10/08/2013

Financial Disclosure

Amy Jost is a consultant to OptiMedica as part of the Medical Staff Advisory Board.
- Consulting work has no influence on this presentation
- Commercial products are mentioned as comparative discussions. The speaker has no financial interest in any of the products mentioned in this presentation.

Objectives:

- To review the various instruments utilized during Anterior Segment Testing
- Differentiate between various optical biometry devices
- Discuss Ultrasound Biomicroscopy and its benefits

Special Thanks

- Cara Fletcher, COA, co-author of this presentation

Instruments for Anterior Segment Testing at CEI-BA

- Optical Biometers:
  - IOLMaster
  - LenStar
- A-scans:
  - Immersion Ultrasound
  - Contact Ultrasound
- UBM (Ultrasound Biomicroscopy)
- Pachymetry
- ECC/Specular Microscopy
- Slit Lamp Camera
- Portable Slit Lamp
- Pupilometer
- PAM
- RAM

- Keratometers:
  - Manual Keratometer
  - Orbscan
  - Pentacam
  - Intact
  - Atlas Topographer
  - EyeSys Topographer
  - Auto-Keratometer
  - IOLMaster
  - LenStar
  - Hand Held Keratometer
  - Galilei G4

- Aberrometers:
  - WaveScan
  - Intact
  - Pentacam

Four Key Components Allow the Cataract Surgeon to Achieve The Planned Refractive Goal (for a normal eye)

- Axial length
- Keratometry
- IOL calculation and formulas
- Surgical technique
Normal Ranges

- Axial length = 22-25mm (average 23.5mm)
  - Axial length within 0.3mm between the two eyes
  - Shorter or longer, run special IOL formula
- K reading = 43 to 45 diopters
  - Flatter or steeper
- ACD = 2.5 to 3.5mm (average 3.24mm)
- Lens Thickness = 3.5 to 5.0mm
- White-to-White = 10.5-12.5mm
  - Important to recheck if Toric IOL

Methods of Biometry

- Optical Biometry
  - IOLMaster
  - LENSTAR
- Ultrasound (A-scan)
  - Immersion
  - Contact

Optical Biometry

IOLMaster

- Axial length
- Corneal curvature
- Anterior chamber depth
- White-to-white (WTW)
IOLMaster Keratometry

- Keratometry
  - Measuring 6 points of cornea
  - Optical zone 2.5mm
  - One K reading is obtained by averaging 5 K's

<table>
<thead>
<tr>
<th>Corneal Curvature Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Arr: 45.72/g2 R8 H1 SD: 0.01 mm</th>
<th>Arr: 45.72/g2 R8 H1 SD: 0.01 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1: 43.07 D @ 65 7.86 mm</td>
<td>R1: 43.21 D @ 139 8.19 mm</td>
</tr>
<tr>
<td>R2: 42.83 D @ 151 7.88 mm</td>
<td>R2: 42.35 D @ 139 7.97 mm</td>
</tr>
<tr>
<td>AD: +0.26 D @ 151</td>
<td>AD: +0.14 D @ 139</td>
</tr>
<tr>
<td>R1: 44.67 D @ 71 8.19 mm</td>
<td>R1: 41.16 D @ 139 8.20 mm</td>
</tr>
<tr>
<td>R2: 42.63 D @ 101 7.90 mm</td>
<td>R2: 45.60 D @ 139 7.96 mm</td>
</tr>
<tr>
<td>AD: +1.16 D @ 161</td>
<td>AD: +1.24 D @ 139</td>
</tr>
<tr>
<td>R1: 41.72 D @ 72 8.19 mm</td>
<td>R1: 41.22 D @ 130 8.19 mm</td>
</tr>
<tr>
<td>R2: 42.94 D @ 162 7.96 mm</td>
<td>R2: 42.45 D @ 40 7.96 mm</td>
</tr>
<tr>
<td>AD: +1.22 D @ 162</td>
<td>AD: +1.20 D @ 40</td>
</tr>
</tbody>
</table>

_Alignment for anterior chamber depth measurement_
Available Calculation Formulas

- From IOLMaster version 5.4.4 and older
  - Holladay I
  - SRK/T
  - Haigis
  - Hoffer Q
  - SRK II (outdated)
  - Haigis-L (after corneal refractive surgery)
  - Phakic IOL
  - Prior Refractive Surgery (historical data)

IOLMaster Technical Specs

<table>
<thead>
<tr>
<th>Measuring range</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial length</td>
<td>14 to 40 mm</td>
</tr>
<tr>
<td>Resolution of display</td>
<td>0.01 mm</td>
</tr>
<tr>
<td>Keratometry</td>
<td></td>
</tr>
<tr>
<td>Area</td>
<td>5 to 10 mm</td>
</tr>
<tr>
<td>Resolution of display</td>
<td>0.01 mm</td>
</tr>
<tr>
<td>Anterior chamber depth</td>
<td></td>
</tr>
<tr>
<td>Area</td>
<td>1.5 to 6.5 mm</td>
</tr>
<tr>
<td>Resolution of display</td>
<td>0.01 mm</td>
</tr>
<tr>
<td>White-to-white (optional)</td>
<td>8 to 16 mm</td>
</tr>
<tr>
<td>Area</td>
<td>0.1 mm</td>
</tr>
</tbody>
</table>

LENSTAR LS 900

LENSTAR

- Axial Length
- Keratometry
- Anterior Chamber Depth
- Corneal Diameter
- Lens Thickness
- Central Pachymetry
- Pupillometry
- Eccentricity of the Visual Axis

LENSTAR Axial Length

LENSTAR Keratometry

- Keratometry
  - Uses two concentric rings with 32 markers for precise measuring
  - Measuring two optical zones
    - 1.65mm and 2.3mm
Sounds waves are transmitted into the ocular tissues in the form of a sound beam. The sound beam encounters an interface and an echo (reflection) is produced which is transmitted back to the element within the probe.

A-scan (amplitude scan) probe uses a flat element that produces a non-focused (parallel) sound beam.

- One dimensional echogram
- 10 MHz frequency

A-scan Biometry

**Available Calculation Formulas**
- Holladay I
- SRK/T
- Haigis
- Hoffer Q
- SRK II (outdated)
- Holladay II Integration Ready

**LENSTAR Technical Specs**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Range</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corneal Thickness (CT)</td>
<td>0.30 - 0.80 mm</td>
<td></td>
</tr>
<tr>
<td>Keratometry</td>
<td></td>
<td>mm</td>
</tr>
<tr>
<td>Display resolution</td>
<td>1 μm</td>
<td></td>
</tr>
<tr>
<td>In vitro repeatability</td>
<td>± 1 μm</td>
<td></td>
</tr>
<tr>
<td>Intracorneal echography (ICE)</td>
<td>1.5 - 5.5 mm</td>
<td></td>
</tr>
<tr>
<td>Display resolution</td>
<td>0.01 mm</td>
<td>± 0.5 mm</td>
</tr>
<tr>
<td>In vitro repeatability</td>
<td>± 0.5 mm</td>
<td></td>
</tr>
<tr>
<td>Lens Thickness</td>
<td>0.5 - 5.5 mm</td>
<td></td>
</tr>
<tr>
<td>Display resolution</td>
<td>0.01 mm</td>
<td>± 0.5 mm</td>
</tr>
<tr>
<td>In vitro repeatability</td>
<td>± 0.5 mm</td>
<td></td>
</tr>
<tr>
<td>Axial Length (AU)</td>
<td>16 - 22 mm</td>
<td></td>
</tr>
<tr>
<td>Display resolution</td>
<td>0.01 mm</td>
<td>± 0.5 mm</td>
</tr>
<tr>
<td>In vitro repeatability</td>
<td>± 0.5 mm</td>
<td></td>
</tr>
</tbody>
</table>

**General Reasons for Use**
- Dense cataracts
- Poor fixation
- Measurements under anesthesia
- Confirmation of optical biometry
Echo Interpretation

Contact Ultrasound

Correct Alignment

Misalignment

Immersion Ultrasound

Probe Alignment

Localisation of the Macula

Tissue Velocities

- **Cornea**: 1,641 M/Sec
- **Aqueous & Vitreous**: 1,532 M/Sec
- **Crystalline lens**: 1,641 M/Sec
- **Soft tissue**: 1,550 M/Sec
- **Silicone oil**: 980 to 1,040 M/Sec
- **Pseudophakic lens**
  - **PMMA**: 2,718 M/Sec
  - **Silicone**: 980 M/Sec
  - **Acrylic**: 2,120 M/Sec

- Helpful when using either contact or immersion especially when measuring a patient with a posterior staphyloma
- Aim probe slightly nasal toward the optic disc for single retinal spike
- Shift probe slightly temporal to locate the macula
Sources of Error in Biometry

- Corneal compression (contact method)
- Incorrect gate placement
- Gain settings either too high or too low
- Misalignment of the sound beam
- Incorrect sound velocity settings

Aphakic A-Scan

Pseudophakic A-Scan

Silicone Filled Vitreous

Improper Gate Placement
Ultrasound Biomicroscopy (UBM)

- Special cup to keep the eyelids open
- Filled with BSS
- Transducer positioned in the BSS ~2mm from the eye to avoid injury
- Measurements taken from multiple different angles

UBM

- UBM image of angle, iris, and zonules (arrow)

- UBM image at the limbus: scleral spur (black arrow), iris (downward arrow) and ciliary sulcus (thick left pointing arrow)

UBM Set-up

- Composite UBM image of the anterior segment

UBM Image of WTW vs. Sulcus

Visante OCT

IOL Vaulted anteriorly
Methods of Keratometry

- Manual keratometer
- Optical Biometry: (IOLMaster, LenStar)
- Corneal Topographer
- Autokeratometer
- Hand-held keratometer
Corneal Topography

- Uses a placido disk technology of concentric rings located on the projection head assembly
- Measures the distance between the rings and their relationships with each other
- System can reconstruct the corneal surface with a higher degree of precision and identify micro irregularities

Galilei G4

- Dual Scheimpflug analyzer with integrated Placido disc

Galilei G4

- Pachymetry and elevation values
- The new Cone Location and Magnitude Index (CLMIaa), based on anterior axial curvature
- Ray-tracing for the real posterior surface

iTrace

- Wavefront Exams- aberrometer (refraction assessment)
- Corneal Topographer (map of cornea)

iTrace

- Corneal Topographer (map of cornea)
IOL Calculations

• Holladay I
  • Average axial length to long axial lengths
  • Uses a surgeon factor
• SRK/T
  • Average axial length to some short axial
    lengths
  • Uses an A-constant
• Hoffer Q
  • Shorter than normal axial lengths
  • Uses an ACD factor

Modern Formulas for IOL Calculations

Downfalls to 3rd Generation Formulas

• Formulas require the axial length and corneal
  curvature to predict the effective lens position
  (ELP)
  • Formulas assume that the longer the eye,
    the deeper the ACD and the shorter the
    eye, the shallower the ACD
  • Clinical cases have shown this is not
    always accurate

Haigis Formula

• Takes into account 3 constants:
  a0 tied to the lens constant, a1 tied to the
  measured ACD, a2 tied to the axial
  length measurement

\[ d = a_0 + (a_1 \times ACD) + (a_2 \times AXL) \]
Holladay II

- Axial length
- Corneal curvature
- ACD
- White-to-white
- Lens thickness
- Age
- Refractive error (prior to cataract if available)

Correlation of Errors to Postoperative Outcomes

- An error of 0.1 mm in the axial length measurement yields an approximate 0.25 diopter postoperative refractive error on an average eye length.

- An error of 1 diopter with the keratometry measurement yields an approximate 1 diopter post-operative refractive error.

Helpful Links

- [www.doctor-hill.com](http://www.doctor-hill.com)
- [www.dochnolladay.com](http://www.dochnolladay.com)
- Holladay II Software
- [www.ascrs.com](http://www.ascrs.com)
- [http://www.augenklinik.uni-wuerzburg.de/ulib/index.htm](http://www.augenklinik.uni-wuerzburg.de/ulib/index.htm)

Resource List

- Warren Hill, MD
  - [www.doctor-hill.com](http://www.doctor-hill.com)
- Sandra Frazier Byrne
  - A-Scan Axial Eye Length Measurements. Published 1995
- ASCRS website: [www.IOIABC.org](http://www.IOIABC.org)

Any Questions?

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