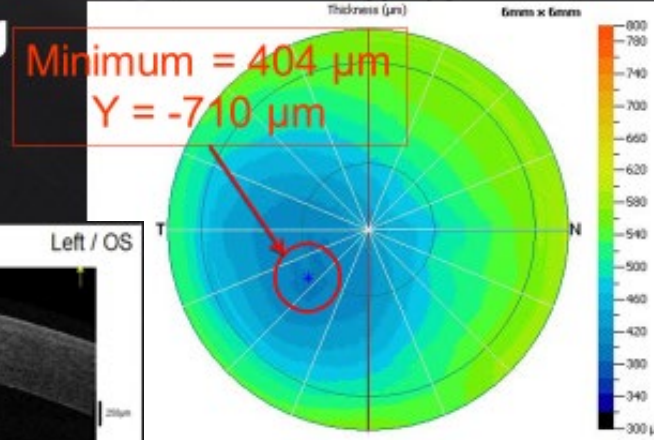
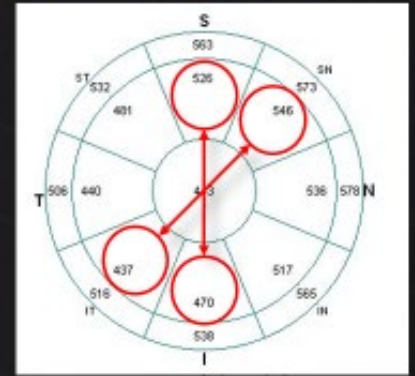
- **Corneal Imaging**
- **Global Pachymetry** – corneal disease dx & management
- **Epithelial Thickness** – keratoconus Dx and monitoring

ASOCT High Resolution Corneal Imaging



Detecting Keratoconic Thinning with OCT "Pachymetric Indices":

- **General thinning**
 - Median
- **Focal thinning**
 - Minimum - median (w/in 5mm zone)
- **Asymmetric thinning**
 - I-S
 - IT-SN
 - Y location of the Min



Pachymetry

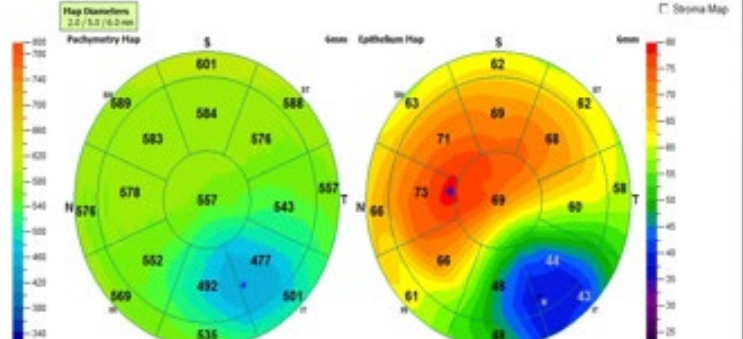
Layer	Offset	Thickness
SN (2.5mm)	136	5-62.5mm
Min	452	Location Y
Min-Median	197	Min-Max
Min-Max	137	

Min thickness at (335mm, -1.713mm) indicated as *

Epithelium statistics within central 5mm

S (2.5mm)	89	I (2.5mm)	89
Min	58	Max	79
Std Dev	10.8	Min-Max	40

Min/Max thickness indicated as *-



AS Imaging & Corneal Thickness (Global + ETM)

Corneo-Scleral Ocular Surface Mapping (Profilometry)

- How to Measure Corneo-Scleral Shape:

- Anterior Segment OCT

- Fluorescein based C-S topographic measurements

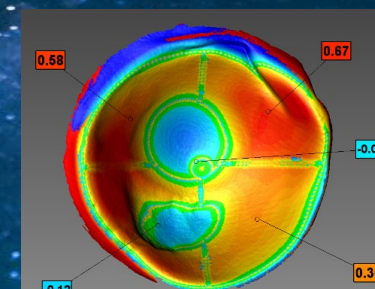
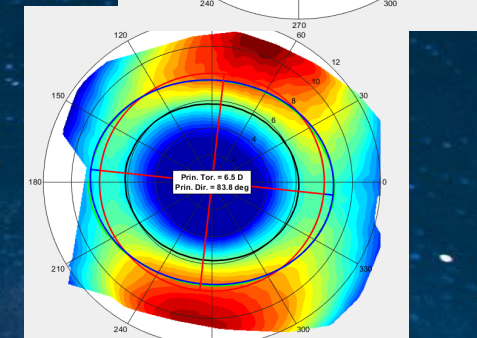
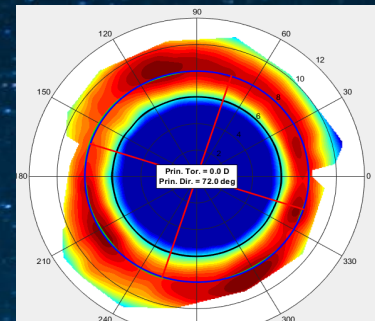
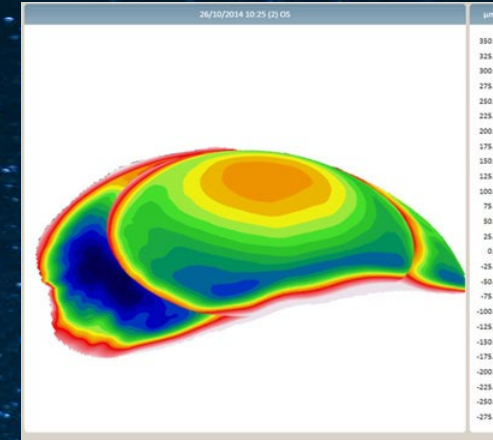
- S-Map 3D (Precision Ocular Metrology)
 - Eye Surface Profiler (Eaglet Eye)

- Scheimpflug Anterior Segment Tomography

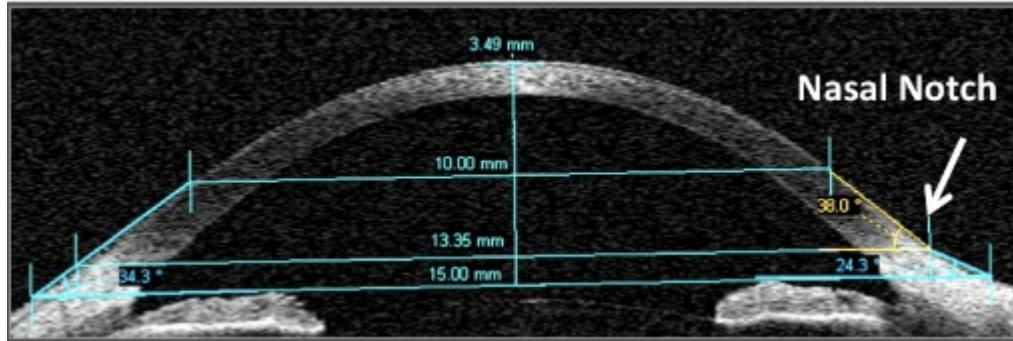
- Pentacam CSP (Oculus)

- Ocular Surface Impression

- EyePrint (EyePrint Prosthetics)



Anterior Segment OCT C-S Shape Measurement



Walker M, Caroline P. 2019 Soft Special Edition

[J Optom.](#) 2013 Jul; 6(3): 141–146.

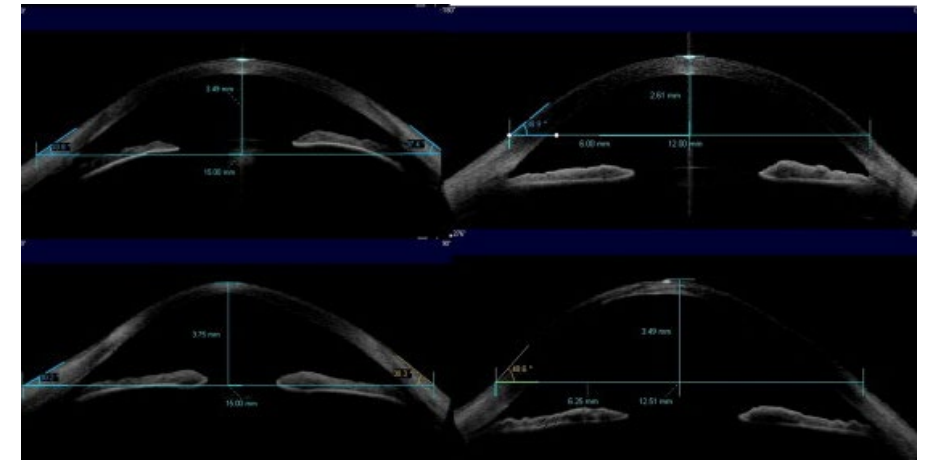
PMCID: PMC3880514

Published online 2013 Mar 14. doi: [10.1016/j.optom.2013.02.002](#)

Language: English | [Spanish](#)

Use of the Visante™ OCT to measure the sagittal depth and scleral shape of keratoconus compared to normal corneae: Pilot study

[Luigina Sorbara](#)^{a,□}, [Jyotsna Maram](#)^b and [Katrin Mueller](#)^c



[Eye Contact Lens.](#) 2008 Mar;34(2):80-3. doi: [10.1097/ICL.0b013e318166394d.](#)

A novel method of fitting scleral lenses using high resolution optical coherence tomography.

[Gemoules G](#)¹.

[Author information](#)

¹ Coppell Family Eyecare, 712 South Denton Tap Road Coppell, TX 75019, USA. greggem@verizon.net

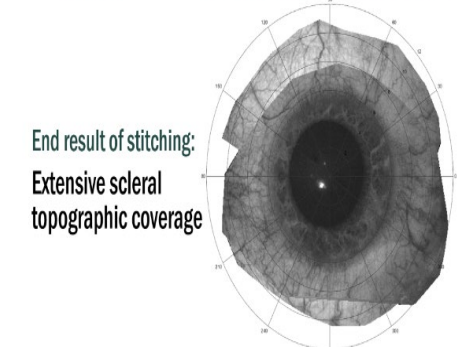
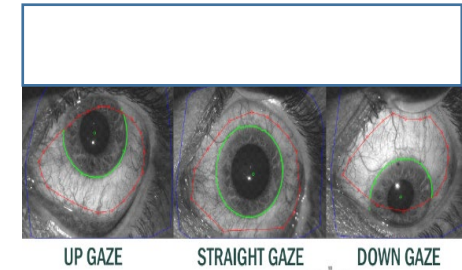
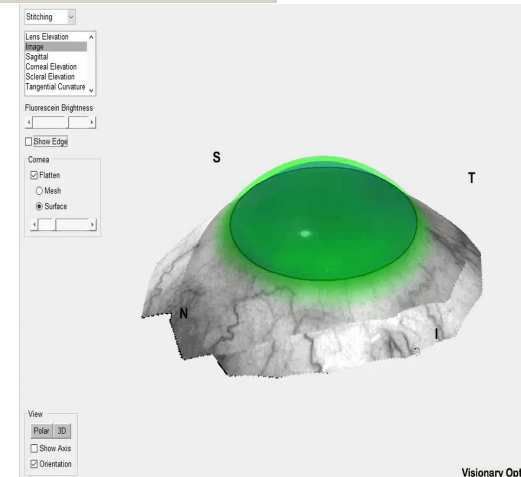
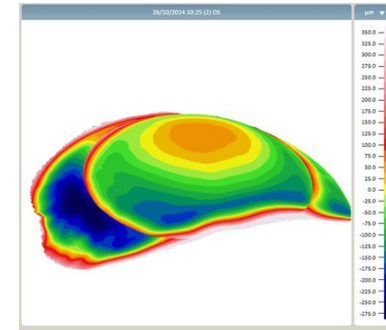
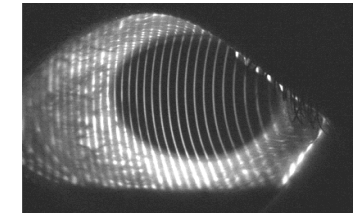
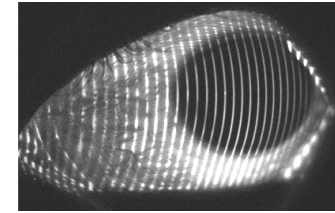
Fluorescein/Reflection based Corneo-Scleral Profilometry Systems



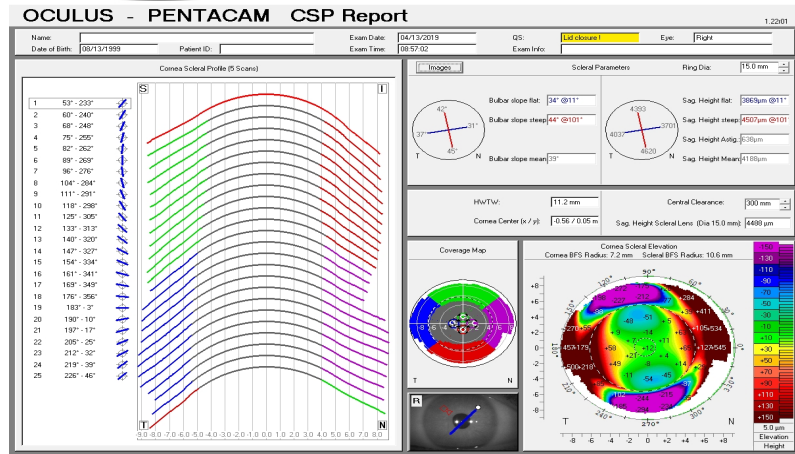
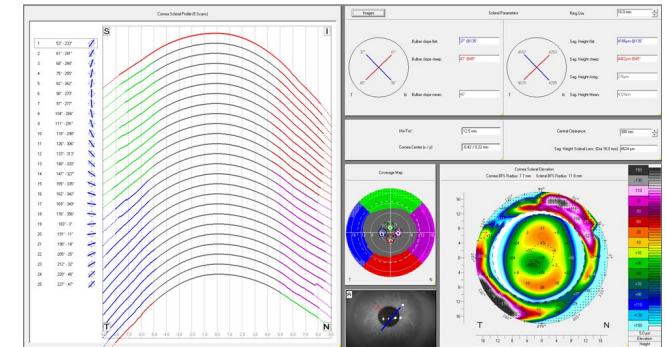
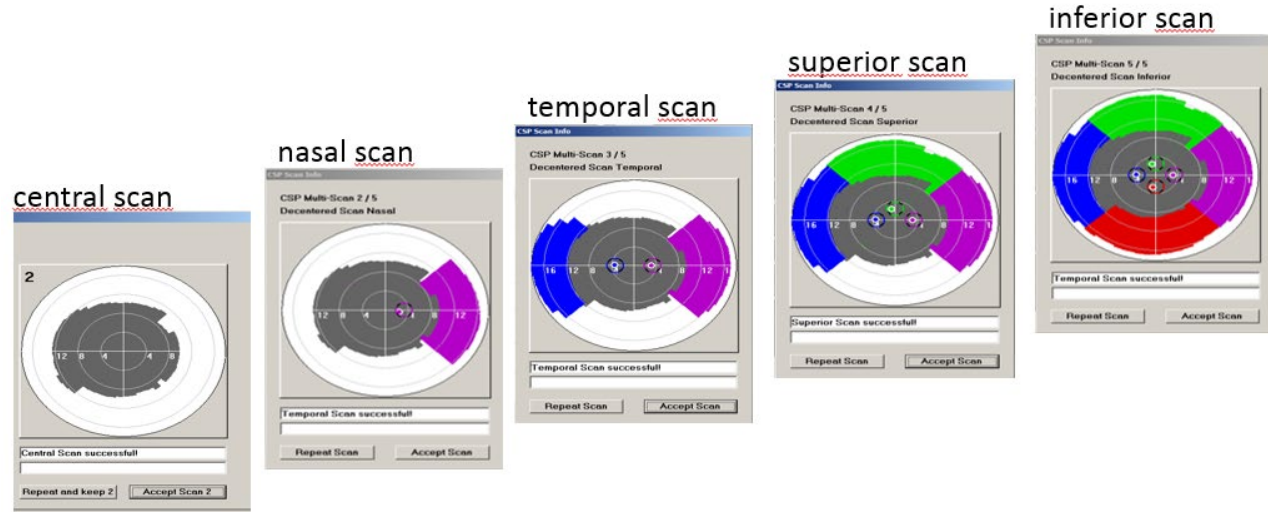
S-Map 3D



Eye Surface Profiler

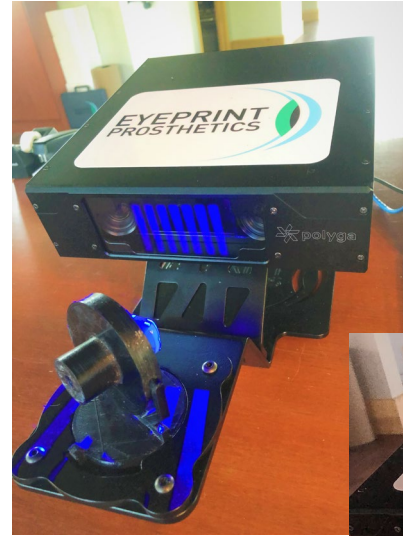
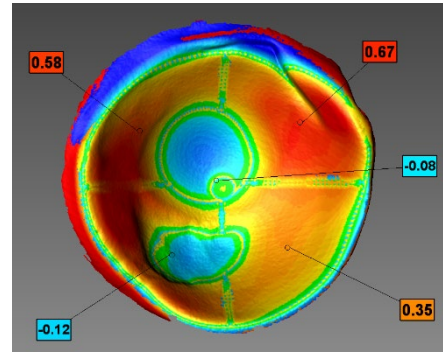
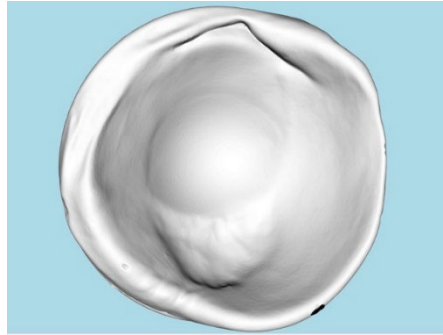


Scheimpflug Elevation Based AS-Tomography



Pentacam CSP Software

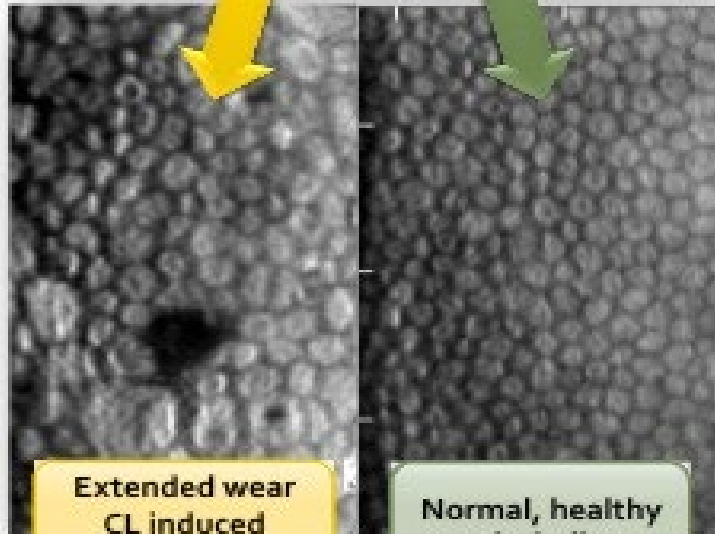
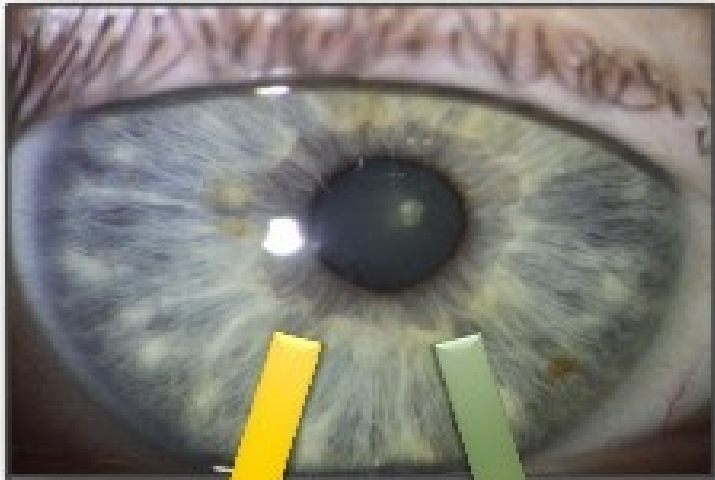
Ocular Surface Impression Technology



EyePrint Prosthetics

* Capable of up to 5 million data points scanned from an impression

Specular Microscopy



Extended wear
CL induced
polymegethism

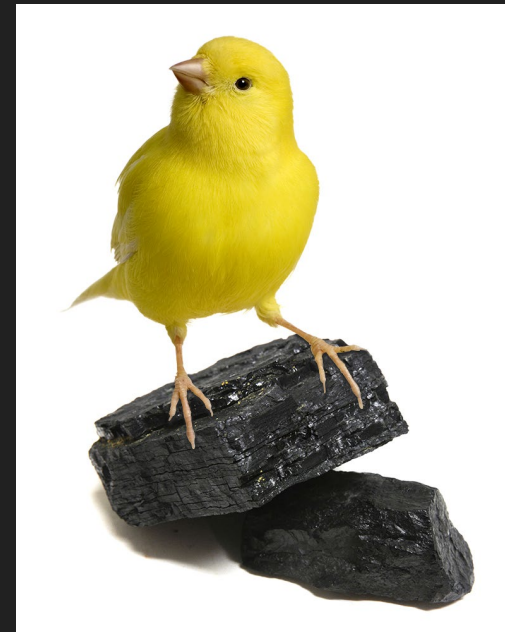
Normal, healthy
endothelium



Specular Microscopy

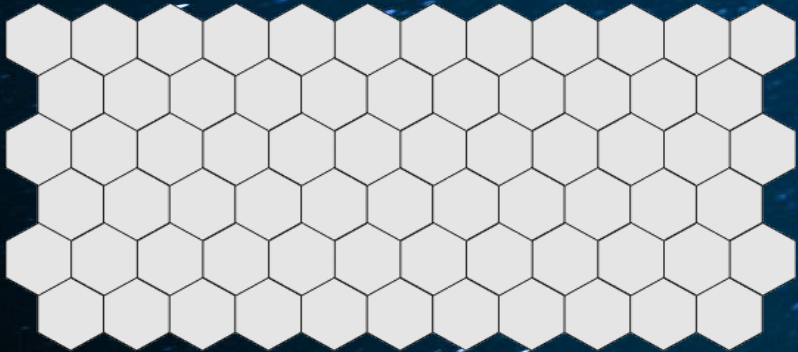
Corneal Endothelial Function:
to maintain corneal
thickness/transparency via “pump
action” and barrier property

- Objective analysis of endothelial cells
 - **Cell density = number of cells per square mm**
 - **Hexagonal cell %: pleomorphism = loss of 6 sided shape**
 - **Coefficient of variation: cell size variation**
- **Indications:** endothelial disease, edema, CL impact, pre & post surgical, trauma, etc.
- Direct visualization of endothelium
 - **Guttae / Fuch's**
- Symmetry is a key metric
- Cell Density does not necessarily equal function
- **Values of interest if:**
 - **CD <1000 cells**
 - **HEX <50%**
 - **CV >40%**
 - **Pachy values**

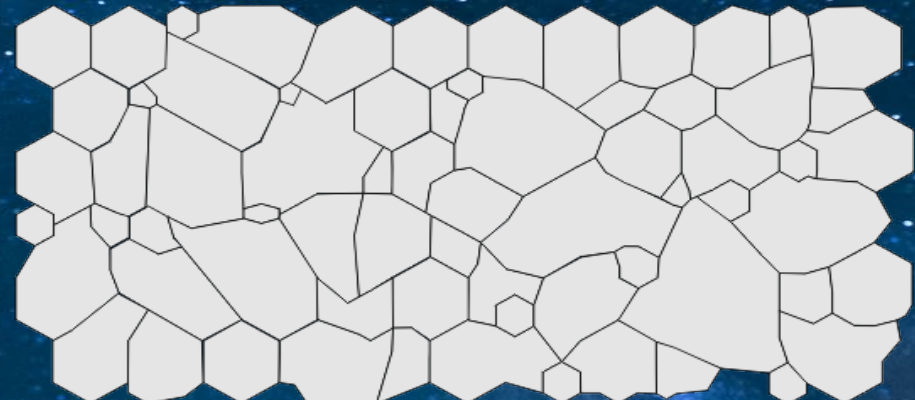


Cell Density Alone Cannot Determine Corneal Stability

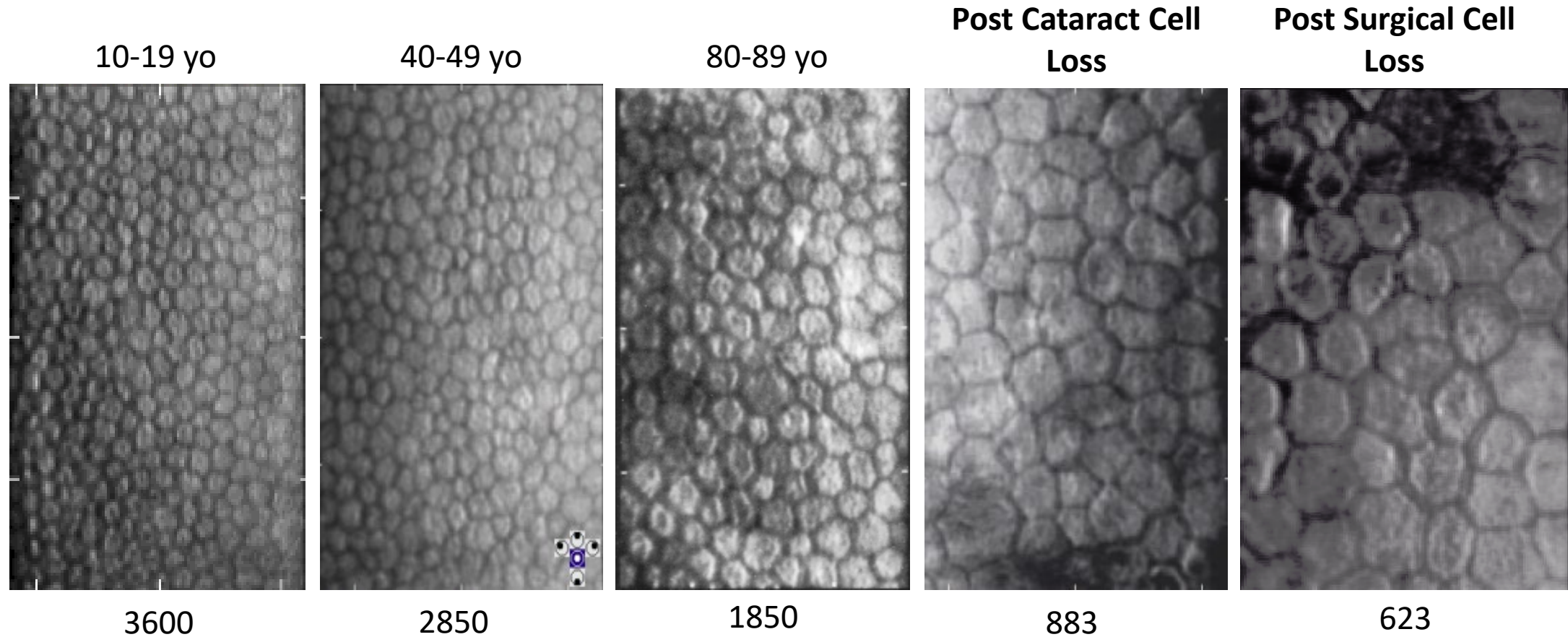
- Normal Cell Count
- 2,500 cells / mm²
- CV = 10
- Low variation in size
- HEX = 100%
- Highest strength and efficiency of endothelial cellular structure



- Normal Cell Count
- 2,500 cells / mm²
- CV = 79
- High variation in size = Polymegethism
- HEX = 25%
- High variability in shape = Pleomorphism



Natural Aging vs. Post-op Cell Loss

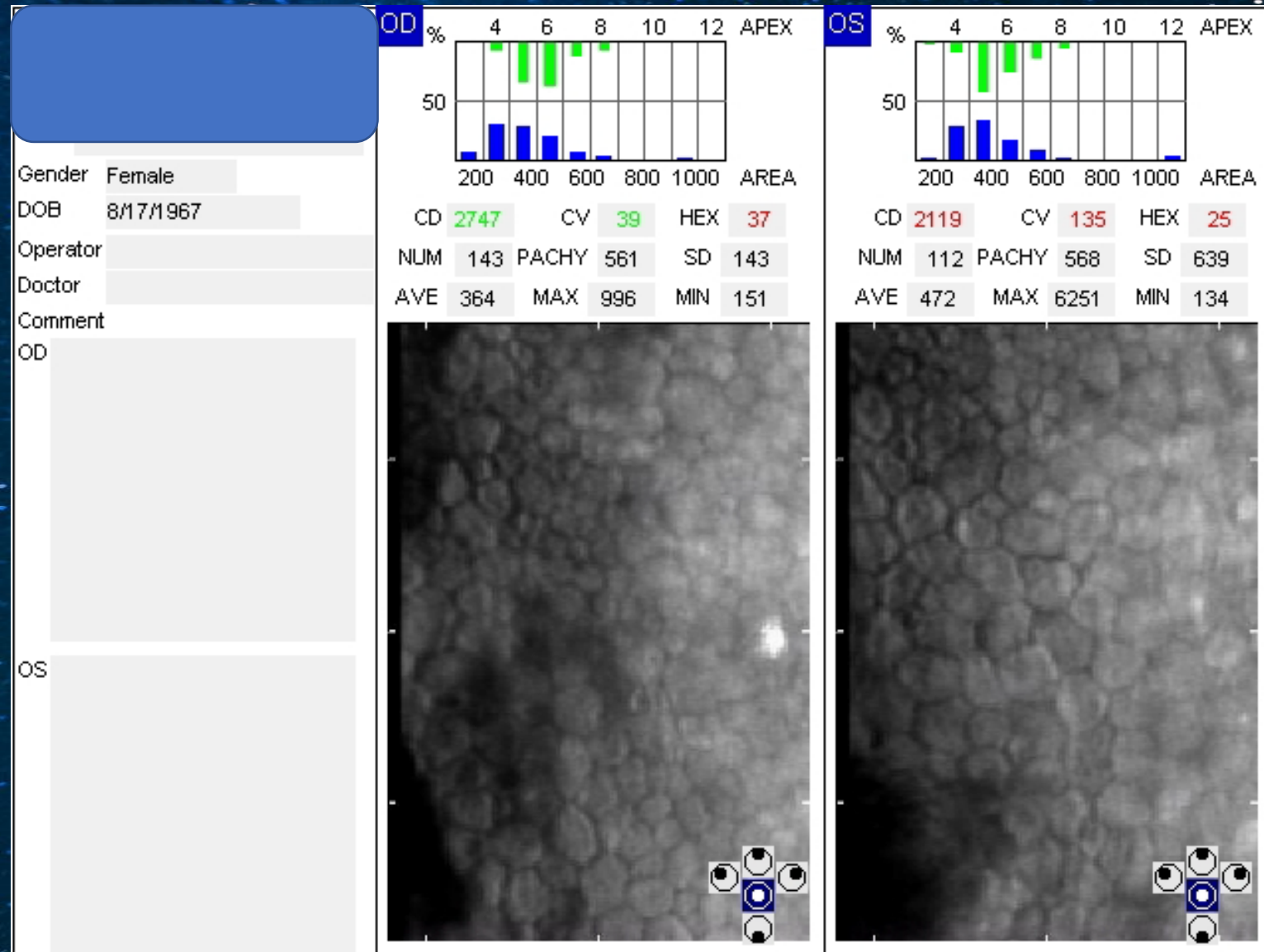


Advantages of Specular Microscopy for the Contact Lens Specialty Practice

- Ability to establish baseline of endothelial morphology at initial visit
- Ability to design a CL treatment plan if needed based on the initial endothelial status
- Ability to monitor for changes to measures during contact lens wear
- Ability to diagnose abnormal endothelial morphology in advance of clinical signs or symptoms (management through prevention?)



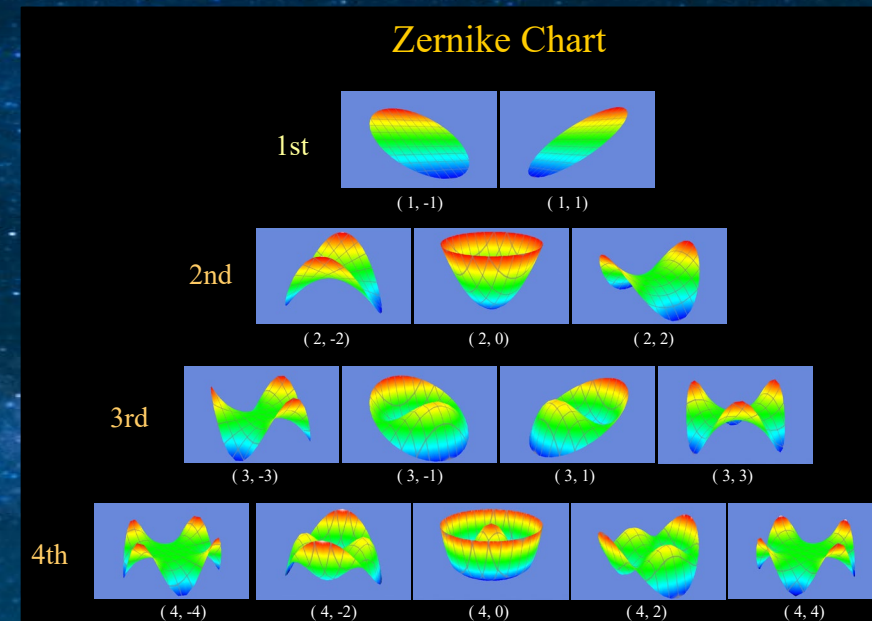
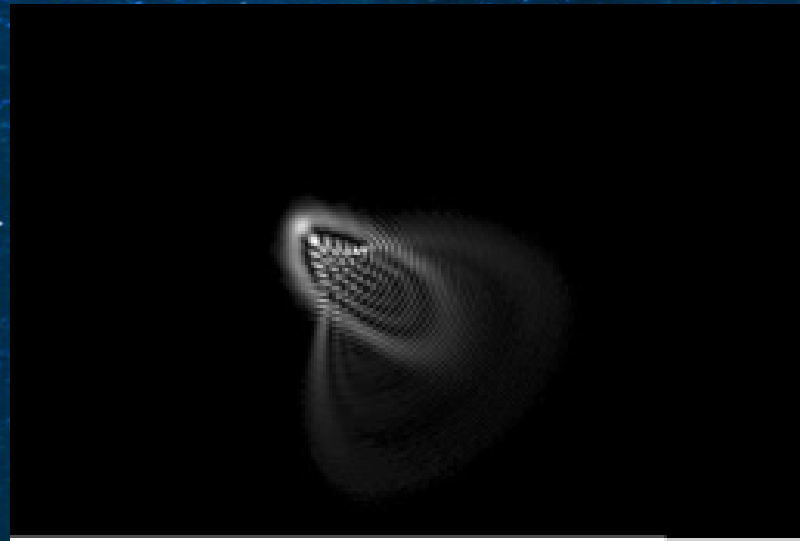
Contact Lens-Induced Corneal Endotheliopathy



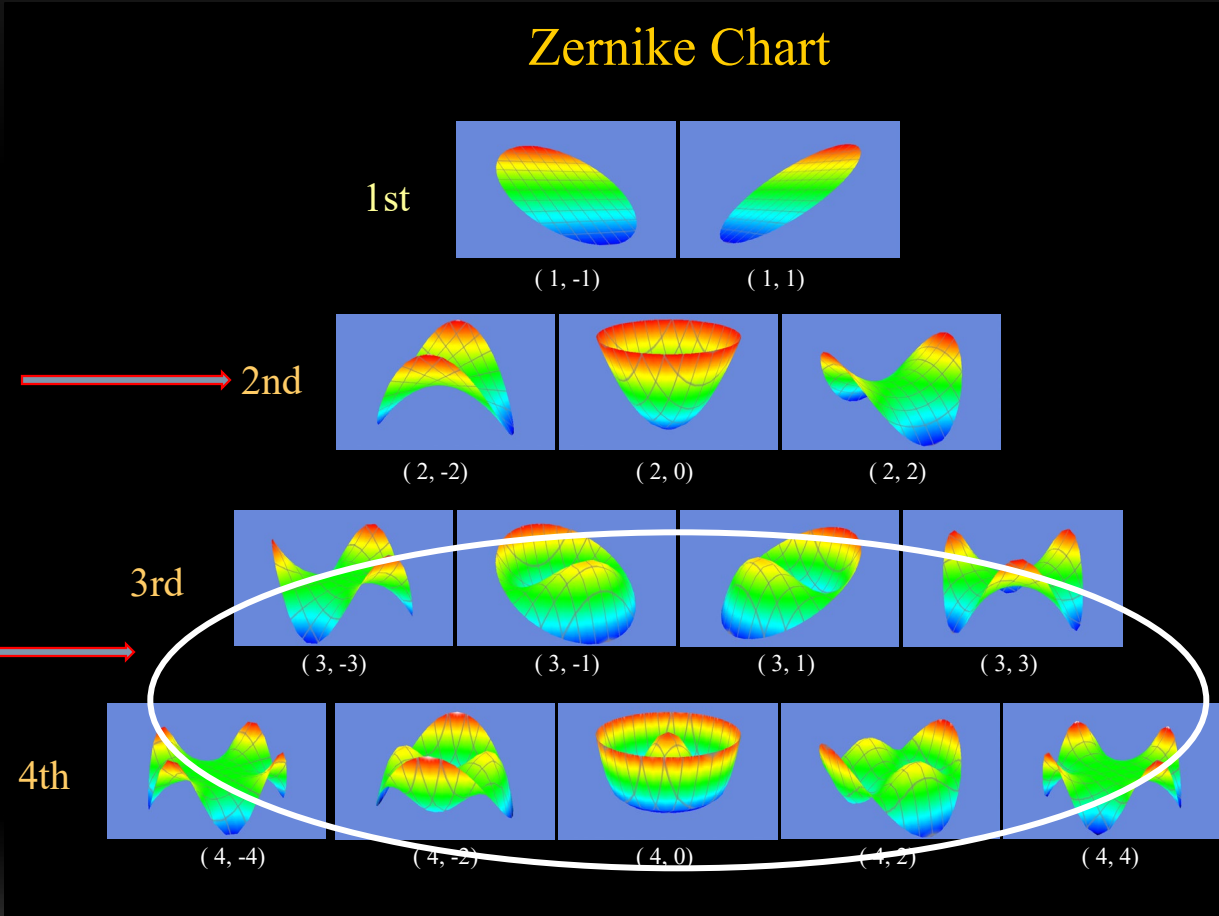
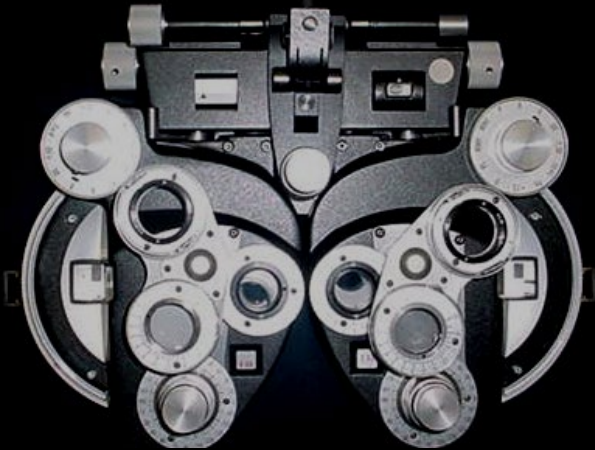
Vision Beyond 20/20

Aberrometry

Analysis & Correction of High Order Aberrations with Novel Contact Lens Technologies



LOW ORDER VS. HIGH ORDER ABERRATIONS



“HIGHER ORDER ABERRATION”

- **Defined as:**

- Any refractive error that cannot be corrected by sphero-cylindrical lens combinations***

- *Examples include coma, trefoil, spherical aberration, chromatic aberration, etc.*

- **Higher order aberrations make up approximately 15-17% of the total aberrations of normal eyes**

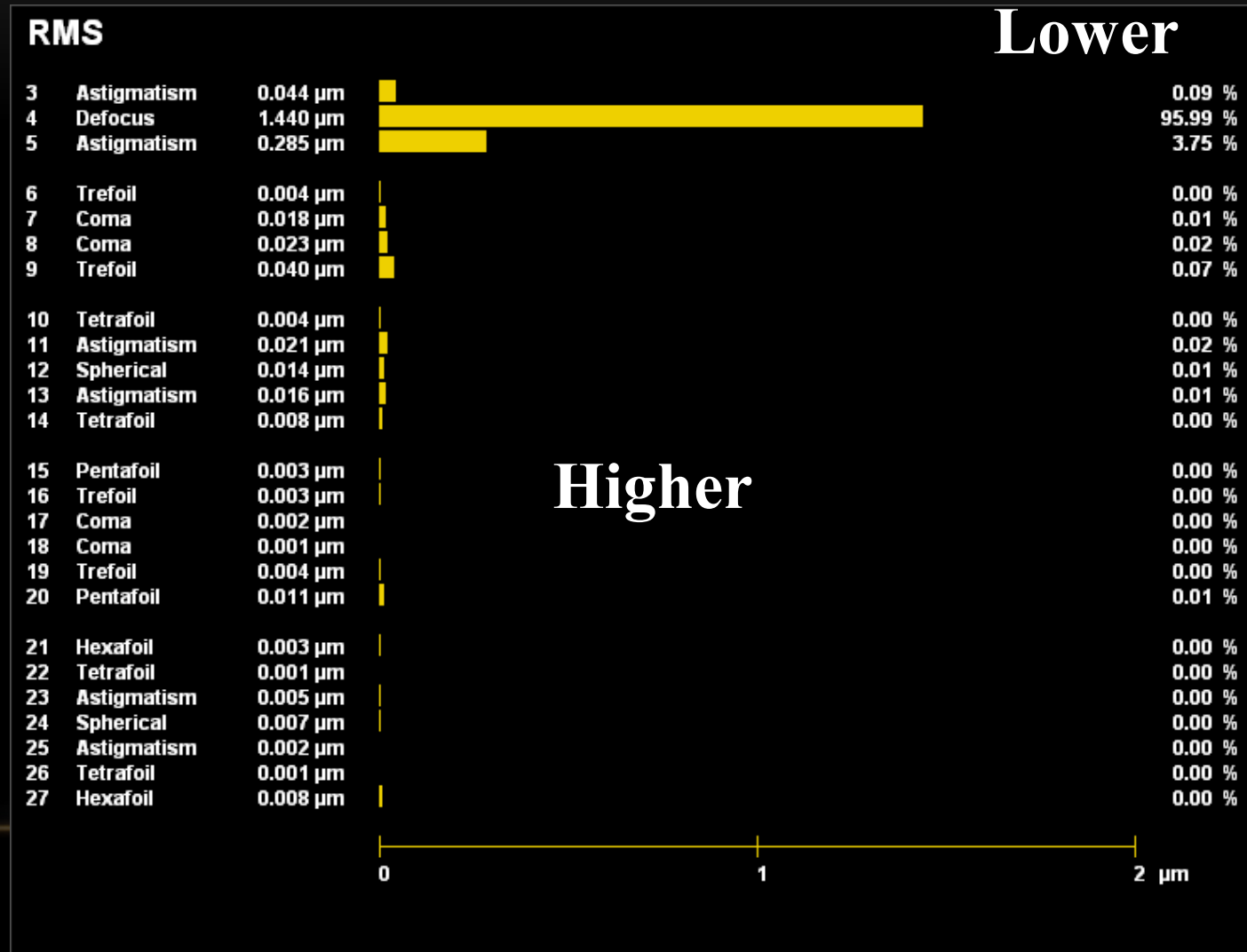
20/10 UNCORRECTED PATIENT

Ref +0.04 + 0.16 X 110



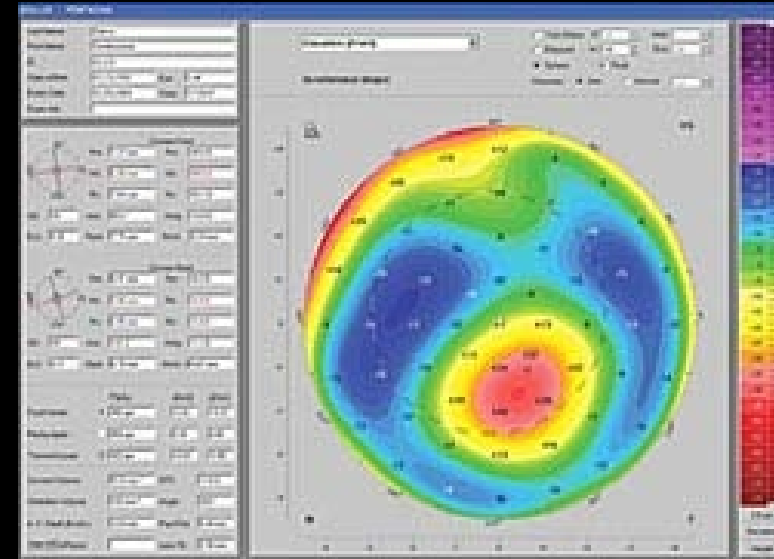
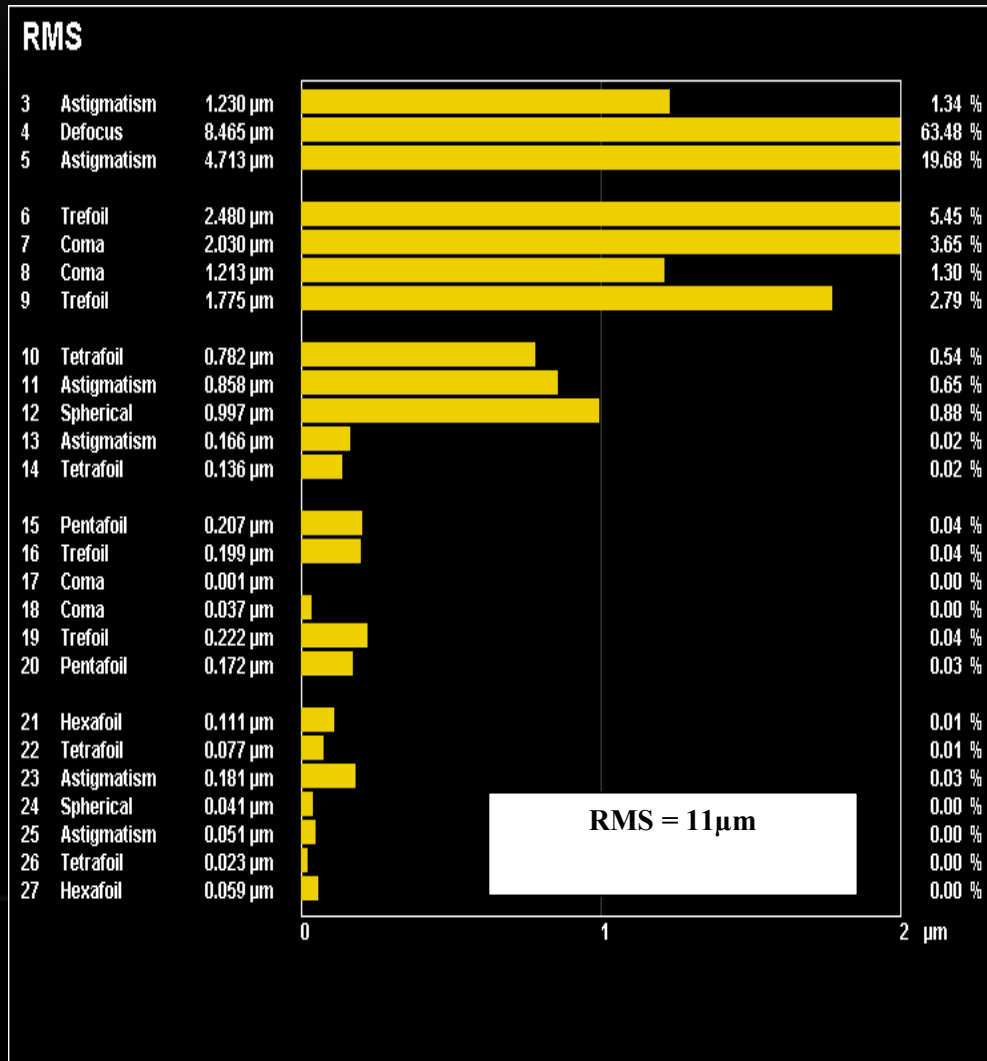
SIMPLE REFRACTIVE ERROR

EG. WHERE 99% OF TOTAL ABBERATION IS LOWER ORDER ABERRATIONS

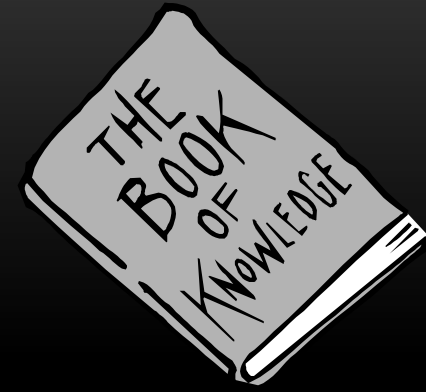


Keratoconus

WITH SIGNIFICANT LOW & HIGH ORDER ABERRATIONS



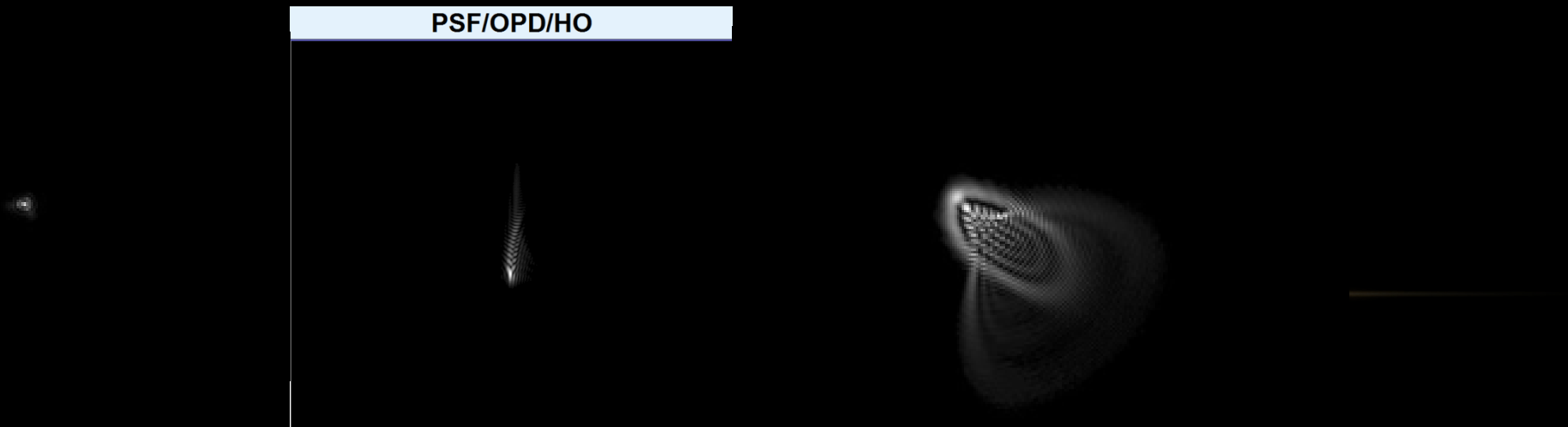
KEY TERMS:

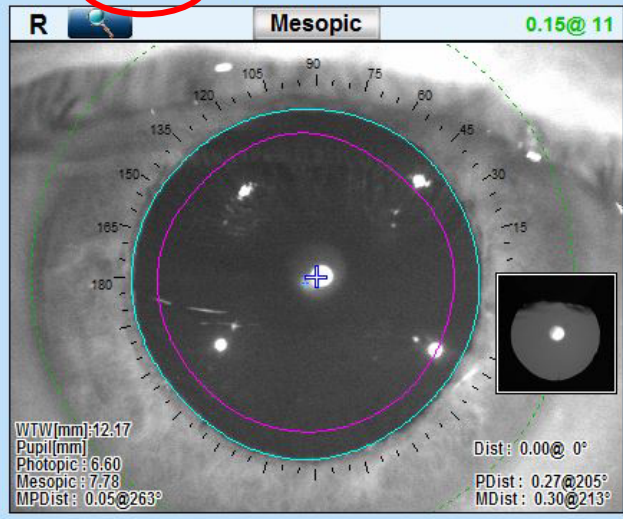
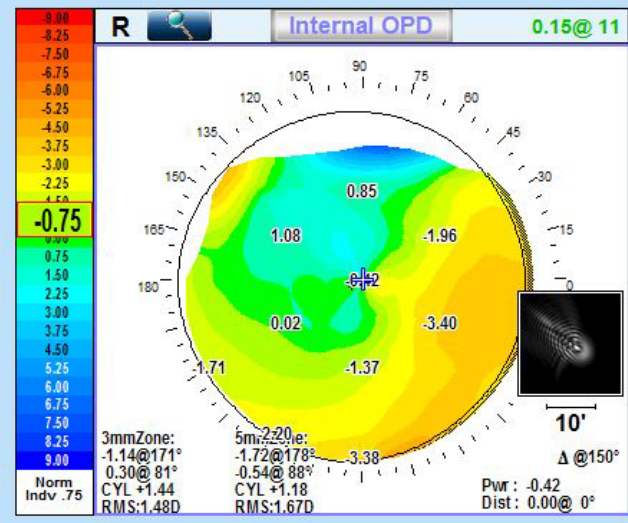
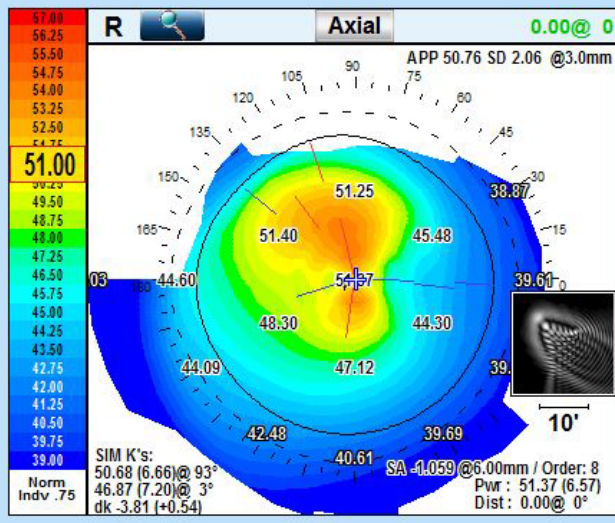
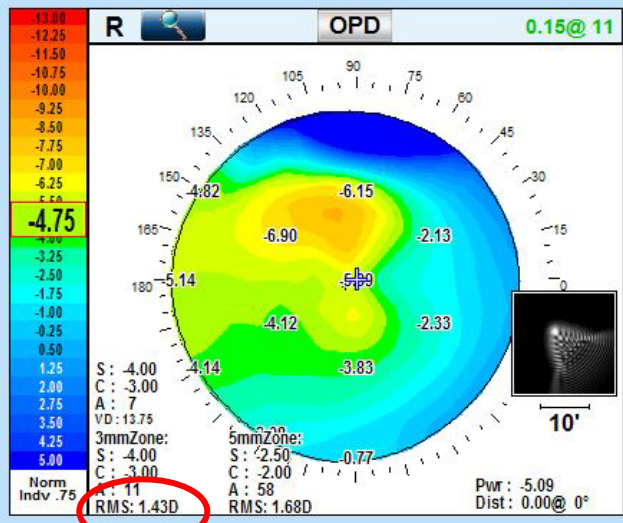


- **Aberrations**
 - Low Order (sphere and cylinder)
 - **High Order** (Coma, Trefoil, S.A., then others)
 - **Root Mean Square (RMS)**
 - Total vs. Low vs. **High**
 - **Total, External and Internal** (HOAs)
 - **Point Spread Function (PSF)**
 - Total vs. Low vs. **High**
 - **Total, External and Internal** (HOAs)
-

POINT SPREAD FUNCTION (PSF)

- **Pictorially demonstration** of what happens to a point source of light that is focused through an optical system.
- The PSF can be differentiated in terms of:
“Total, Corneal, Internal” and **“Total vs. High Order”**
- *Excellent Educational Tool*





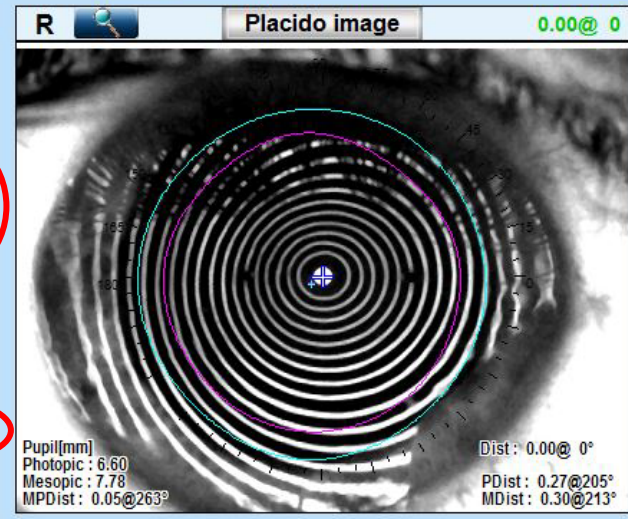
HOA [μm]: Cornea@4.00mm

Total, Internal@4.00mm / Order = 4

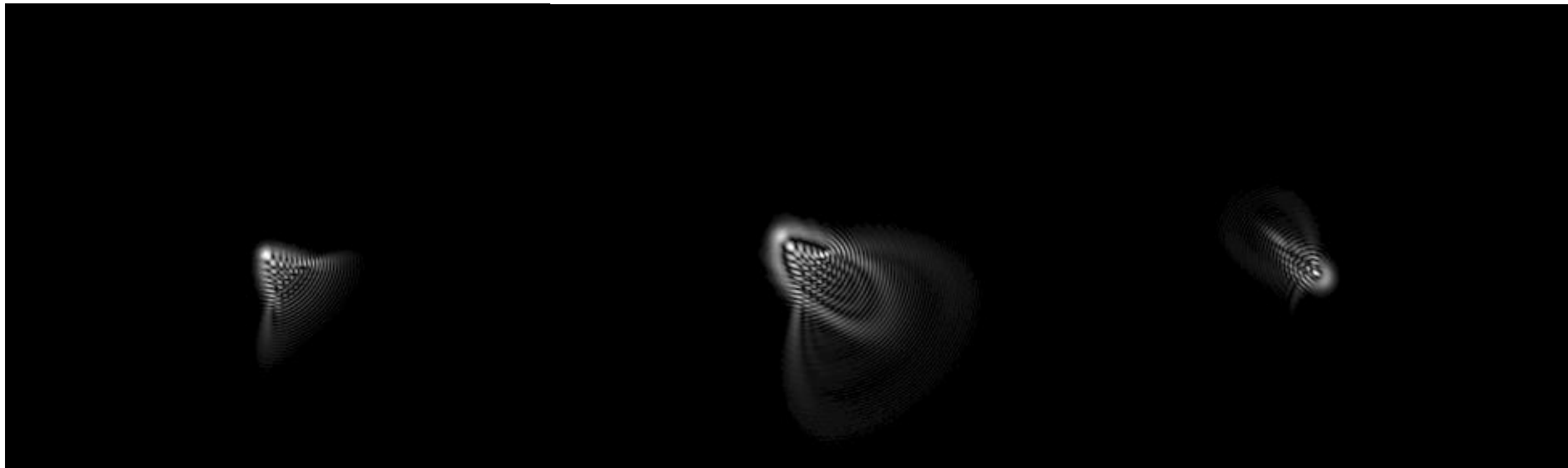
	T.Sph	T.Coma	T.Tre	HO
Total:	0.082	0.383	0.175	0.433
Cornea:	0.232	0.788	0.053	0.828
Internal:	0.151	0.411	0.126	0.459

Refraction: VD = 13.75mm

	Sph	Cyl	Axis	RMS
REF	-4.00	-3.00	7	
WF@6.00	-3.00	-2.25	18	1.39D
Diff	+1.00	+0.75	11	



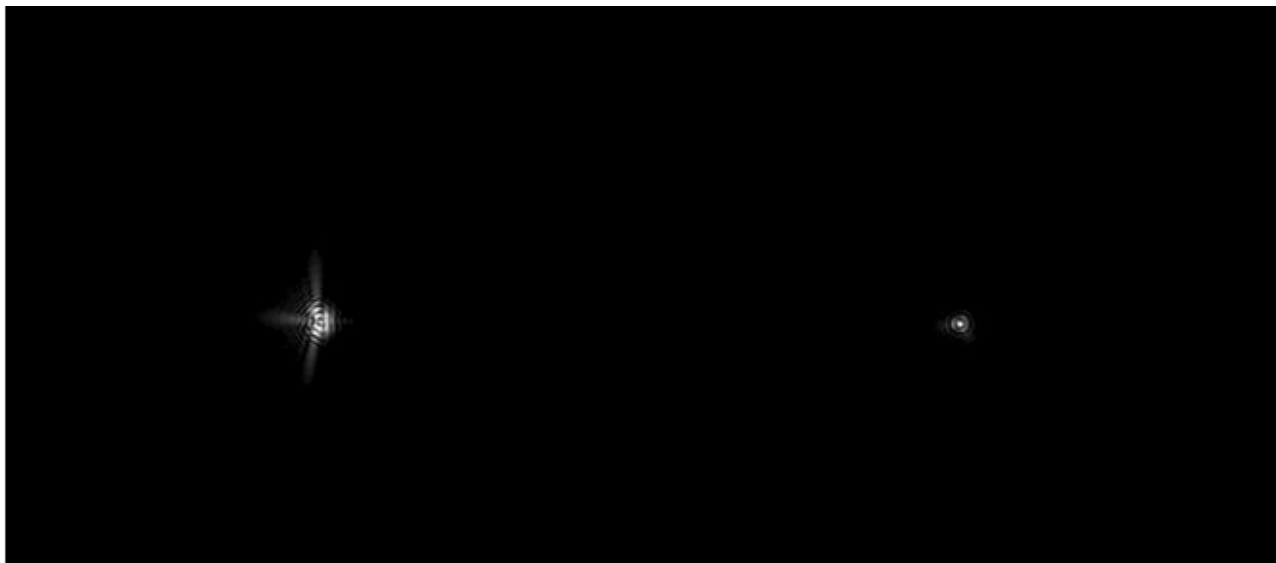
Keratoconus: elevation of total HOAs, anterior corneal HOAs and internal HOAs (from posterior cornea)



Total PSF

Corneal PSF

Internal PSF



Total PSF w/ Scleral CL

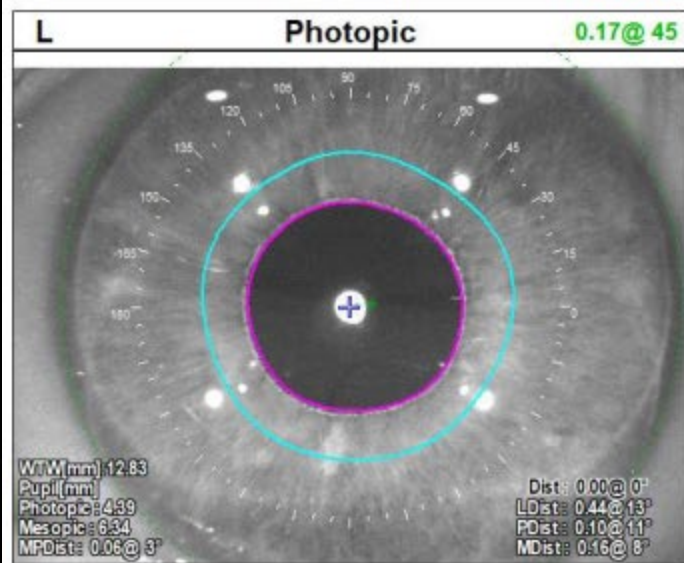
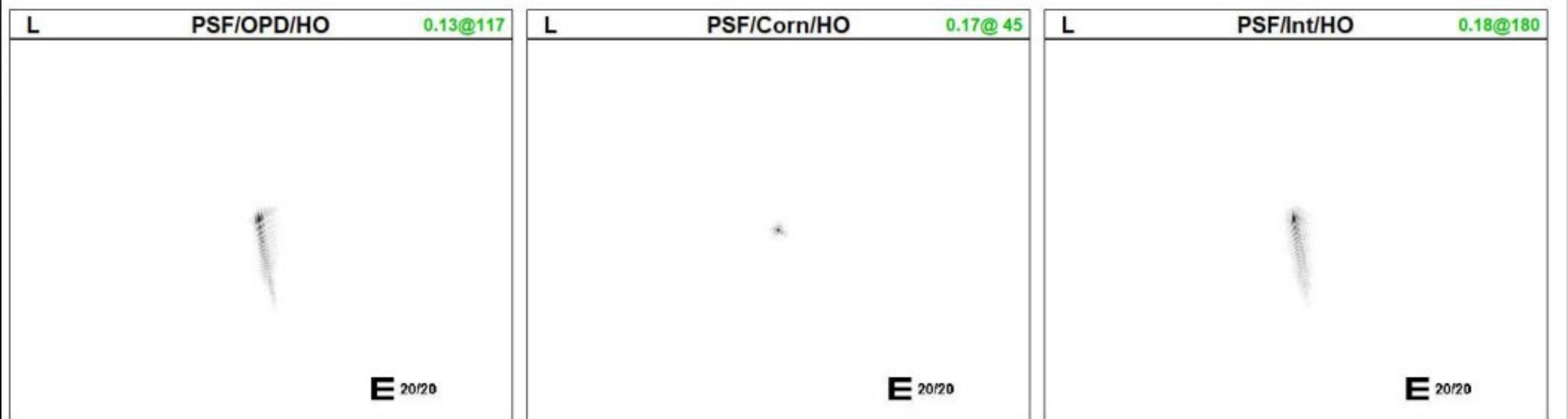
Corneal PSF w/Scleral CL

Point Spread Function Images:

TOP: KC without CL

Bottom: KC with scleral lens on with residual HOAs from posterior corneal irregularities

EXTERNAL / INTERNAL HOA "OFFSET" (W RIGID CL ON – RESIDUAL HOA)



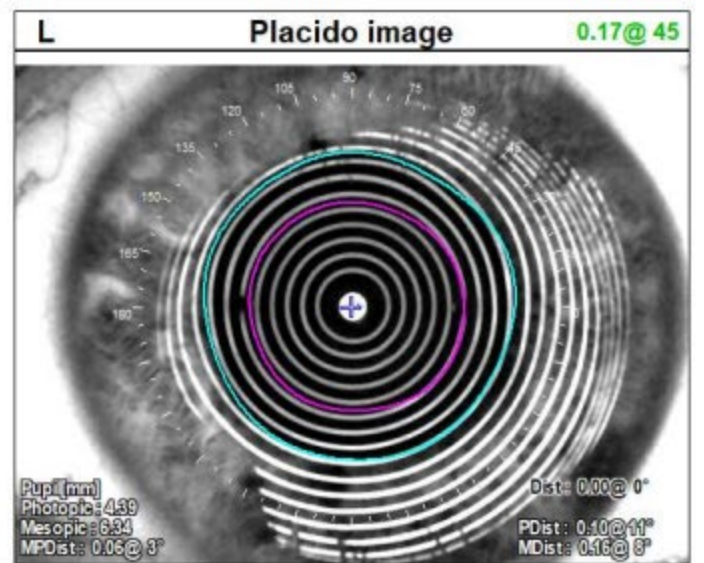
HOA [μm]: Cornea@4.00mm L

Total, Internal@4.00mm / Order = 4

	T.Sph	T.Coma	T.Tre	HO
Total:	0.052	0.317	0.399	0.514
Cornea:	0.058	0.011	0.020	0.064
Internal:	0.006	0.309	0.417	0.522

Refraction: VD = 13.75mm

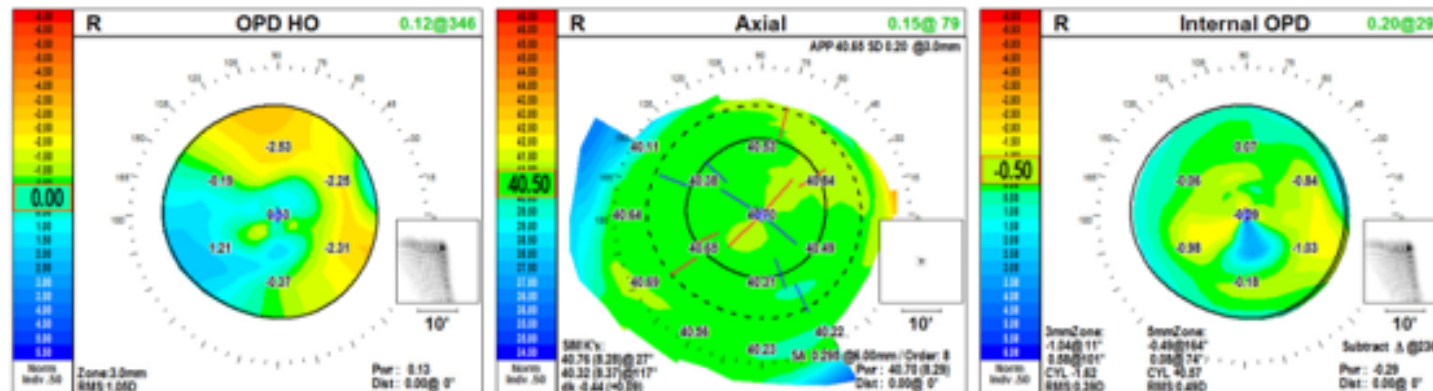
	Sph	Cyl	Axis	RMS
REF	-0.75	-0.00	0	
WF@6.00	-1.00	-0.25	4	0.87D
Diff	-0.25	-0.25	---	



Case: KC treatment w/ Scleral HOA Correction

HOA Reduction Anterior Cornea with Scleral CL & Residual HOAs from Posterior Cornea in Keratoconus

(Point Spread Function Images)



Total HOAs

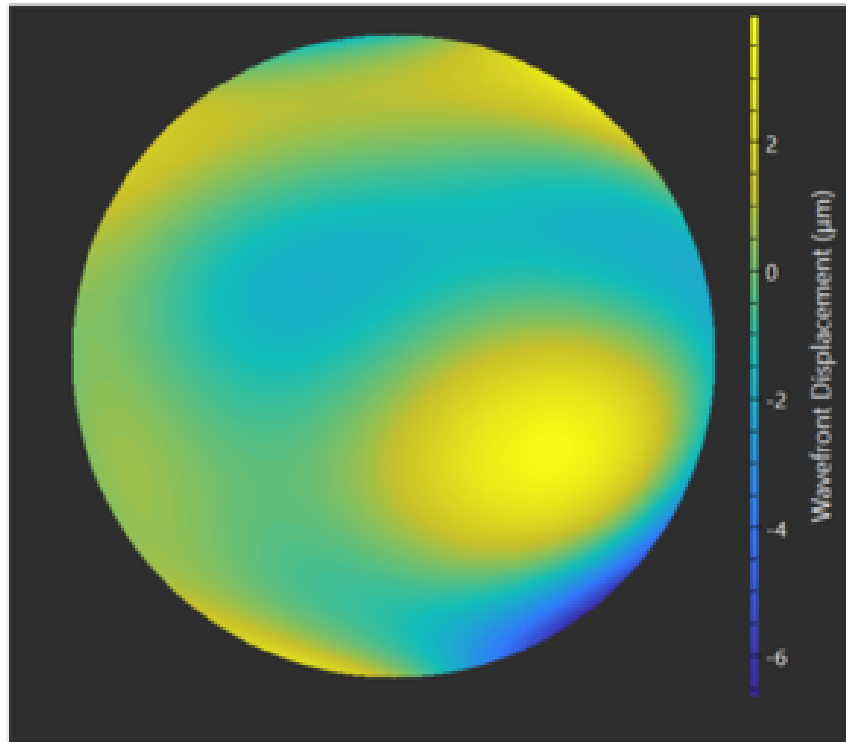
Anterior HOAs

Internal HOAs

[Scleral CL on keratoconic eye demonstrating the virtual elimination of anterior HOAs but internal HOAs (from posterior corneal irregularity) result in significant residual HOAs of the total visual system).

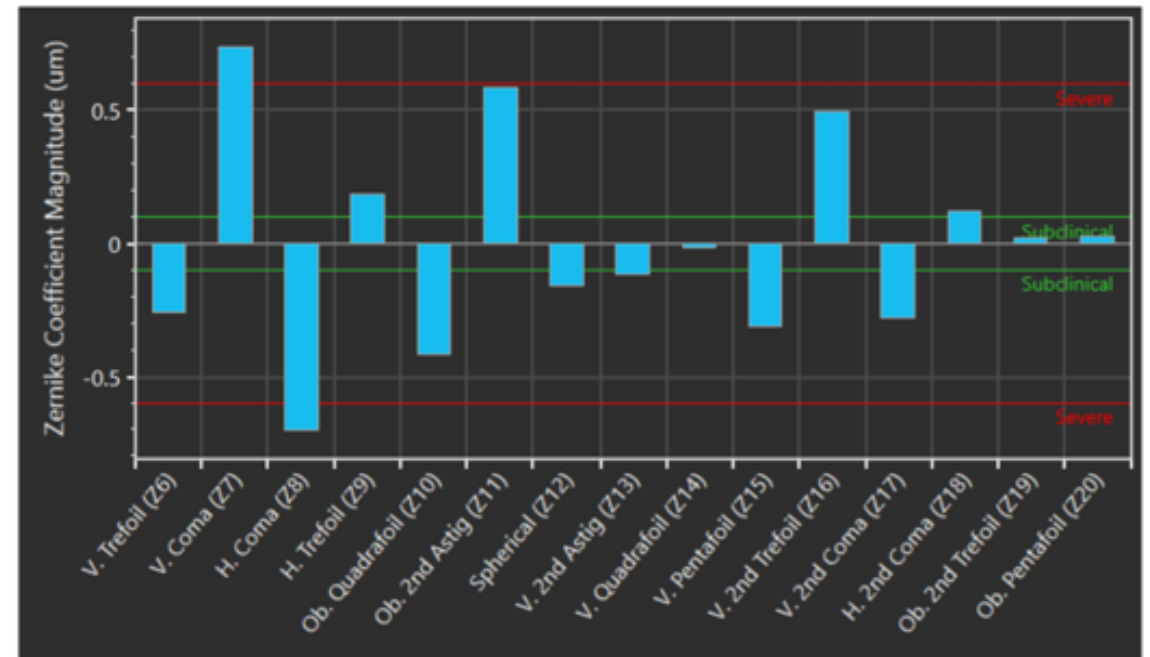
Case: KC treatment w/ Scleral HOA correction

Wavefront Map (HOA Only)



Total HOA over standard scleral lens. **HOA RMS: 1.46 μm**

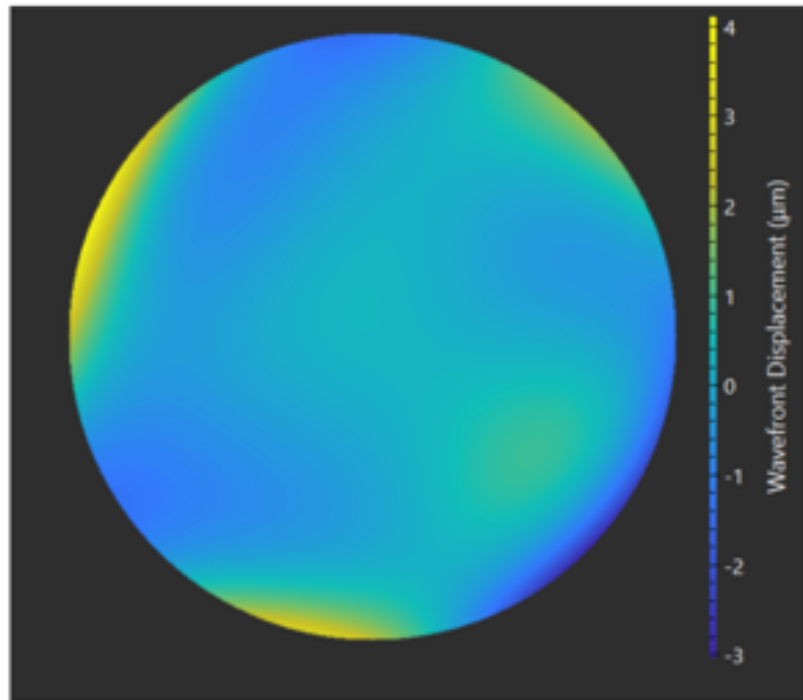
Zernike Bar Plot



Zernike bar graph showing significant elevations of various specific HOAs measured over standard scleral lens

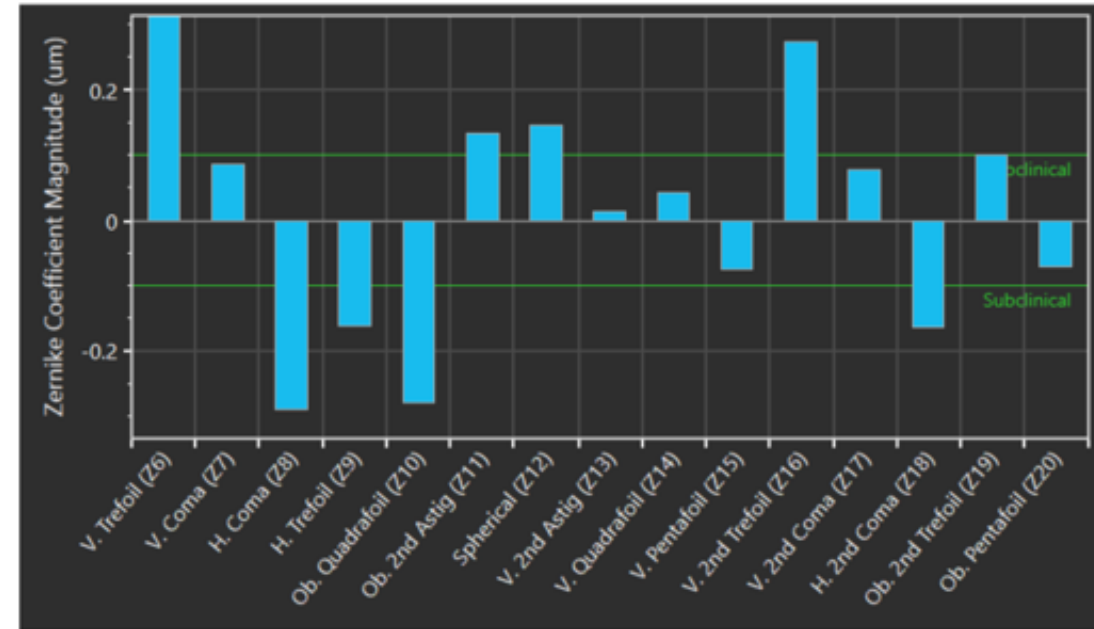
Case: KC treatment w/ Scleral HOA correction

Wavefront Map (HOA Only)



Total HOAs over HOA corrected scleral. **HOA RMS: 0.72 μm**
(apx. 50% reduction HOA RMS vs. standard scleral)

Zernike Bar Plot



Zernike bar graph showing significant reduction of multiple specific HOAs with HOA correcting scleral vs. standard scleral.

Genetic Testing of Corneal Disease

Keratoconus – polygenetic (75 genes/+2300 variants)

Corneal Dystrophy - single gene

Avellino - GENE Detection System AGDS™
Sample Collection and Shipping Procedures

156189 (Transferrin Growth Factor, Beta Induced) gene detection for traits linked with Avellino Corneal Dystrophy

- 1. Test Requisition Form**
Complete Test Requisition Form including clinic and patient information. Top only goes with sample and bottom copy remains with clinic. Inquire about electronic requisition and iPad application if ordered.
- 2. Label SWAB**
Write Patient's Name on label on Test Requisition Form and then peel off and place on side of SWAB protective tube. Verify sample ALU number on the SWAB tube is identical to number printed at the top of the Test Requisition Form. Verify date printed on side of SWAB protective tube is not expired. Note: SWABS do not have preservatives, chemicals.
- 3. Collect Cells from Patient**
Test to the top, breaking sterile seal and remove sample stick. If patient has either had food, soft drink or chocolate recently, we recommend a rinsing time with water to remove residue. Sample patients one row by row for the collection of epithelial cells, taking at least 10 swipes from the inside of both cheeks to capture sufficient cells on the SWAB.
- 4. Place in Transport Bag**
Return sample stick into protective case and place into non-sealing transport bag and seal. If properly labeled, several patient SWABS may be placed into one sealed Transport Bag. If sample not shipped that day, sample may be stored in refrigerator for up to 3 days until ready to send by courier.
- 5. Send by Courier for Testing**
Place samples and top piece of Test Requisition Form into ziploc bag. US pay pad and zip addressed envelope. Package will be sent overnight to:
Avellino Labs USA, Inc.
1505 Adams Drive, Suite B-2
Menlo Park, CA 94025
Have Questions? Call Customer Support: (800) 290-1241

AVELLINO AGDS™
Questions / Technical Support Information or Order of Additional Supplies:
Call: (800) 290-1241 | www.avellino.com
Email: info@avellino.com | sales@avellino.com

Indications:

- F/H
- “Clinical Confusion”
- Pre-Surg.
- +++

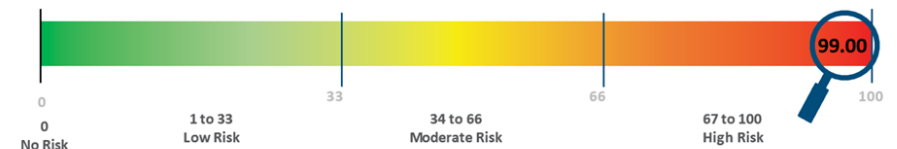
FINAL RESULTS SUMMARY:

CONDITION TESTED	RESULT	DETAIL	EXPLANATION
Keratoconus (KC)	HIGH genetic risk	99 polygenic risk score	Tested for 75 covered genes and thousands of variants associated with KC
TGFBI Corneal Dystrophies (CD)	Negative for TGFBI Corneal Dystrophies	No pathogenic variants detected	Tested positive for 0 out of 70 known variants associated with TGFBI corneal dystrophies

This AvaGen Genetic Test result should be considered with other clinical criteria, the patient's family history and communicated in a setting that includes appropriate genetic counseling.

Keratoconus (KC) Risk Assessment

Based on the polygenic genetic risk score of **99.00**, this patient's risk for **KC** is **high**.



THANK YOU!



International Keratoconus
Academy

Of Eye Care Professionals