Clinical Applications of Anterior Segment OCT

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What Does Anterior Segment OCT Do?

- 2-dimensional cross section image of the anterior segment
  - Conjunctiva
  - Cornea
  - Anterior chamber
  - Iris/Angle
  - Lens
  - Sclera

Understanding Anterior Segment OCT

- Vendors
- How does AS-OCT work?
- Technical aspects
- What does AS-OCT measure?
- How is AS-OCT used clinically?

Image Anterior Segment

- Low magnification image

Image Anterior Segment

- High magnification image

Anterior Segment OCT Vendors

- Bioptigen Handheld OCT
  - Heidelberg Spectralis- AAO 2011
  - Opko Spectral OCT SLO
  - Optovue RT-Vue with CAM
  - iVue
  - Topcon AAO 2011
  - Zeiss Visante and Cirrus

Bioptigen

Courtesy of Sunita Sayeram and Joseph Vance

Heidelberg Spectralis

Courtesy of Tim Steffens

Opko Spectral OCT SLO

Courtesy of Opko
**Optovue RT-Vue with CAM**

Courtesy of Bruno Bertoni, CRA, OCT-C and Tamera Davis, CRA

**Zeiss Cirrus**

4mm scan length

Internal optics

Software alignment needed

**Zeiss Stratus**

This is not FDA approved!

**Zeiss Stratus**

1 Week After Phaco and 1-Piece Posterior Chamber IOL

**Zeiss Visante**

Courtesy of Alexis Smith, OCT-C, CRA

**1 Week After Phaco and 1-Piece Posterior Chamber IOL**

**Dislocated IOL**

IOL in the Capsular Bag

**Tecnis One-Piece**

**Causes of the Dislocated IOL**

- IOL not in capsular bag but in ciliary sulcus
- Ruptured zonules
- Hole in posterior capsule
- Broken haptic
- Crimped haptic

Courtesy of Zeiss
Relationship Between the IOL and the Capsular Bag?

- How can I obtain a 2-dimensional cross-sectional image of the anterior segment of the eye?
  - Anterior segment OCT
  - Immersion B-scan ultrasound

Ultrasound Biomicroscopy (UBM)

- 2-dimensional cross-sectional image of anterior segment
- Multiple meridians

OCT Versus UBM

- 2-dimensional cross-sectional images of anterior segment
- Multiple meridians
- OCT provides more fine detail and magnified image
- OCT non-contact versus UBM contact (water bath)
- OCT more useful to the anterior segment surgeon because easy to use

Dislocated IOL UBM

- 4:00
- IOL haptic truncated

OCT Specifications Comparison

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Stratus</th>
<th>Cirrus</th>
<th>Visante</th>
<th>RT-Vue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Width</td>
<td>6.0 mm</td>
<td>6.0 mm</td>
<td>2.95 mm</td>
<td>5.5 mm</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>2.0 µm</td>
<td>0.6 µm</td>
<td>0.7 µm</td>
<td>1.0 µm</td>
</tr>
<tr>
<td>Transverse Resolution</td>
<td>2.0 µm</td>
<td>1.5 µm</td>
<td>1.0 µm</td>
<td>1.5 µm</td>
</tr>
<tr>
<td>Scan Depth</td>
<td>2.0 mm</td>
<td>2.3 mm</td>
<td>2.3 mm</td>
<td>2.2 mm</td>
</tr>
<tr>
<td>Optical Power</td>
<td>125 µW</td>
<td>125 µW</td>
<td>100 µW</td>
<td>750 µW</td>
</tr>
</tbody>
</table>

Visante is designed specifically for Anterior Segment OCT.

OCT Versus UBM

- MD or photographer performs UBM
- Photographer performs OCT
- OCT and UBM require communication between MD and photographer
- Anatomic structure(s)
  - Location
  - Magnification
  - Imaging protocol

What Are the Technical Aspects of Anterior Segment OCT?

OCT and UBM require communication between MD and photographer.
**Anterior Segment Specifications**

- **Specifications Visante RT-Vue**
  - SLD Wavelength: 1310 nm, 840 nm
  - Optical Power: < 6500 µW, 750 µW

  The longer wavelength of light and stronger optical power allow TD technology to penetrate deeper into the angle.
  
  The shorter wavelength of light and lower optical power make it possible for the SD technology to also image the retina.

**Anterior Segment Specifications**

- **Specifications Visante RT-Vue**
  - SLD Wavelength: 1310 nm, 840 nm
  - Scan Depth: 3 mm, 6 mm, 2-2.3 mm
  - Scan Length: 10 mm, 16 mm

  Higher wavelength allows for deeper scan depth and longer scan length.
  
  More scan depth is able to image cornea to lens.
  
  Longer scan length can image limbus to limbus.

**OCT Image Comparison**

- **Stratus 3 mm**
- **Visante 16 mm**
- **Cirrus 4 mm**
- **RT-Vue 8 mm**

  Longer scan length gives overview. Shorter scan length gives more resolution.

**Why is Scan Length Important?**

- **DSEK**
  - Limbus to Limbus Imaging is necessary to ensure proper attachment of the donor tissue
- **Scleral Contact Lens Fitting**
  - Needed to view the entire lens in one image
- **Glaucoma**
  - Able to measure both angles from one image.

**Slipped DSEK Comparison**

- **Longer vs Shorter Scan Length**

**Scleral Contact Lens**

**Glaucoma**

**Why Do I Image the Cornea?**

- Analysis of new corneal transplantation techniques
- Management of postop complications
- Document healing of surgical incisions
- Plan operations
- Management of corneal ulcers
- Evaluate extent of tumors of the ocular surface
- Measurements of the anterior segment

**Fuchs Corneal Dystrophy**

- Fuchs dystrophy
- Inherited disease of corneal endothelium
- Endothelium dysfunctional
- Corneal edema
- Vision decreases
- Guttae obscure endothelium
- Specular microscopy
**Corneal Endothelium Function**
- Pumps H₂O out of the cornea into the anterior chamber
- Keeps corneal stroma at 78% H₂O
- Transparent at thickness 550 μ
- Pachymetry is a measurement of corneal thickness
- Gauges health of cornea

**Corneal Edema**
- Hazy cornea
- Corneal folds

**Fuchs Dystrophy Treatment**
- Penetrating keratoplasty
- Full thickness recipient cornea removed
- Full thickness donor cornea sutured into place
- 360° full thickness corneal wound
- 1 year for visual rehabilitation
- Irregular healing of wound results in variable visual results due to astigmatism

**Penetrating Keratoplasty**
- Epithelial defect
- Irregular healing of full thickness incision

**DSEK: Descemet’s Stripping Endothelial Keratoplasty**
- Diseased endothelium removed (30 μ)
- Donor endothelium and stroma inserted (~150 μ)
- Small incision (5 mm)
- Rapid healing and visual rehabilitation in 30 to 60 days

**OCT to Monitor Health of DSEK**
- Position
- Attachment of graft to recipient
- Quality of interface
- Corneal thickness

**DSEK**

**DSEK 4 Weeks Post-op**
- Ultrasound pachymetry 549 μ
Ultrasound Pachymetry Incorrect

• Normal thickness 550 μ
• 30 μ endothelium and Descemet’s membrane removed
• 180 μ donor cornea implanted
• Pachymetry after DSEK should be at least 700 μ

DSEK 4 Weeks Postop

Visante Flap Tool

Corneal thickness 789 μ

Detached DSEK 1 Day Postop

Anterior Segment OCT

• DESK attachment 360° would indicate primary donor failure
  Require graft replacement
• DSEK detachment
  Reattach graft with air

DSEK Reattachment

1 day postop 1 week postop 7 weeks postop 4.5 months postop

Malpositioned DSEK

Malpositioned DSEK

Automated Global Pachymetry

180° meridian

Slipped inferiorly

Slipped inferiorly
Available Measurements

- Corneal thickness
- Anterior chamber depth
- Anterior chamber angle
- Incision
- Tumor

Corneal Thickness

- Corneal thickness 769 μ

Pachymetry Data Points

Global Pachymetry
- 16 line scans
- 2048 data points in one map

Pachmate Pachymetry
- 1 data point

Anterior Chamber Depth

Pre-Op

Post-Op

Measuring Angles

- AOD: angle-opening distance
- TIA: trabecular-iris angle
- TISA: trabecular-iris space area

Clear Corneal Incision

Descemet's detachment
Endothelial misalignment
Epithelial misalignment
Endothelial gape
Epithelial gape
Loss of coaptation

Tumors / Cysts

Unable to use measurement features in Raw Mode
Artifacts

Must understand what is real and what is artifact on the scan

Artifacts

• Corneal Reflex
• Inverted Image (in Spectral Domain)
• Shadowing
• Image Averaging
• Algorithm Failure
  – Pachymetry: Corneal surface lines
  – Pachymetry: Lids

Corneal Reflex

Inverted Image Spectral Domain

Shadowing?

Shadowing

Image Averaging

Top: Non-averaged Scans
Bottom: Averaged Scans

Averaging

Enhanced High Res Cornea Mode

Measuring with Averaging

Enhanced High Res Cornea Mode
How Else Does Anterior Segment OCT Help Me With Patients?

- Visualize Depth of Corneal Scar
- Dewarping Enhanced Mode
- Algorithm Failure Due to Lids
- Algorithm Failure Due to Corneal Surface Lines
- Algorithm Failure Due to Lids
- Algorithm Failure Due to Corneal Surface Lines
- Algorithm Failure Due to Corneal Surface Lines
Ocular Surface Tumors

- Does the tumor extend into the cornea, sclera, and anterior chamber angle?
- Plan operative procedure

Corneal and Conjunctival Intraepithelial Neoplasia

Infectious Keratitis

- Hazy cornea
- Difficult to see extent of corneal involvement
- Monitor response to medical therapy

Fungal Corneal Ulcer

Anterior Chamber Depth

- Important for IOL calculation
- Theoretical prediction formula: Haigis
- Required to predict the post-op position of the IOL
- Correct IOL power can be inserted
- 0.05 mm ACD error = 0.03 diopter IOL power error

Pre-op Phaco IOL Calculation

Anterior Chamber Depth

IOLMaster

Visante

Irregular Pupil

Gonioscopy

Peripheral anterior synechiae

Holes in iris
What Are the Issues for Billing Anterior Segment OCT?

Billing

- 0187-T: Temporary Code, Medicare reimbursement varied according to Medicare regions
- 92132: AMA established CPT code, Medicare covers this code. Some states may have a Local Medical Review Policy (LMRP) for specific diagnosis are covered.
- SCANNING COMPUTERIZED OPHTHALMIC DIAGNOSTIC REPORT, BILATERAL

Medicare leads to....

- Cigna Government Services: (TN, NC, ID)
- Highmark Medicare Services: (PA, DC, MD, DE, NJ)
- First Coast Service Options, Inc.: (FL, Puerto Rico, US Virgin Islands)
- Noridian Administrative Services: (ME, MA, VT, NH, RI)
- Palmetto GBA: (HI, CA, NV)
- Cahaba: (MN, MS, AL, GA)

Billing Codes

- 0187: ANATOMICAL NARROW ANGLE BORDERLINE GLAUCOMA
- 364.71: POSTERIOR SYNECHIAE OF IRIS
- 364.70: ADHESIONS OF IRIS UNSPECIFIED
- 364.64: EXUDATIVE CYST OF PARS PLANA
- 364.63: PRIMARY CYST OF PARS PLANA
- 364.62: EXUDATIVE CYSTS OF IRIS OR ANTERIOR CHAMBER
- 364.61: IMPLANTATION CYSTS OF IRIS AND CILIARY BODY
- 364.60: IDIOPATHIC CYSTS OF IRIS AND CILIARY BODY
- 364.59: OTHER IRIS ATROPHY
- 364.57: DEGENERATIVE CHANGES OF CILIARY BODY
- 364.56: DEGENERATIVE CHANGES OF CHAMBER ANGLE
- 364.54: DEGENERATION OF PUPILLARY MARGIN
- 364.53: PIGMENTARY IRIS DEGENERATION
- 364.52: IRIDOSCHISIS
- 364.51: ESSENTIAL OR PROGRESSIVE IRIS ATROPHY
- 224.0: BENIGN NEOPLASM OF EYEBALL EXCEPT CONJUNCTIVA CORNEA
- 224.0: BENIGN NEOPLASM OF EYEBALL EXCEPT CONJUNCTIVA CORNEA
- 190.4: MALIGNANT NEOPLASM OF CORNEA
- 190.0: MALIGNANT NEOPLASM OF EYEBALL EXCEPT CONJUNCTIVA CORNEA

Billing Codes

- 996.69: INFECTION AND INFLAMMATORY REACTION DUE TO OTHER LOCALIZED ORGANISM
- 996.53: MECHANICAL COMPLICATION OF PROSTHETIC OCULAR LENS
- 379.39: ANTERIOR DISLOCATION OF LENS
- 379.32: SUBLUXATION OF LENS
- 379.31: APHAKIA
- 379.33: ANTERIOR DISLOCATION OF LENS
- 379.32: SUBLUXATION OF LENS
- 379.31: APHAKIA
- 370.06: PERFORATED CORNEAL ULCER
- 370.05: MYCOTIC CORNEAL ULCER
- 371.73: CORNEAL STAPHYLOMA
- 371.72: DESCEMETOCELE
- 371.71: CORNEAL ECTASIA
- 370.03: CENTRAL OPACITY OF CORNEA
- 379.31: APHAKIA
- 379.33: ANTERIOR DISLOCATION OF LENS
- 379.32: SUBLUXATION OF LENS
- 379.31: APHAKIA
- 370.06: PERFORATED CORNEAL ULCER
- 370.05: MYCOTIC CORNEAL ULCER
- 371.73: CORNEAL STAPHYLOMA
- 371.72: DESCEMETOCELE
- 371.71: CORNEAL ECTASIA
Thanks for your help!

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