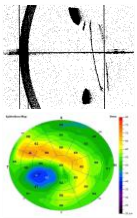
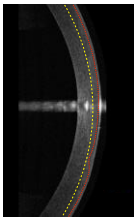
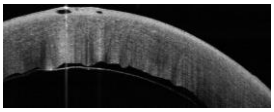
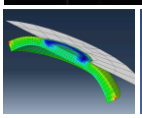
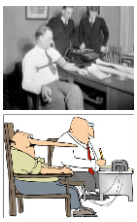




Baylor College of Medicine

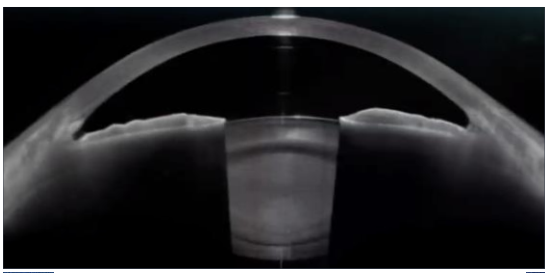
Novel Applications of Leading Edge OCT for the Diagnosis & Treatment of Anterior Segment Disease

MP Weikert, MD ◆ Forum on Laser-Based Imaging ◆ Washington, DC ◆ April 8, 2019

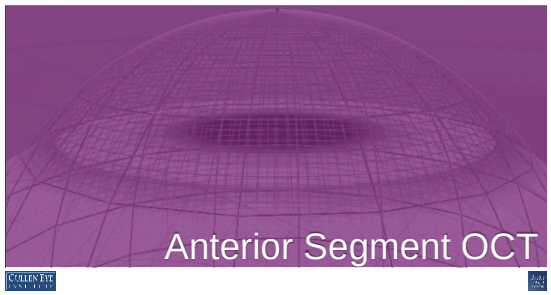

Disclosures

Alcon Laboratories, Inc. (C)
Ziemer Ophthalmic Systems, Inc. (C)



Optical Coherence Tomography

- Low coherence interferometry
- Evolution:
  - Time domain → Spectral (Fourier) domain → Swept source
  - Faster scan speeds (up to 100,000 A-scans/sec)
  - Higher resolution (axial → 5 µm, transverse → 15 µm)
  - Deeper penetration (IR)



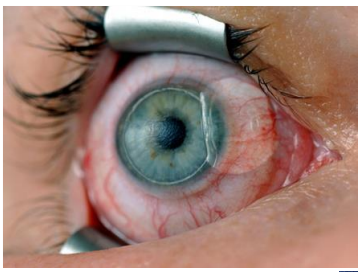
Anterior Segment OCT

1. Clinical Imaging
2. Biometric Applications
3. Biomechanical Assessment
4. Intraoperative Guidance

Clinical Imaging

Clinical Imaging

- Post-LASIK poor vision
- 28-y/o ♂ presented double vision after LASIK OD:
  - Prolonged steroid treatment
  - Monocular diplopia
- UCVA:
  - OD: 20/25-2
  - OS: 20/20+2
- MR:
  - OD: -0.50 +1.25 x 170 20/25+2
  - OS: -0.50 +0.25 x 110 20/15



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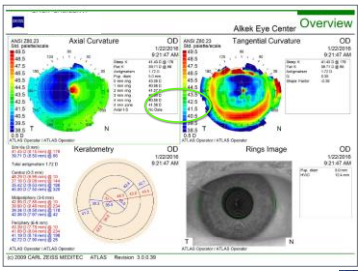

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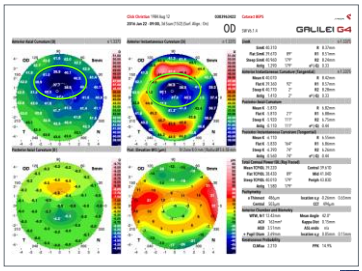

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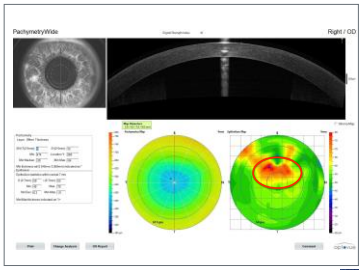

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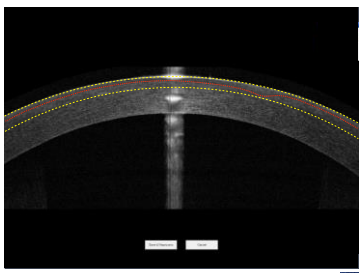
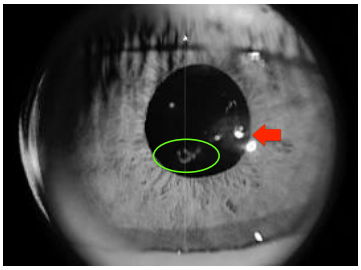


Clinical Imaging

- Post-LASIK poor vision
- Post-LASIK foreign body



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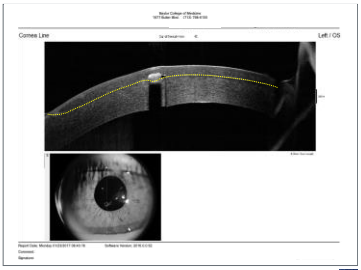

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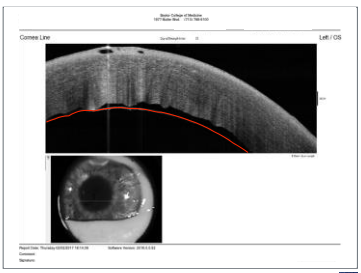

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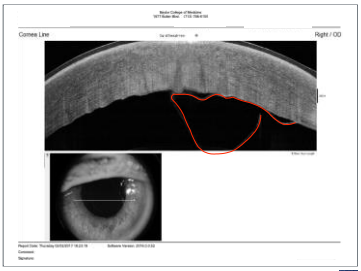

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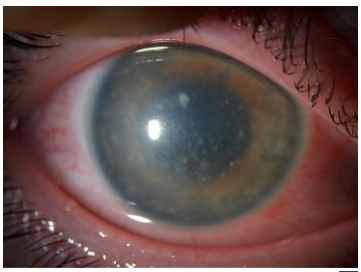
- Intracorneal deposits & anterior stromal irregularity



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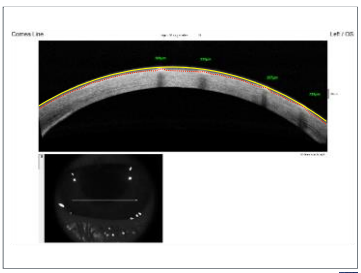

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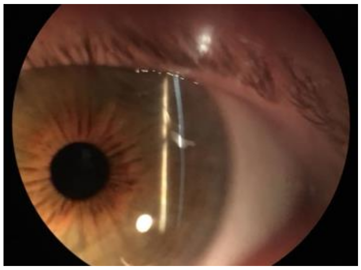

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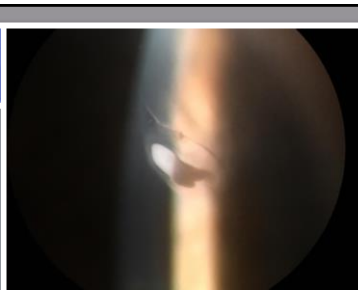

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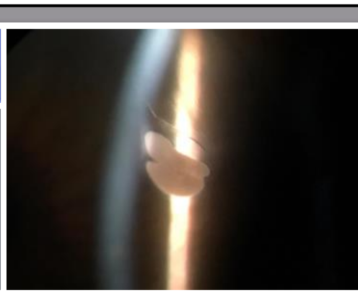

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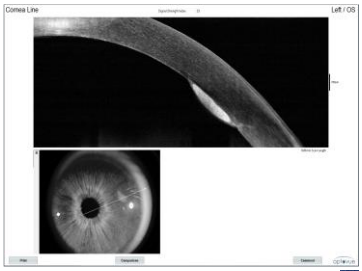

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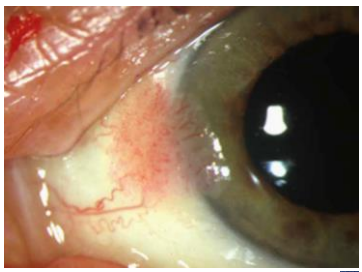

*Nanji AA, et al. Int Ophthalmol Clin; 57(3):47-62

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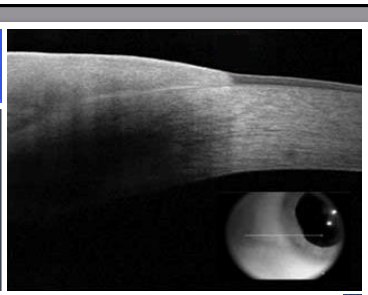

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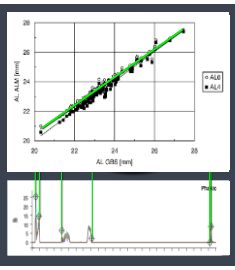
Biometric Applications

Biometric Applications

- Axial Length Measurement:
  - Current displayed ALs utilize "group refractive index"
    - Average refractive index across optical segments
    - Optical path length regression fit to U/S
    - Under-represented at AL extremes
    - "Segmented" AL available



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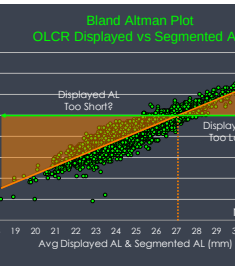

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Biometric Applications

- Total Keratometry (TK):
  - Anterior keratometric measurements
  - Posterior SS-OCT measurements
- Pre- & Post-CE/IOL:
  - Crystalline lens & IOL tilt
  - Mean CL tilt = 3.6° ± 1.1° (1.1° - 6.7°)
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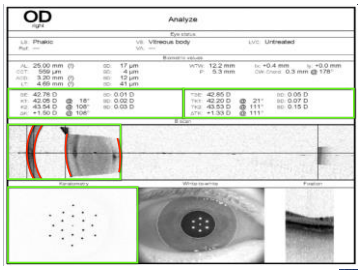

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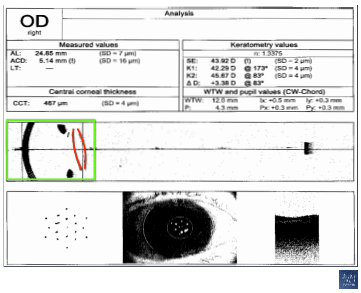
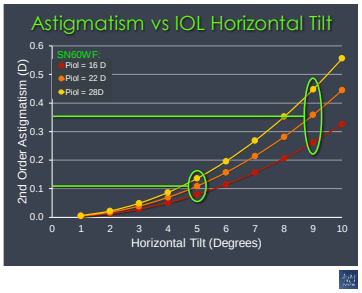


Biometric Applications

- Aspheric (Non-Toric IOL):
  - Induced ATR astigmatism
  - Horizontal tilt around vertical meridian
  - Astigmatism magnitude ↑ w/ ↑ Tilt & ↑ IOL power



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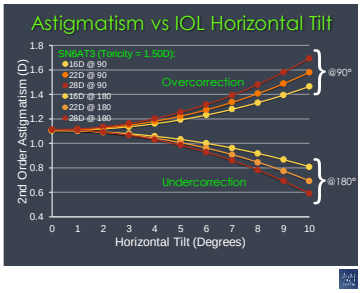

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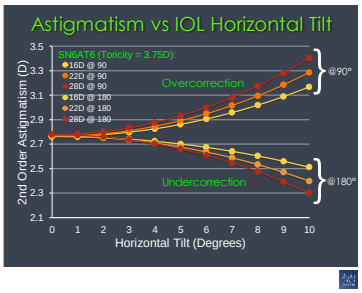

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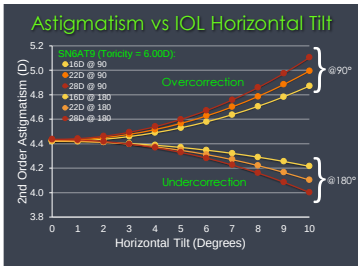
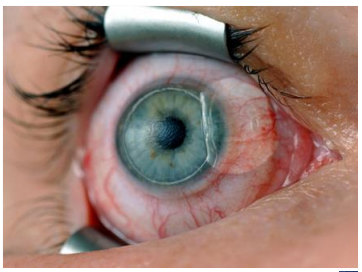


Biometric Applications

- Post-Laser Refractive Surgery
  - True corneal power?
  - Effective lens position (ELP)?
- 65-y/o ♂ with:
  - h/o LASIK OU
  - Monovision - OS near



IOL Calculations

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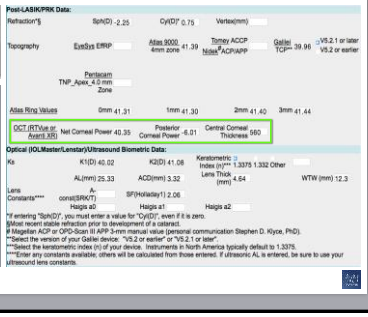

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- 65-y/o ♂ with:
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- Recommended IOL (Tgt -1.50)
  - Range 21.0 to 23.5D
  - Chosen IOL = 23.0D
  - UCVA J1+
  - MR: -3.00 20/20

Using ΔMR		Using no prior data	
[1]Adjusted EffRP	--	[2]Wang-Koch-Maloney	22.08 D
[2]Adjusted Atlas 9000 (4mm zone)	21.73 D	[2]Shammas	23.58 D
[1]Adjusted Atlas Ring Values	22.49 D	[3]Haigis-L	23.05 D
Masket Formula	23.00 D	[1]Galilei	21.10 D
Modified-Masket	23.27 D	[2]Potvin-Hill Pentacam	--
[1]Adjusted ACCP/ACP/APP	--	[4]OCT	21.41 D
[5]Barrett True K	22.72 D	[5]Barrett True K No History	23.12 D

Average IOL Power (All Available Formulas): 22.51 D
Min: 21.10 D
Max: 23.58 D

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Calculation Method	Refractive Prediction Error (D)
Clinical History	-1.60
Masket	-1.50
Modified Masket	-1.68
Adjusted Atlas	-0.68
Wang-Koch-Maloney	-0.89
Shammas	-1.89
Haigis-L	-1.49
Barrett True-K	-1.31
Barrett True-K - No Hx	-1.58
OCT	-0.44
ORA	-1.33

IOL PREDICTION ERROR (MAE)

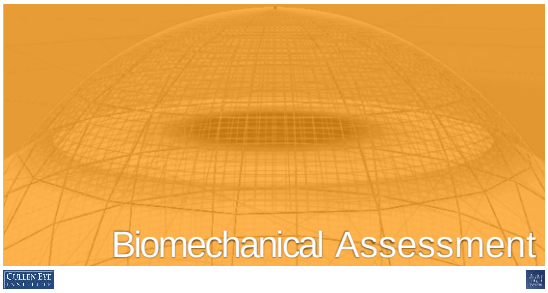
(POST-OP EMMETROPIC IOL POWER - PREDICTED IOL POWER)

n = 104

IOL Calculations

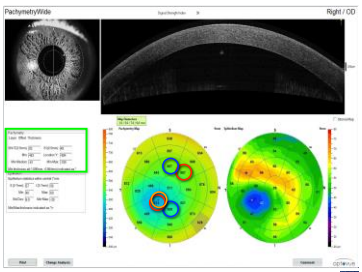
- Retrospective review:
  - 104 Eyes
  - No LASIK/PRK data known
- Formulas compared:
  - OCT performed best out of individual formulas
  - Average of OCT, Barrett True K, & Haigis-L performed best overall

*In-House Data



Biomechanical Assessment

- OCT pachymetry
  - Indirect (via "shape")
- Normal (n = 133) vs KCN (n = 82)
- Corneal pachymetric maps (8 meridional scans)
- 5-Variable regression formula



*Qin B, Huang D, et al. J Cataract Refract Surg 2013; 39(12):1864-1871

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- Normal (n = 133) vs KCN (n = 82)
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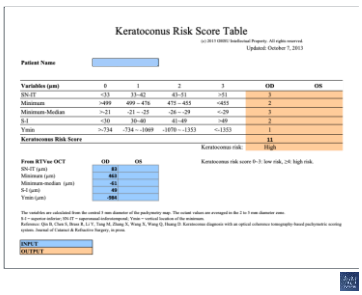
- 5-Variable regression formula
- KCN Risk scoring system
  - Low risk = 0-3
  - High risk ≥ 4
  - Sensitivity = 91%
  - Specificity = 93%



Keratoconus Risk Score Table

Updated: October 7, 2013

Patient Name

Variables (µm)	0	1	2	3	OD	OS
SN-IT	<33	33~42	43~51	>51	3	
Minimum	>499	499 ~ 476	475 ~ 455	<455	2	
Minimum-Median	>-21	-21 ~ -25	-26 ~ -29	<-29	3	
S-I	<30	30~40	41~49	>49	2	
Ymin	>-734	-734 ~ -1069	-1070 ~ -1353	<-1353	1	
Keratoconus Risk Score					11	
				Keratoconus risk:	High	

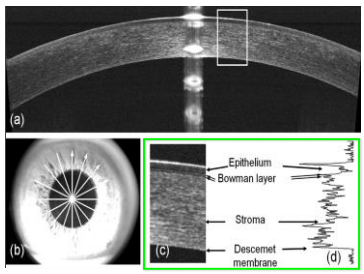
From RTVue OCT

	OD	OS
SN-IT (µm)	82	
Minimum (µm)	463	
Minimum-median (µm)	-62	
S-I (µm)	48	
Ymin (µm)	-984	

Keratoconus risk score 0~3: low risk, ≥4: high risk.

INPUT
OUTPUT

*Qin B, Huang D, et al. J Cataract Refract Surg 2013; 39(12):1864-1871

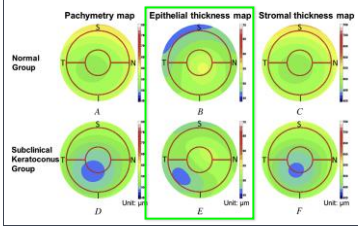


Biomechanics Assessment

- Epithelial thickness patterns
  - Indirect (via "shape")

*LI Y, Huang D, et al. J Cataract Refract Surg 2016; 42 (2):284-295

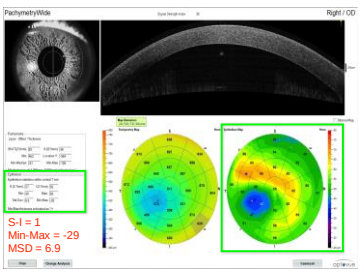
Average Pachymetric Maps



Biomechanics Assessment

- Epithelial thickness patterns
  - Indirect (via "shape")
- NI (n = 150) vs FF KCN (n = 50)
  - FF KCN = Inferotemporal thinning (stroma & epi)
- Epithelial uniformity variables:
  - S-I
  - Min-Max
  - Map Std Dev (MSD)
  - Pattern Std Dev (PSD)

*LI Y, Huang D, et al. J Cataract Refract Surg 2016; 42 (2):284-295



Biomechanics Assessment

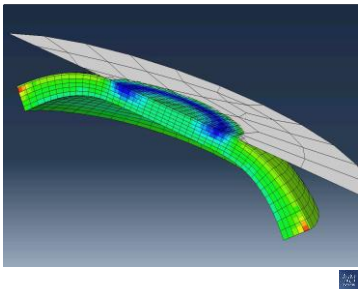
- Epithelial thickness patterns
  - Indirect (via "shape")
- NI (n = 150) vs FF KCN (n = 50)
  - FF KCN = Inferotemporal thinning (stroma & epi)
- Epithelial uniformity variables:
  - S-I → 3.0 ± 4.9 µm
  - Min-Max → -15.5 ± 7.1 µm
  - MSD → 4.1 ± 1.9
  - PSD → 0.104 ± 0.024

Epi PSD Best → Sensitivity 96%, Specificity 100%, AUROC 0.985

*LI Y, Huang D, et al. J Cataract Refract Surg 2016; 42 (2):284-295

OCT Elastography

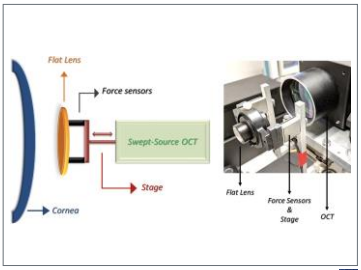
- Cornea is viscoelastic:
  - Nonlinear relationship b/w stress (force/area) & strain (deformation)
- Cornea biomechanics are also spatially dependent



*DeStefano VS, et al. PLoS One 2018; 13(12):e0209480

OCT Elastography

- Cornea is viscoelastic:
  - Nonlinear relationship b/w stress (force/area) & strain (deformation)
- Cornea biomechanics are also spatially dependent
- Measure response to applied force by tracking OCT speckle pattern



*DeStefano VS, et al. PLoS One 2018; 13(12):e0209480

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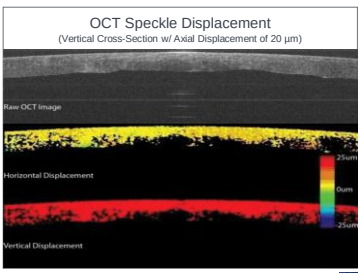
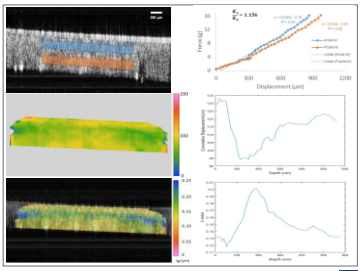


Ford MR, et al. J Biomed Optics 2011; 16(1):016005-1-7.

OCT Elastography

- Cornea is viscoelastic:
  - Nonlinear relationship b/w stress (force/area) & strain (deformation)
- Cornea biomechanics are also spatially dependent
- Measure response to applied force by tracking OCT speckle pattern
- Determine depth-dependence of corneal stiffness

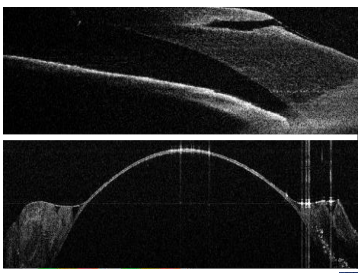


*DeStefano VS, et al. PLoS One 2018; 13(12):e0209480

Intraoperative Applications

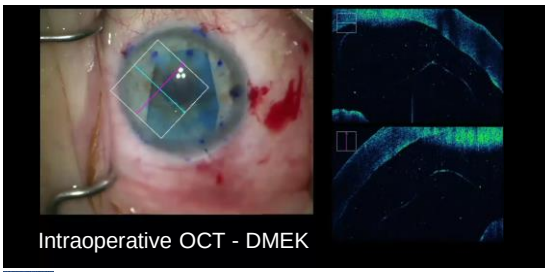
Intraoperative Applications

- Zeiss Rescan® 700:
  - Integrated into the Lumera 700
  - Foot pedal control
  - Heads-up display
  - Potential to integrate w/ IOL Master 700 & Callisto
- Leica EnFocus®:
  - Requires adapter
  - Foot pedal control
  - No heads-up display



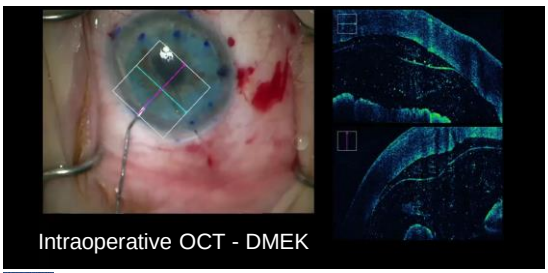
Muftuoglu O, et al. J Cataract Refract Surg 2013; 39:1348-1357

Intraoperative OCT - DSAEK



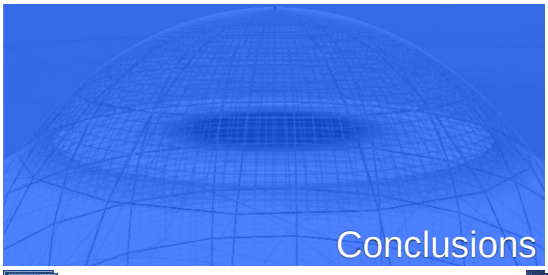
Intraoperative OCT - DMEK

*Courtesy of BJ Dupps, MD



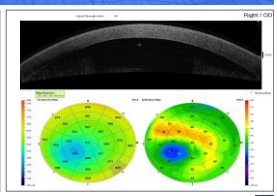
Intraoperative OCT - DMEK

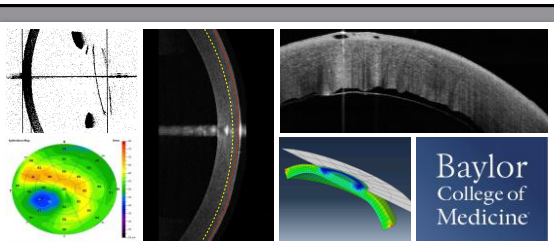
*Courtesy of BJ Dupps, MD



Conclusions

- OCT has substantially improved in image quality
- Increased speed, resolution, & penetration expand applications
  - Clinical imaging
  - Biometric applications
  - Biomechanical assessment
  - Intraoperative guidance





Novel Applications of Leading Edge OCT for the Diagnosis & Treatment of Anterior Segment Disease

MP Weikert, MD ◆ Forum on Laser-Based Imaging ◆ Washington, DC ◆ April 8, 2019