

:Wavefront-Guided Redo *Addressing the problem*

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Wavefront Analysis in Post-LASIK Eyes and Its Correlation with Visual Symptoms, Refraction, and Topography

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Purpose: To evaluate the information assessed with the LADARWave wavefront measurement device and correlate it with visual symptoms, refraction, and corneal topography in previously LASIK-treated eyes.

Participants: One hundred five eyes (58 patients) of individuals who underwent LASIK surgery were evaluated.

Design: Retrospective, noncomparative case series.

Main Outcome Measures: Complete ophthalmologic examination, corneal topography, and wavefront measurements were performed. Correlations were made between the examinations and symptoms.

Methods: Wavefront measurements were assessed with the LADARWave device. Manifest, cycloplegic refraction, and topographic data were compared with wavefront refraction and higher order aberrations. Visual symptoms were correlated to higher order aberrations in 3 different pupil sizes (5-mm, 7-mm, and scotopic pupil size). Pearson's correlation coefficient and generalized estimating equations were used for statistical analysis.

Results: In post-LASIK eyes, wavefront refraction components were poorly correlated to manifest and cycloplegic components. The comparison between manifest, cycloplegic, and wavefront refraction with total amount of higher order aberrations showed no strong correlation. The comparison between topography and manifest, cycloplegic, and wavefront refraction did not show strong correlation. Visual symptoms analysis showed correlation of double vision with total coma and with horizontal coma for the 5-mm and 7-mm pupil size; correlation between starburst and total coma for the 7-mm pupil size; and correlation of double vision with horizontal coma, glare with spherical aberrations and with total aberrations, and starburst with spherical aberrations for the scotopic pupil size. Scotopic pupil size had a positive association with starburst and a negative association with double vision.

Conclusions: The LADARWave wavefront measurement device is a valuable diagnostic tool in measuring refractive error with ocular aberrations in post-LASIK eyes. A strong correlation between visual symptoms and ocular aberrations, such as monocular diplopia with coma and starburst and glare with spherical aberration, suggest this device is valuable in diagnosing symptomatic LASIK-induced aberrations. Horizontal coma was correlated with double vision, whereas vertical coma was not. *Ophthalmology* 2004;111:447-453 © 2004 by the American Academy of Ophthalmology.

Why H.O.A. Are so Important???



POOR VISUAL QUALITY AFTER
REFRACTIVE SURGERIES



What Accounts for Refractive Error?

- 83% Sphere/Cylinder
- 17% "Other"
 - Coma
 - Trefoil
 - Spherical Aberration
 - Higher Order Aberration
- Higher order aberrations directly affect patient's quality of vision



Relation between Cylinder and HOA

- Subjective refraction is referred to as the sphere and cylinder
- When the HOA exist, the subjective refraction becomes pupil size and HOA dependent

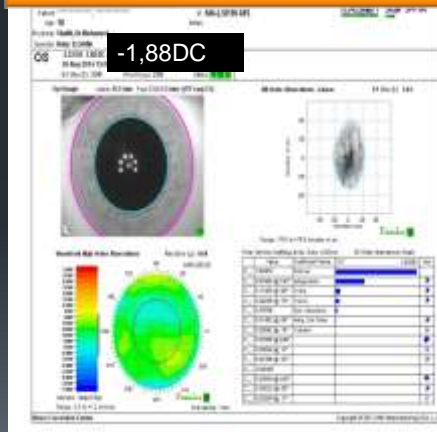
$$C = \frac{4\sqrt{6}}{R^2} \{Z3^2 + Z5^2 - 2\sqrt{15}(1-\epsilon^2)[Z3Z11 + Z5Z13] + 15(1-\epsilon^2)^2[Z11^2 + Z13^2]\}^{1/2}$$

George Dai. Wavefront Optics for Vision Correction (SPIE Press, 2008)



- Conventional ablation profiles is a manifest refraction based procedure

Manifest refraction 2.50 -1.50 x15°



Sources of Post-LASIK Unsatisfaction

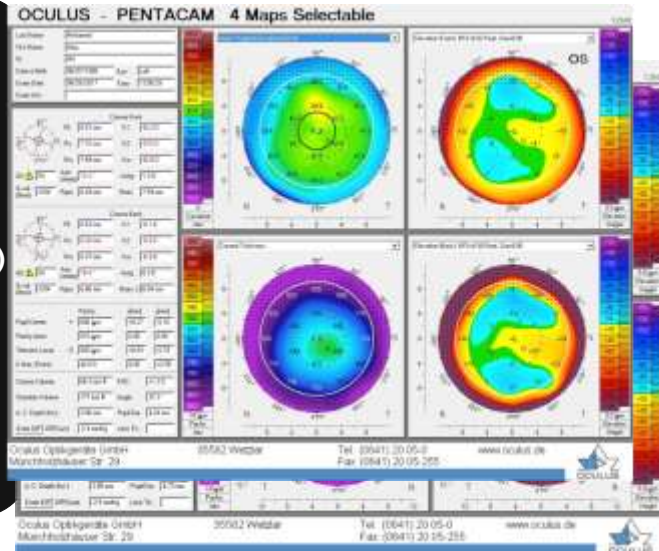
A straight forward
Tomographic data
for a 19 Ys. Lady
with:

-2.00 -0.50 X 30 (OD)

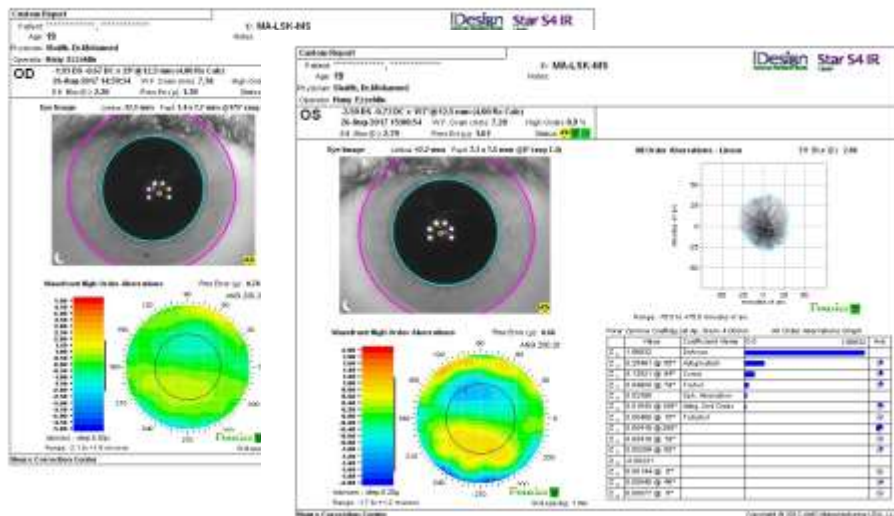
-2.50 -0.75 X 155 (OS)

CCT: 603 & 600 μ m

BCVA: 1.2 (OU)

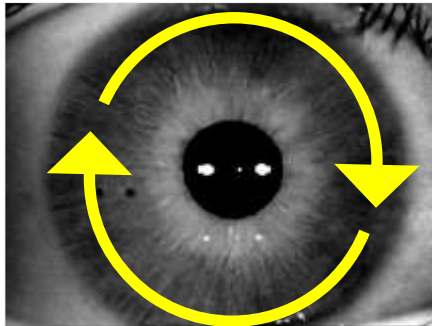


Sources of Post-LASIK Unsatisfaction



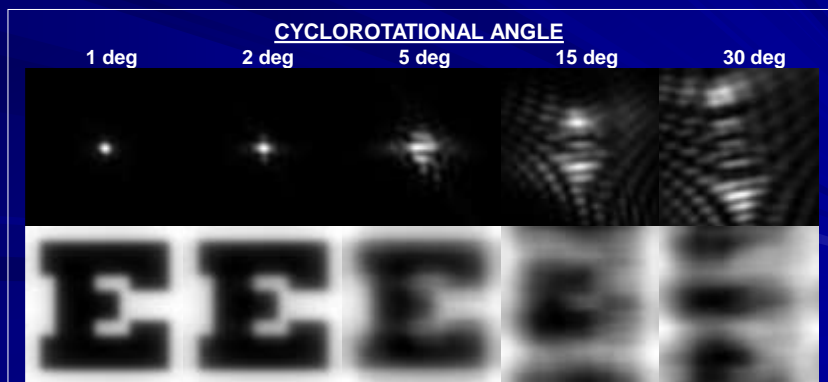
Sources of Post-LASIK Unsatisfaction

- Rotational movement of the eye around the Z-axis **“Cyclotorsion”**



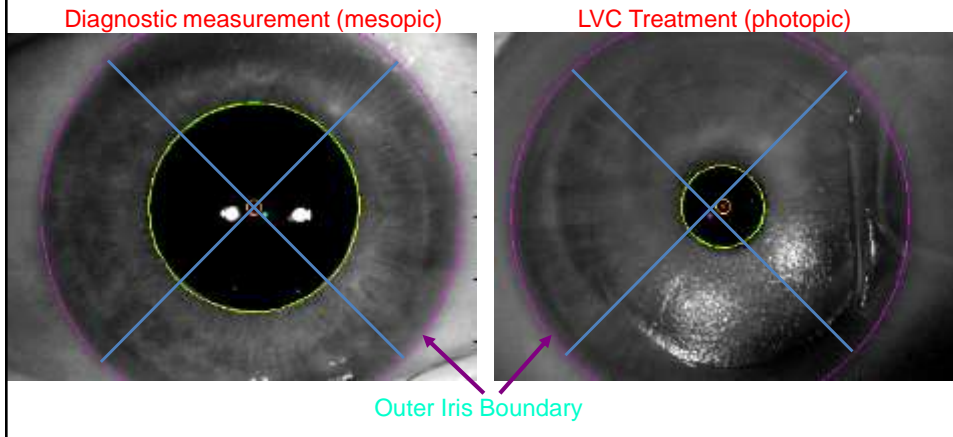
Is 2 Degrees Significant?

- Residual PSF and Blurred Eye Chart Letters
- Real eye: $-0.15\text{DS} -1.01\text{DC} \times 0^\circ$



Sources of Post-LASIK Unsatisfaction

- As the pupil changes size, its centroid may not remain stationary, relative to the outer iris boundary



Clinical impact of pupil centroid shift

Shift of pupil centroid between aberrometer and laser

0.0mm 0.1mm 0.2mm 0.3mm 0.4mm 0.5mm 0.6mm 0.7mm 0.8mm 0.9mm

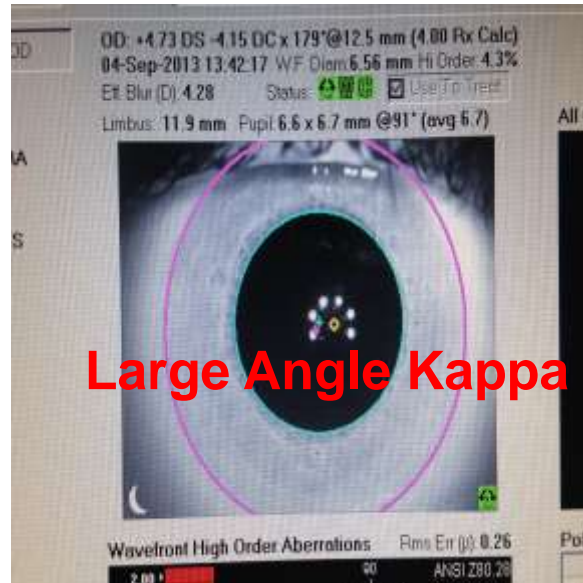
Induced RMS error

0.0 μ 0.09 μ 0.19 μ 0.30 μ 0.40 μ 0.51 μ 0.61 μ 0.72 μ 0.83 μ 0.94 μ

PreOp

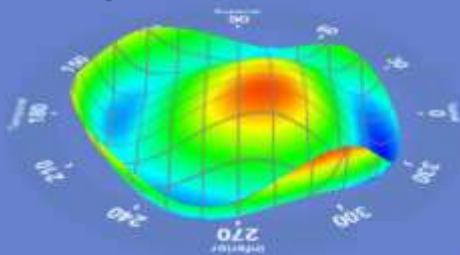


Sources of Post-LASIK Unsatisfaction



Wavefronts Change With Position

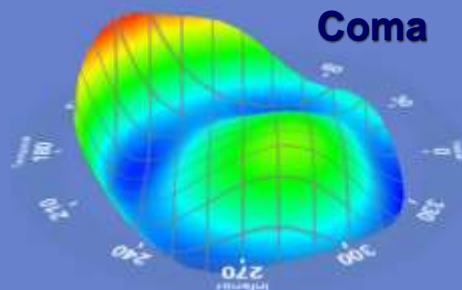
Spherical Aberration

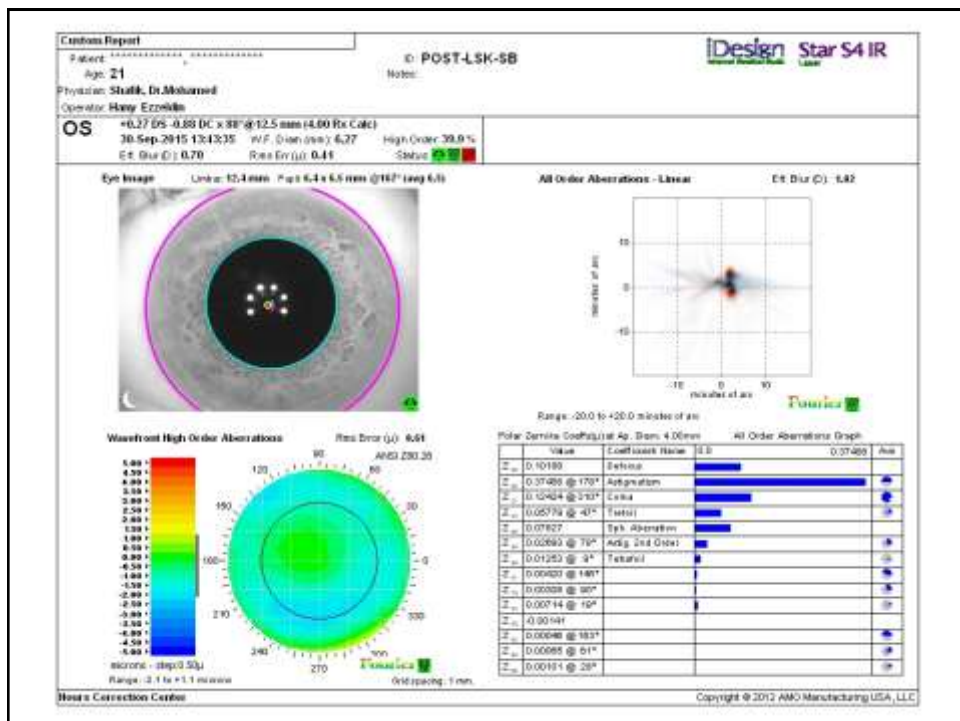
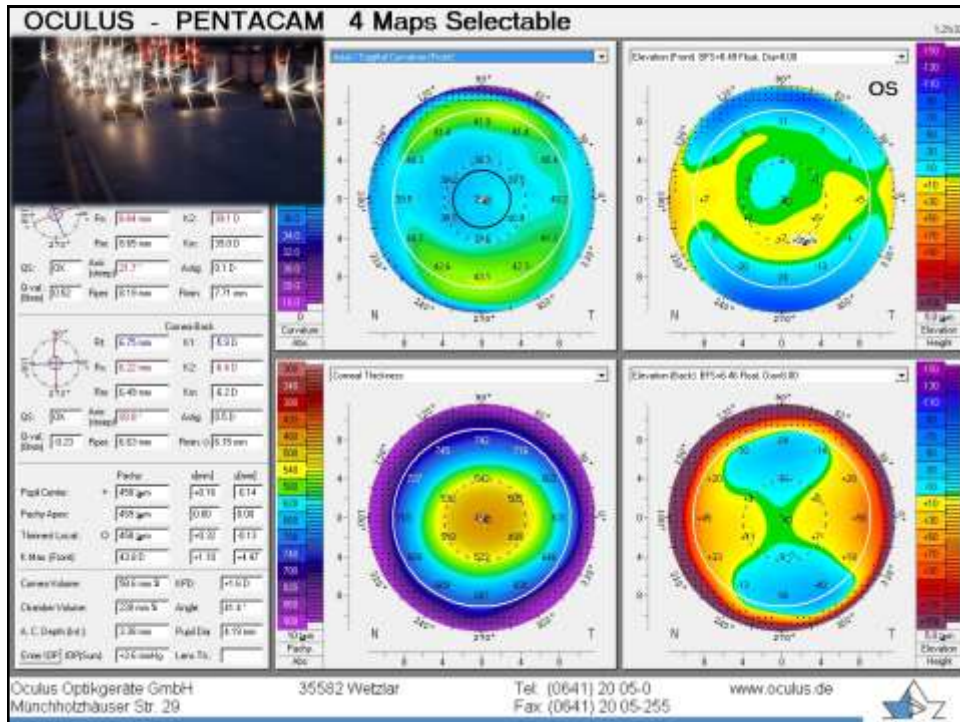


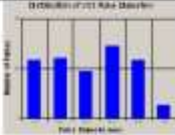
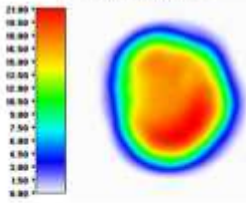
Same diameter
Same vertical scale
Same eye
Center shifted by 500 μ

With this shift,
you would be correcting the
eye **above** with the
wavefront **to the right!**

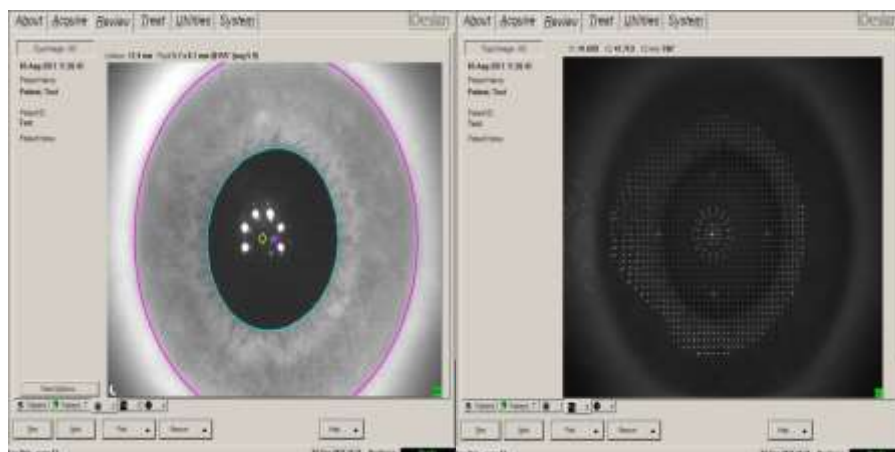
Coma



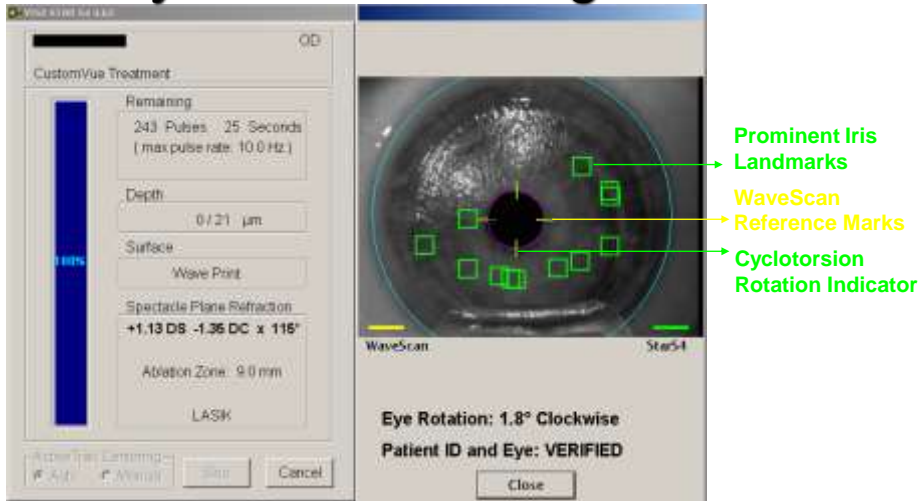


Surgical Treatment Plan Report - Star		ID: POST-LSK-5B		iDesign StarS4IR CustomVue	
Patient: Age: 22		Notes:			
Physician: Shaikh, Dr. Mohamed				Exam Date: 13-Jul-2016 15:25:26	
Operator: Hany Ezzeldin					
OS	Wt R (4.00mm D) -0.12 DS -0.63 DC x 101° @12.5mm SE -0.43 Manifest -0.33 DS -0.75 DC x 88° @12.5mm SE -0.71				
W.S. Diam (mm): 7.75 H.O.A. Residual (μ): 1.17 High Order: 188.19% Manifest: +0.00 DS -0.75 DC x 88° @12.5mm (3.0 m. lane)					
K1 (D): 38.75 K2 (D): 39.25 K2 Axis (°): 78 (Entered)					
Treatment Type: LASIK Correction Type: CustomVue % Monogram Adjustment:					
Physician Adjustments - SPH (D): 40.00 CYL (D): -0.60 VTX (mm): 12.50					
Total Correction - SPH (D): -0.12 CYL (D): -0.63 Axis (°): 101 VTX (mm): 12.50					
Presbyopic Correction: No					
Scotopic Pupil (mm): 8.00 Optical Zone (mm): 6.00 Effective Zone (mm): 8.00 Flap Diameter (mm): 9.00 Corneal Thickness (μ): 520 Intended Flap Thickness (μ): 110 Max. Ablation Depth (μ): 20.3 Est. Residual Bed Depth (μ): 390 Additional Information:		 <p>No. of Pulses: 155 Treatment Time (sec): 7.8</p>		 <p>Ablation Depth (microns)</p> <p>Unlaid Diam: 12.4 mm Pupil: 8.1 x 8.1 mm @59° (avg 8.1) Photopic Pupil: 5.8 x 7.0 mm @74° (avg 7.0)</p>	
Beaver Correction Center		Ver 5.1.2		Copyright © 2012 AMO Manufacturing USA, LLC	

Sources of Post-LASIK Unsatisfaction



WF-Guided Ablation Cyclotorsional Registration



Analyze Your Patient's Complaint



How can aberrations affect our vision?

Convolution of the Different Zernike Modes

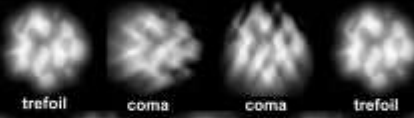
Radial order

2nd

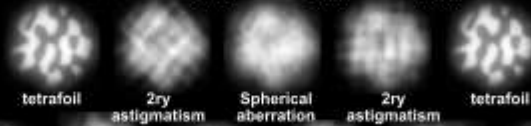


Diffraction-limited object

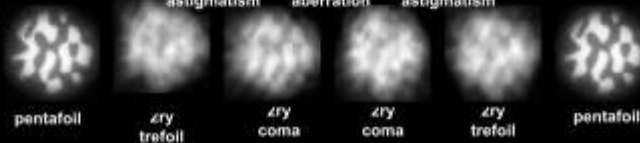
3rd



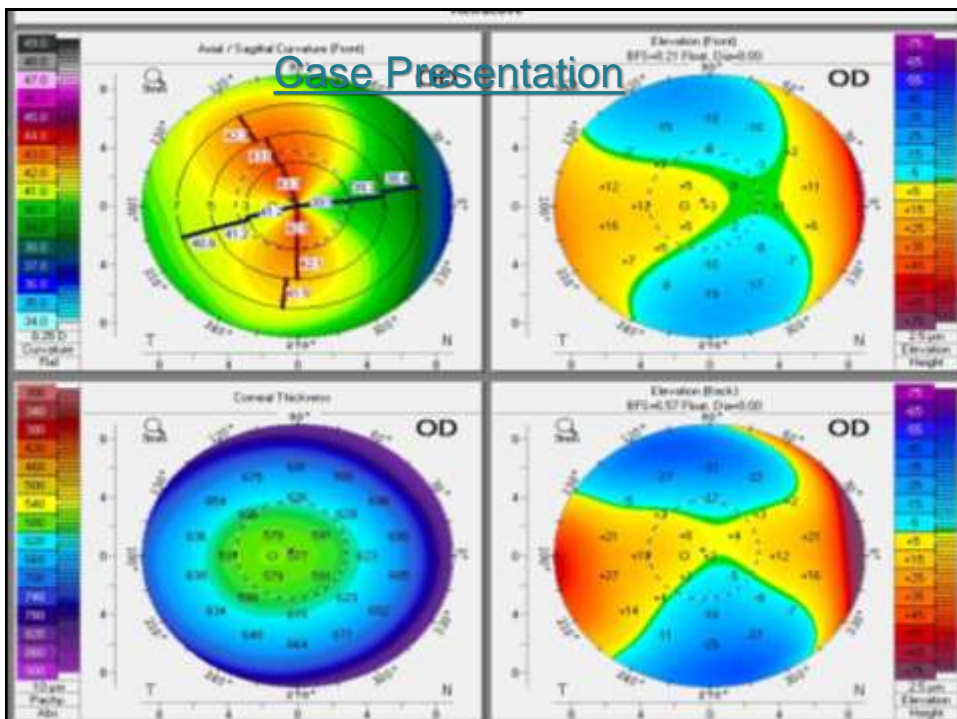
4th

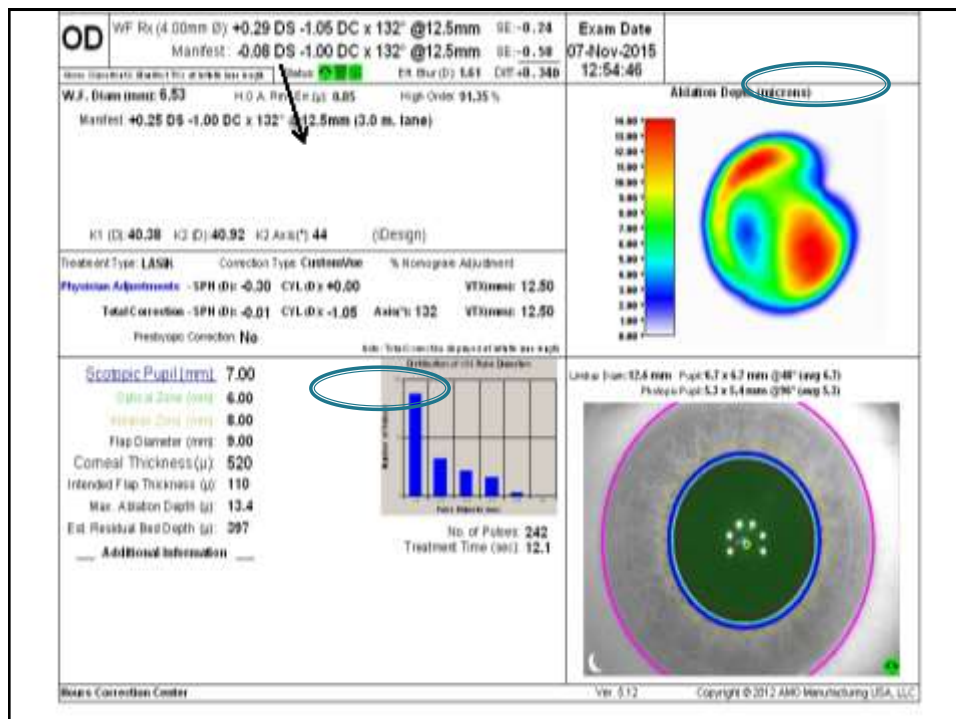
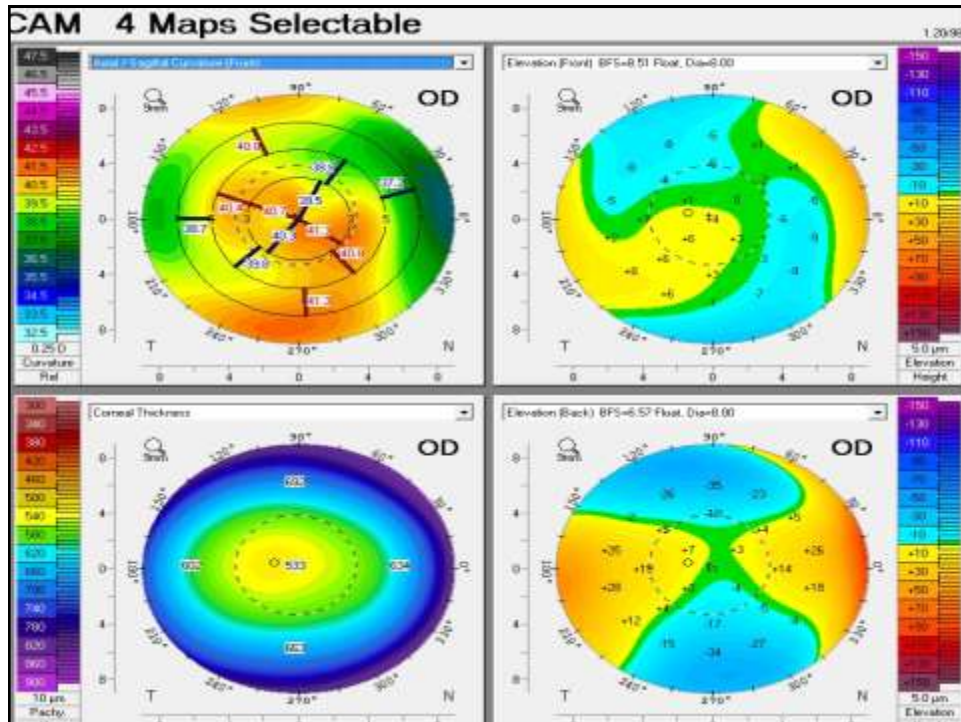


5th

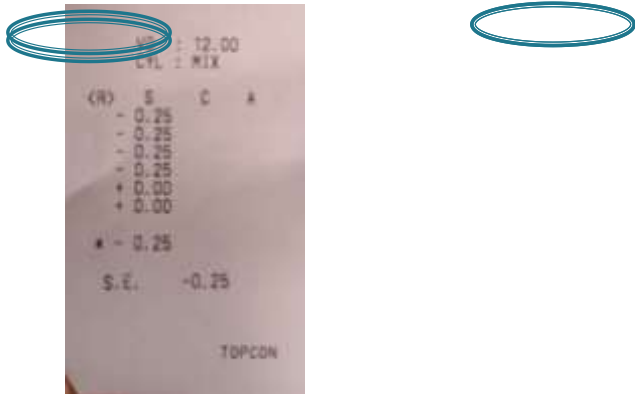



Case Presentation





UAVA 1.5, no Ghosting, Happy and Satisfied

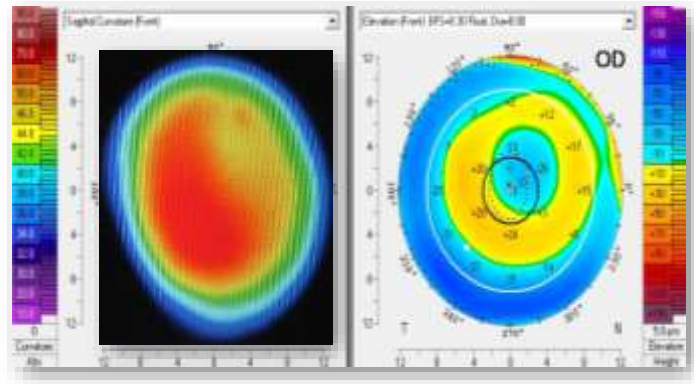
CASE 3. Post LASIK Decentration

- 25 y lady
- Had LASIK in July 2010 for -11.00 ?. Presented with ghosting, poor night vision
- UCVA 0.1
- Manifest Refraction: -2.50 -1.00 x 120
- BCVA 0.3
- CCC 468 μ m
- Untreatable to date due to lack of capture with previous aberrometer

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CASE 3. Post LASIK Decentration Ablation Profile design over the irregular cornea



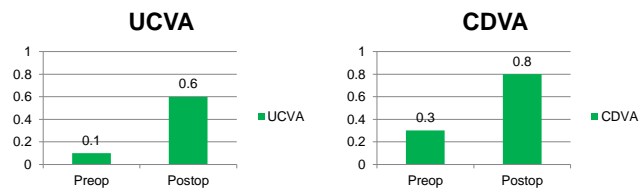
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CASE 3. Post LASIK Decentration. Results: 12 months after CustomVue LASIK powered by iDesign

Ablated tissue thickness 41 μm

Manifest Refraction -0.75 -0.5 X180

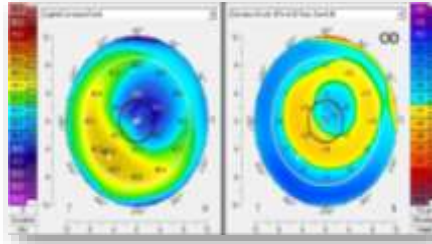


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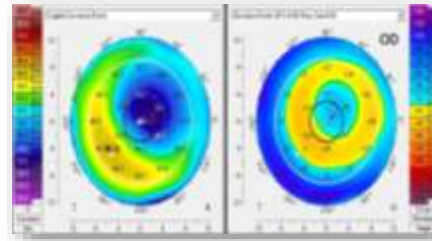


CASE 3. Post LASIK Decentration. Preop vs Postop Pentacam

Pre-Op



Post-Op

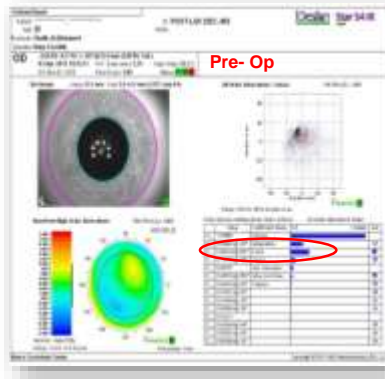


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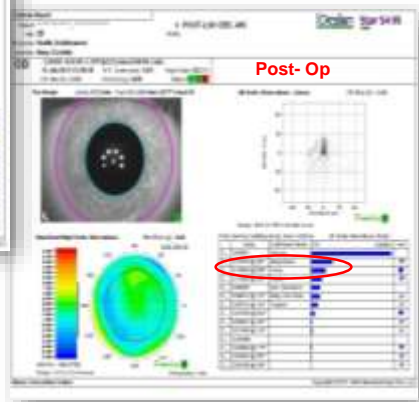


CASE 3. Post LASIK Decentration . Preop vs Postop iDesign Map

Pre-Op



Post-Op



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Conclusions

***Wavefront-Guided Redo can
Address the Problem!***

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Thank You

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