

RAY-TRACING MEASUREMENT OF OPTICAL PROPERTIES CONTRIBUTING TO DYNAMIC ACCOMMODATIVE POWER AFTER LASER ANTERIOR CILIARY EXCISION

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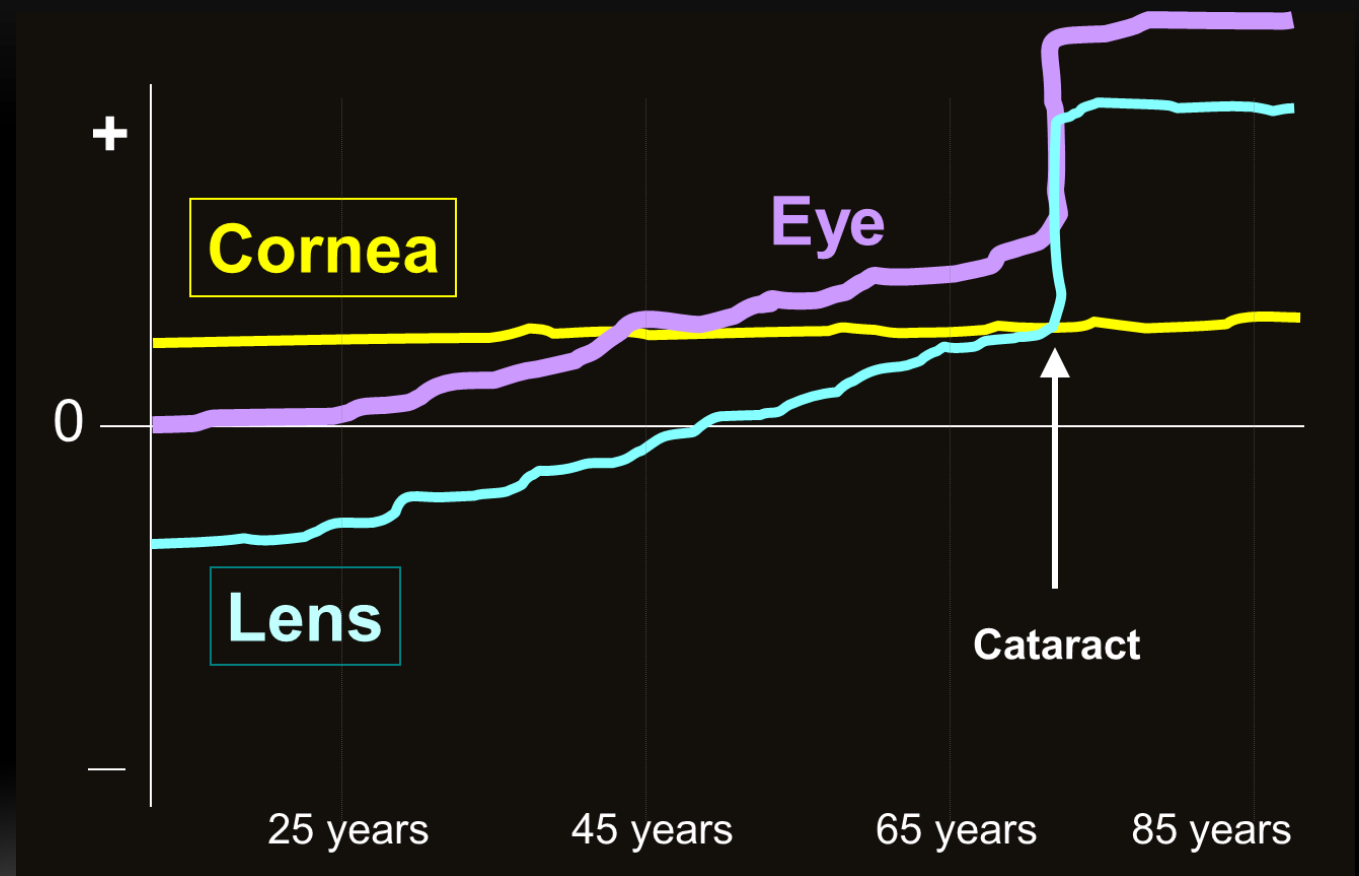
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SPHERICAL ABERRATION AND AGE

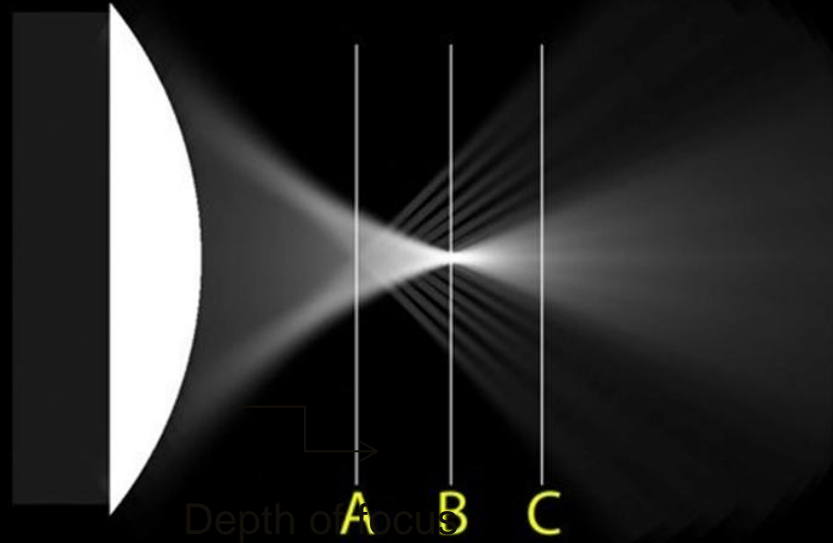
- Corneal spherical aberration (SA) is stable with age
- The aging crystalline lens becomes less negative (or even more positive)
- The total optical SA increases by adding to the positive corneal SA



SPHERICAL ABERRATION AND DEPTH OF FOCUS

Depth of Focus (DOF):
range of defocus error that
degrades the retinal image
quality.

Uncorrected spherical Aberration



A



B

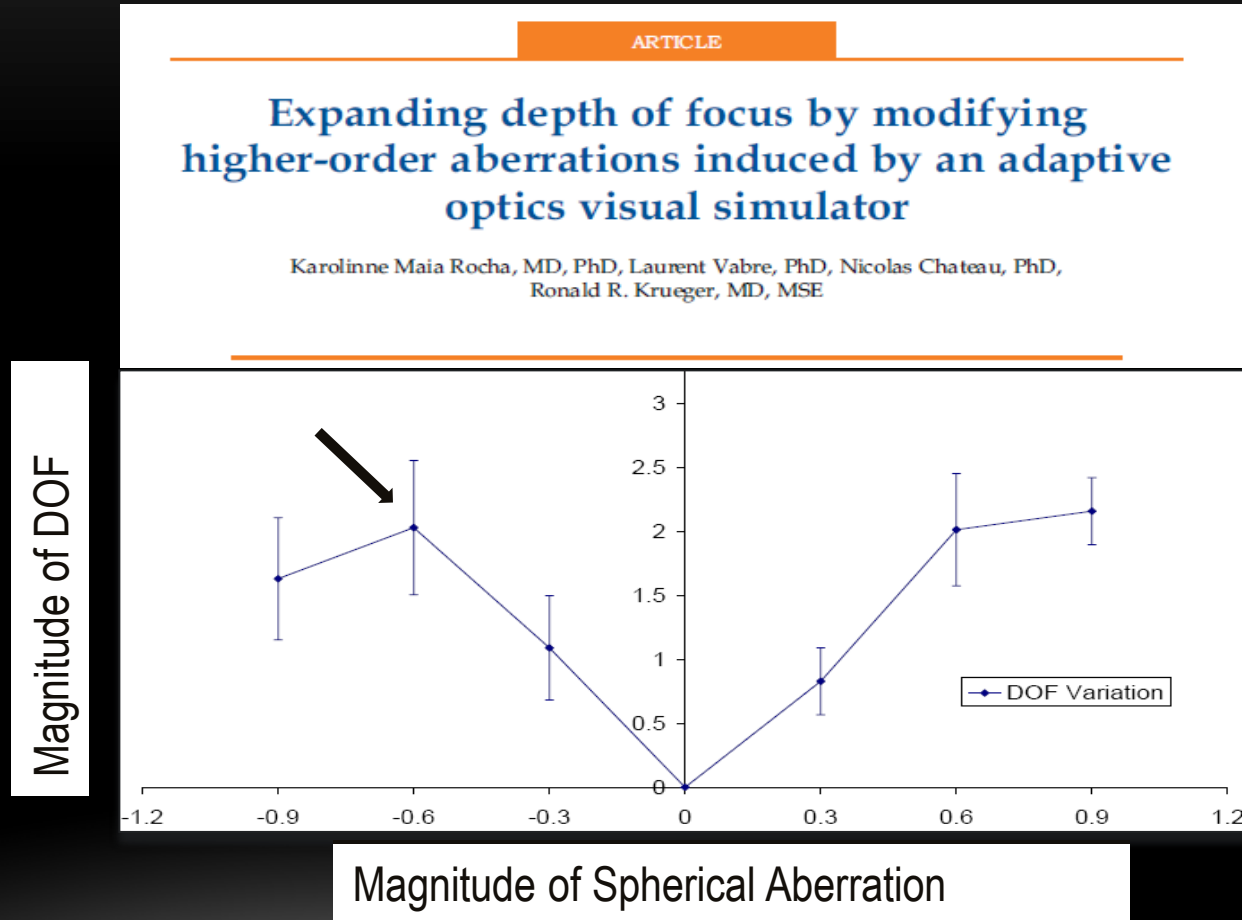


C



SPHERICAL ABERRATION AND DEPTH OF FOCUS

- Both positive and negative spherical aberration expands the DOF
- DoF curve strongly increased (up to 2D) as spherical aberration was increased to ± 0.6 microns.



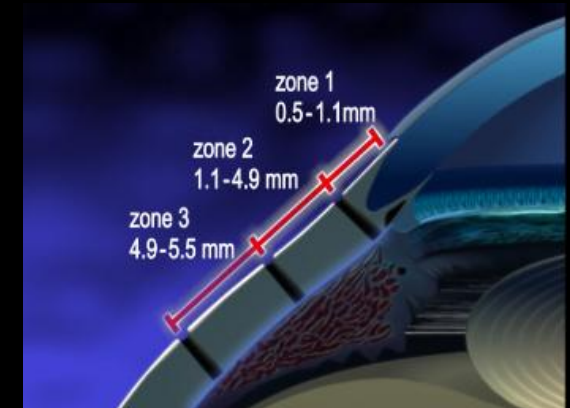
RAY-TRACING EVALUATION OF PSEUDO VS TRUE ACCOMMODATION IN PATIENTS S/P LASER ANTERIOR CILIARY EXCISION

Purpose: Define changes in spherical aberration, Coma, Trefoil, and defocus during dynamic accommodation in patients following a procedure for presbyopic restoration.

- 6 presbyopia patients underwent bilateral laser anterior ciliary excision.
- iTrace measurements were performed at distance and 40 cm to assess accommodative ability.

LASER ANTERIOR CILIARY EXCISION

- Theory: scleral excisions in 3 physiologically critical zones partially restores biomechanics of the accommodative system.
- Procedural objective:
 - Restore mechanical efficiency of the natural accommodative mechanism.
 - Improve biomechanical mobility to achieve accommodative power
- Procedural Methods:
 - Nine excisions per quadrant
 - 600 μ m spot size in mathematical diamond matrix pattern using Er:Yag laser with fiber optic probe
 - Each matrix performed in four oblique quadrants



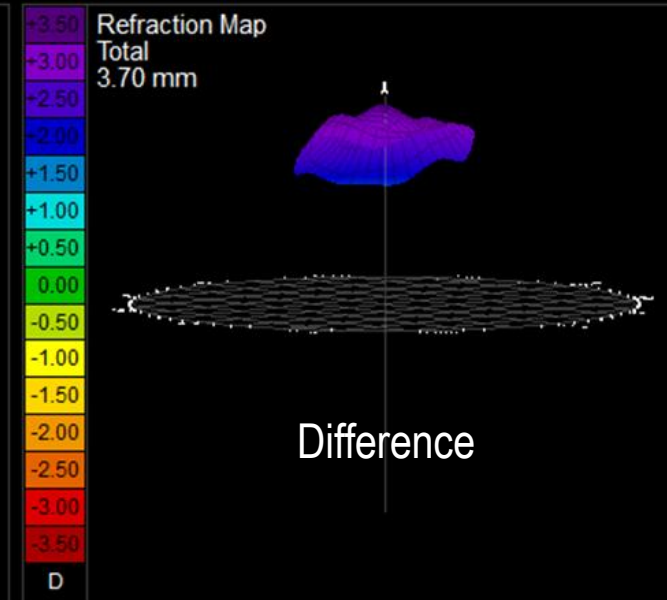
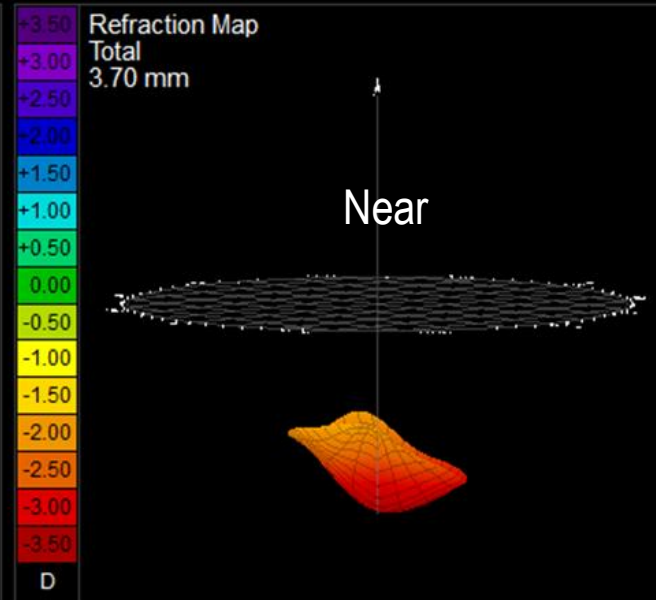
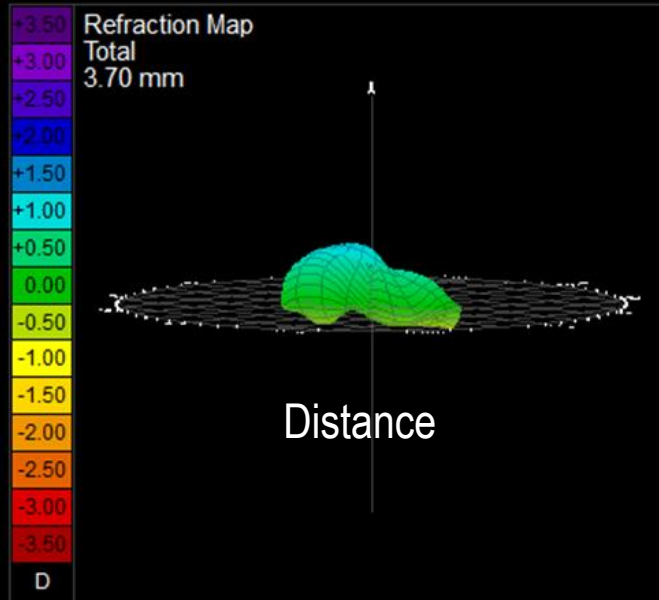
OBJECTIVE MEASUREMENT OF TRUE ACCOMMODATION



WF Comparison Display

HOYA iTrace
Surgical Workstation

K. F. Accomodation young patient
ID: 18



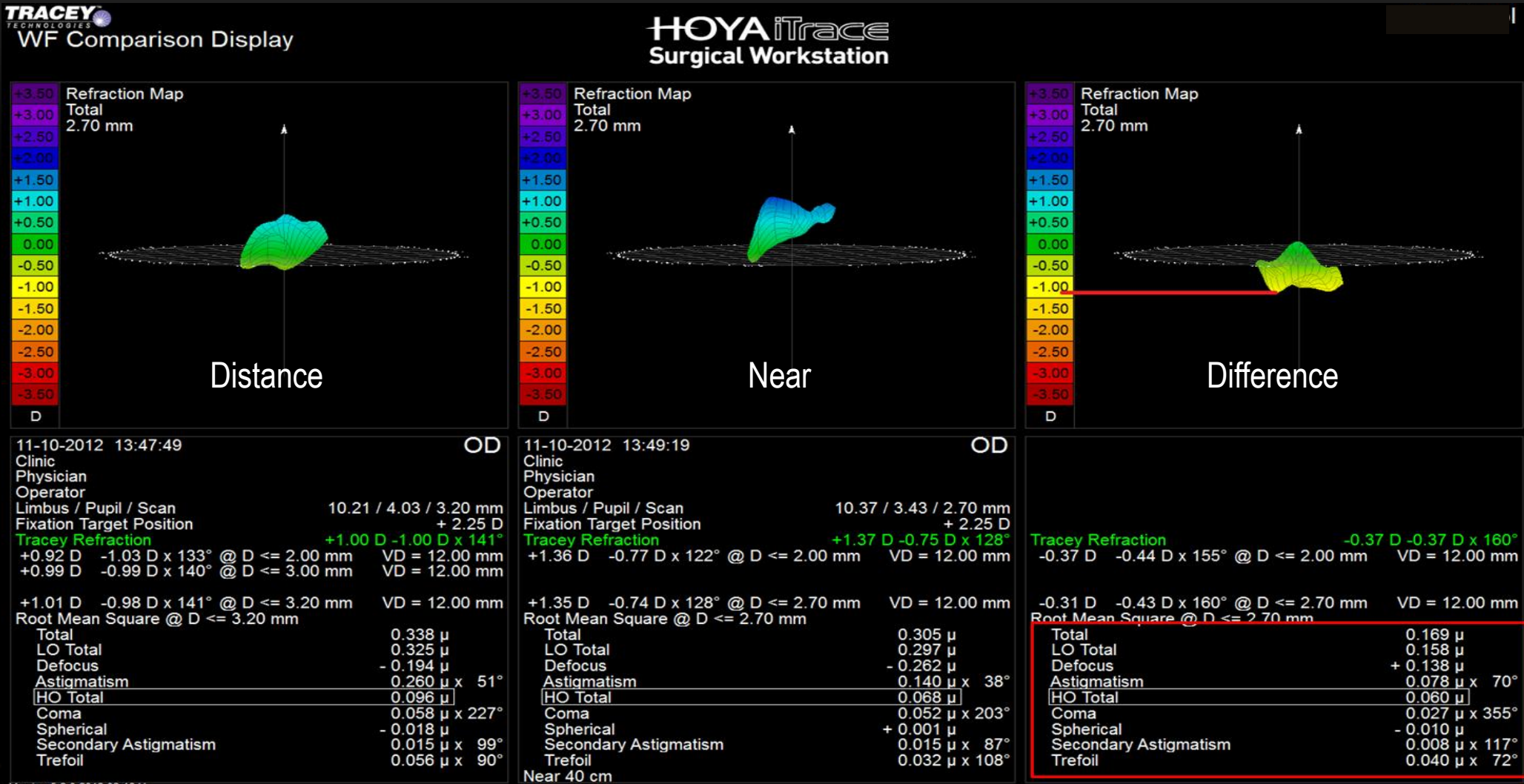
04-21-2009 05:35:32 OD
Clinic
Physician
Operator
Limbus / Pupil / Scan 12.05 / 4.56 / 3.70 mm
Fixation Target Position + 0.50 D
Tracey Refraction +0.50 D -0.62 D x 123°
+0.62 D -0.83 D x 130° @ D <= 2.00 mm = 12.00 mm
+0.58 D -0.75 D x 125° @ D <= 3.00 mm = 12.00 mm
+0.52 D -0.65 D x 123° @ D <= 3.70 mm = 12.00 mm

04-21-2009 06:58:22 OD
Clinic
Physician
Operator
Limbus / Pupil / Scan 11.91 / 5.51 / 4.70 mm
Fixation Target Position - 1.75 D
Tracey Refraction -2.25 D -0.75 D x 133°
-2.30 D -1.13 D x 128° @ D <= 2.00 mm = 12.00 mm
-2.30 D -0.94 D x 131° @ D <= 3.00 mm = 12.00 mm
-2.13 D -0.73 D x 132° @ D <= 4.70 mm = 12.00 mm

Tracey Refraction +2.75 D -0.25 D x 69°
+2.98 D -0.21 D x 34° @ D <= 2.00 mm = 12.00 mm
+2.89 D -0.21 D x 65° @ D <= 3.00 mm = 12.00 mm
+2.81 D -0.24 D x 69° @ D <= 3.70 mm = 12.00 mm

- The iTrace (Houston, TX) objectively measures refraction and HOAs.
- A refractive difference between distance and near refraction demonstrates true accommodation.

OBJECTIVE MEASUREMENT OF PSEUDOACCOMMODATION



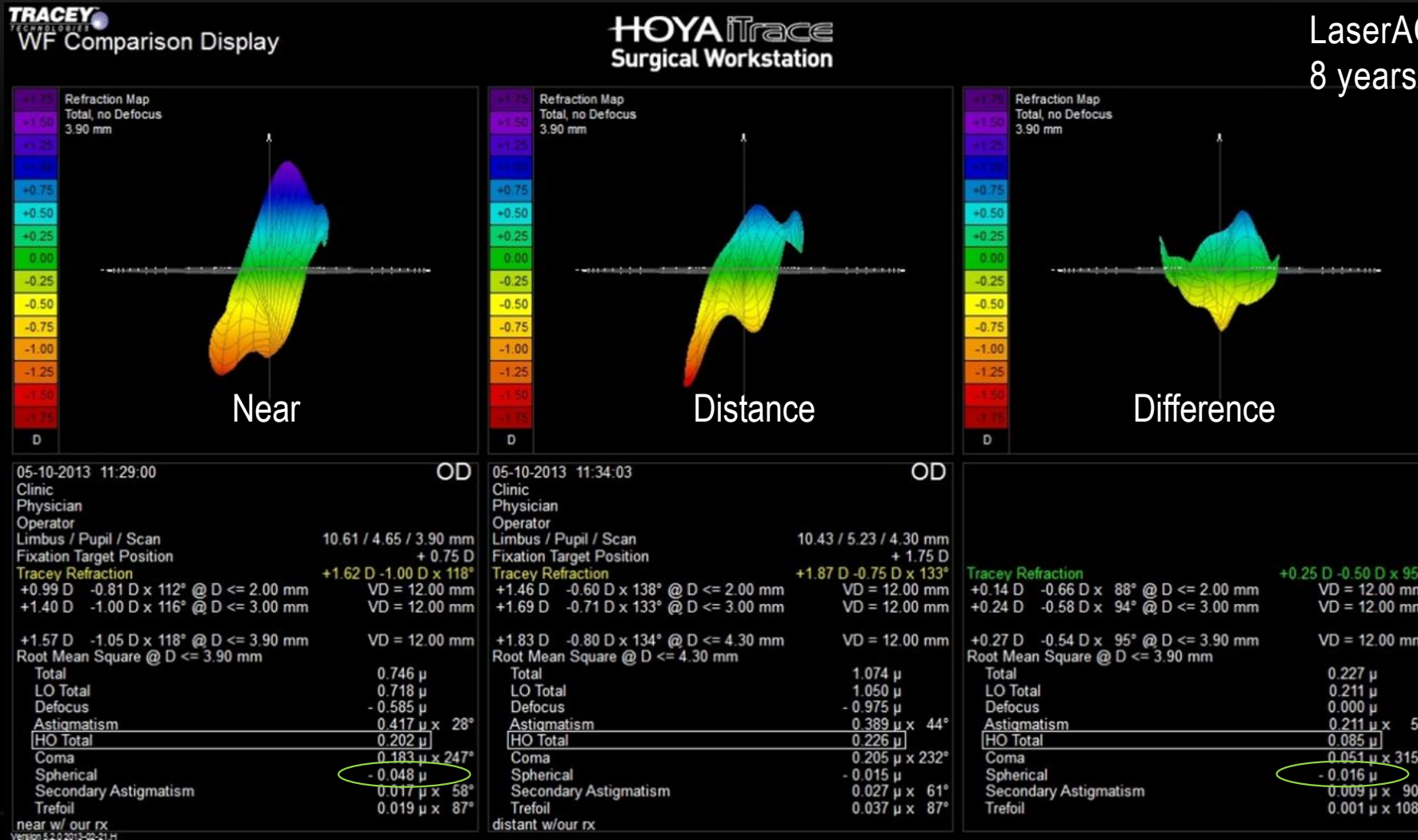
The iTrace compares HOAs at distance and near to determine the change in aberrations: total eye, coma, spherical aberration, trefoil, and secondary astigmatism.

DYNAMIC WAVEFRONT ANALYSIS OF ACCOMMODATION

- Six patients S/P laser anterior ciliary excision were evaluated:
 - 3 short-term patients (0-6 months)
 - 3 long-term patients(6-8yrs)
- ITrace difference maps were created for each patient

Difference Distance to Near BCVA	Mean Rx	Total Aberration	Total HOA	Spherical Ab	Coma	Trefoil
N = 6	0.04	0.15	0.11	-0.011	0.06	0.0005
SD	± 0.03	± 0.08	± 0.07	± 0.021	± 0.05	± 0.007

SPHERICAL ABERRATION AND DEPTH OF FOCUS



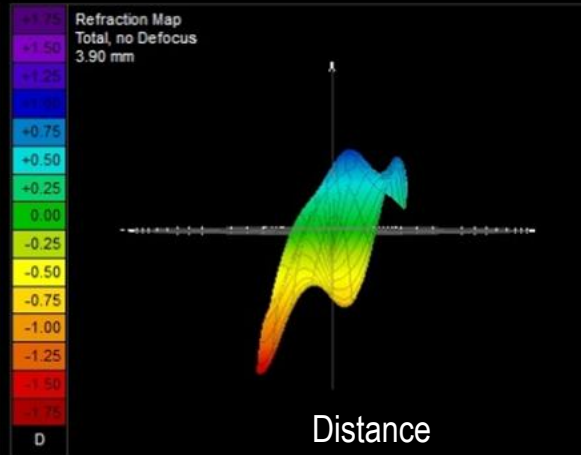
- Specific HOA have a greater impact on depth of focus, visual acuity and quality
- SA shifts toward negative values during accommodation

SPHERICAL ABERRATION AND DEPTH OF FOCUS

TRACEY
TECHNOLOGIES
WF Comparison Display

HOYA Trace
Surgical Workstation

LaserACE patient
8 years after procedure.



05-10-2013 11:29:00 OD

Clinic
Physician
Operator
Limbus / Pupil / Scan 10.61 / 4.65 / 3.90 mm
Fixation Target Position + 0.75 D
Tracey Refraction +1.62 D -1.00 D x 118°
+0.99 D -0.81 D x 112° @ D <= 2.00 mm VD = 12.00 mm
+1.40 D -1.00 D x 116° @ D <= 3.00 mm VD = 12.00 mm

+1.57 D -1.05 D x 118° @ D <= 3.90 mm VD = 12.00 mm
Root Mean Square @ D <= 3.90 mm

Total	0.746 μ
LO Total	0.718 μ
Defocus	-0.585 μ
Astigmatism	0.417 μ x 28°
HO Total	0.202 μ
Coma	0.183 μ x 247°
Spherical	-0.048 μ
Secondary Astigmatism	0.017 μ x 58°
Trefoil	0.019 μ x 87°

near w/ our rx
Version 5.2.0 2013-02-21.H

05-10-2013 11:34:03 OD

Clinic
Physician
Operator
Limbus / Pupil / Scan 10.43 / 5.23 / 4.30 mm
Fixation Target Position + 1.75 D
Tracey Refraction +1.87 D -0.75 D x 133°
+1.46 D -0.60 D x 138° @ D <= 2.00 mm VD = 12.00 mm
+1.69 D -0.71 D x 133° @ D <= 3.00 mm VD = 12.00 mm

+1.83 D -0.80 D x 134° @ D <= 4.30 mm VD = 12.00 mm
Root Mean Square @ D <= 4.30 mm

Total	1.074 μ
LO Total	1.050 μ
Defocus	-0.975 μ
Astigmatism	0.389 μ x 44°
HO Total	0.226 μ
Coma	0.205 μ x 232°
Spherical	-0.015 μ
Secondary Astigmatism	0.027 μ x 61°
Trefoil	0.037 μ x 87°

distant w/our rx

Tracey Refraction +0.25 D -0.50 D x 95°

+0.14 D -0.66 D x 88° @ D <= 2.00 mm VD = 12.00 mm
+0.24 D -0.58 D x 94° @ D <= 3.00 mm VD = 12.00 mm

+0.27 D -0.54 D x 95° @ D <= 3.90 mm VD = 12.00 mm
Root Mean Square @ D <= 3.90 mm

Total	0.227 μ
LO Total	0.211 μ
Defocus	0.000 μ
Astigmatism	0.211 μ x 5°
HO Total	0.085 μ
Coma	0.051 μ x 315°
Spherical	-0.016 μ
Secondary Astigmatism	0.009 μ x 90°
Trefoil	0.001 μ x 108°

- Note the reduction in hyperopia while viewing the 40 cm target and change in spherical aberration.

CONCLUSIONS

- Ray-tracing technology can objectively measure dynamic accommodation and is a critical device to differentiate true accommodation from pseudo-accommodation
 - Specific optical correlations were identified during dynamic accommodation pre-op/post-op LaserACE which may explain the improvement in dynamic accommodative capacity and visual acuity in these patients
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