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

MP Weikert, MD

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

Clinical Imaging
Biometric Applications
Biomechanical Assessment
Intraoperative Guidance
Clinical Imaging

Post-LASIK poor vision
- 28-y/o presented double vision after LASIK OD.
- Prolonged steroid treatment
- Monocular diplopia
- UCVA:
  - OD: 20/25
  - 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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Clinical Imaging

- Post-LASIK poor vision
- Post-LASIK foreign body
- DMEK detachment
Clinical Imaging

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- Intracorneal deposits & anterior stromal irregularity
- Corneal opacities & post-cataract surgery abnormalities
Clinical Imaging

- Post-LASIK poor vision
- Post-LASIK foreign body
- DMEK detachment
- Intracorneal deposits & anterior stromal irregularity
- Corneal opacities & post-cataract surgery abnormalities
- Ocular surface neoplasia

Biometric Applications

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

Axial Length Measurement:
Displayed AL vs Segmented AL

Bland Altman Plot
- Displayed AL vs Segmented AL
- N = 7144

Biometric Applications

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- "Segmented" AL may improve accuracy of IOL calculations

**Biometric Applications**

- **Axial Length Measurement**
  - Current displayed ALs utilize group refractive index
  - Average refractive index across optical segments
  - Optical path length regression fits US
  - Under-represented at AL extremes
  - "Segmented" AL available
  - "Segmented" AL may improve accuracy of IOL calculations

- **Total Keratometry (TK)**
  - Anterior keratometric measurements
  - Posterior SS-OCT measurements

- **Pre & Post-CIOL**
  - Crystalline lens & IOL tilt
  - Mean CL tilt = 3.6° ± 1.1° (1.1° - 6.7°)
  - Mean IOL tilt = 4.8° ± 1.6° (0.2° - 9.3°)

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Biometric Applications

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

- Toric IOLs:
  - 
    - Overcorrection
    - Undercorrection
  - Effect depends upon IOL toricity
**IOL Calculations**

- Post-Laser Refractive Surgery
- True corneal power?
- Effective lens position (ELP)?
- 65-yr-old with:
  - h/o LASIK OU
  - Monovision - OD near
  - Recommended IOL, Tgt -1.50
  - Range 21.0 to 23.5D
  - Chosen IOL = 23.0D
  - UCVA J1+
  - MR: -3.00 20/20

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**Calculation Method**

- Refractive Prediction Error (D)

<table>
<thead>
<tr>
<th>Method</th>
<th>Refractive Prediction Error (D)</th>
</tr>
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<tbody>
<tr>
<td>Clinical History</td>
<td>-1.60</td>
</tr>
<tr>
<td>Masket</td>
<td>-1.50</td>
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<tr>
<td>Modified Masket</td>
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<td>Adjusted Atlas</td>
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<td>Barrett True-K : No Hx</td>
<td>-1.58</td>
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<tr>
<td>OCT</td>
<td>-0.44</td>
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<tr>
<td>ORA</td>
<td>-1.33</td>
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</tbody>
</table>

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**IOL Prediction Error (MAE)**

- Post-OP Emmetropic IOL Power - Predicted IOL Power
- No Prior Data
- Retrospective review
- 104 Eyes
- No LASIK/PRK data known
- Formulas compared:
  - OCT performed best out of individual formulas
  - Average of OCT, Barrett True-K
  - A weighted, performed best overall

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Biomechanical Assessment

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

KCN Risk Scoring System
- Low risk = 0 - 3
- High risk ≥ 4
- Sensitivity = 91%
- Specificity = 93%
Biomechanics Assessment

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

Average Pachymetric Maps

Epithelial thickness patterns:
- Indirect (via "shape")
- N (n = 150) vs FF KCN (n = 50)

Epithelial uniformity variables:
- S_I
  - Min-Max
  - Map Std Dev (MSD)
  - Pachek Std Dev (PSD)
  - Epi PSD Best

S_I = 3.0 ± 4.9 µm
Min-Max = 29
MSD = 6.9
PSD = 0.104 ± 0.024

Epi PSD Best → Sensitivity 96%, Specificity 100%, AUROC 0.985
Cornea is viscoelastic:
- Nonlinear relationship between stress (force/area) and strain (deformation)
- Cornea biomechanics are also spatially dependent

Measure response to applied force by tracking OCT speckle pattern


OCT Elastography

**OCT Elastography**

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

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**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

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Conclusions

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

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