The Role of Corneal Topography/Tomography in Cataract Surgery

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Financial Disclosure

Amgen: Outside Reviewer
Angiotech: Consultant
Genzyme: Consultant
Novartis: Consultant
Beaver-Visitec: Consultant

Not relevant to today’s talk
Introduction

- Increasing public awareness about cataract surgery
- Greater emphasis on expected visual outcomes (pts want perfect vision day 1)
- Heightened importance of accurate IOL power calculation
- IOL power calculations have reached new levels
  - IOL Master (Carl Zeiss Meditec)/ Lenstar (Haag Streit)
  - Accurate keratometric readings
  - Advanced IOL formulas
  - Personalized Lens constants
  - IOLs in 0.25D steps
- Altered corneas still a challenge
In addition to AL, precise keratometry is essential for good cataract outcomes. However, keratometry provides no information about the peripheral cornea or its symmetry (including optical biometry). Alternatively, corneal topography provides detailed analysis of the cornea. Technology and capabilities have expanded. However, its role in cataract surgery remains vaguely defined. Cases studies used to demonstrate examples were corneal topography is particularly useful.
The Role of Corneal Topography/Tomography in Cataract Surgery

- Two groups: Refractive and Pathology
- **Refractive**: Pre-op planning/candidacy
  - On-axis astigmatism/ LRIs
  - Presbyopic IOLs (Restor/ReZoom/Crystalens)
  - Toric IOL
  - Post-LVC/RK
- **Corneal Pathology**: Pre or Post CE
  - Secondary corneal astigmatism/irregularity
  - Post PKP
  - Poor vision after cataract surgery
Corneal Topography Introduction

- Traditional corneal topography was designed to measure anterior corneal curvature.
- Traditional corneal topography measures tear film specular reflection.
- However, placido based imaging does not evaluate posterior cornea.
- Slit lamp topography + placido technology (Orbscan II) or rotating Scheimpflug tomography provides composite picture of cornea (Pentacam or Galilei).
Traditional Corneal Topography

- Placido-based topographic imaging
  - Measures anterior corneal curvature only: all data is derived from curvature maps
- 4 basics maps:
  - Sagittal/Axial
  - Tangential/local/instantaneous
  - Refractive
  - Elevation (pseudoelevation)
Traditional Corneal Topography

- Axial/Sagittal/Color Maps
  - Good starting point for ruling out irregular corneal shapes (KCN/PMD)
  - Irregular shape = difficult refraction (BSCVA < 20/20)
  - KCN: inferior placed apex
  - PMD: ATR astig with kissing birds/ butterfly/moustache pattern
- Cons: Curvature maps are shift variable. Values and topography change as center of map shifts
Corneal Tomographic Elevation

- Orbscan, Pentacam, Galilei measure true elevation, placido technology does not.
- Slope and curvature data can be secondarily derived from an elevation map.
- Elevation maps are shift invariant.
Screen patients for pathologic causes of astigmatism (irreg vs reg) and corneal irregularities

- Corneal pathology
  - Pterygium
  - ABMD
  - Salzmann’s degen
  - Terrien’s Marginal degen
  - Furrow degeneration
  - FFKC/Pellucid
  - CL molding
Contact Lens Pathology

- RGPCL molding and resolution (K 42.1 to 45.2 OS)

Corneal topography showing corneal molding associated with flat-fitting RGP contact lenses (left side) and resolution 1 month after discontinued lens wear (right side).
64yo WM presents with fluctuating vision OU and recurrent pterygium x 2 and early cataracts OS>OD

MRx:
- OD: +4.50-2.75x171 20/30
- OS: +6.50-4.50x166 20/40

OS Ks:
- 37.8D/44.9D@68
- Ave K: 41.0D
- 7.1D
- SE: +4.50
Pterygium Induced Astigmatism

- 2 months after excision with AMT/MMC and Symblepharon ring OS

- OS Mrx: +1.75-1.00x89 20/25 (preop 20/40)

- OS Ks:
  - 44.7D/45.5D@158
  - 0.8D vs 7.1D preop astig
  - Ave K: 45.1D vs 41.0D preop
  - SE: +1.25 vs +4.50
Corneal Degenerations

Keratoconus

Klyce / Maeda
KCI
62.2% Similarity
Clinical
Keratoconus
Interpreted

Smolek / Klyce
KSI
39.9% Severity
Keratoconus
Suspect
Interpreted

S1K: 47.78 @158°

Related Indices:
S1K: 47.78
S1A: 1.58
OBI: 5.32
IAI: 0.58

Keratoconus
Screening System

Pellucid
Anterior Basement Membrane Dystrophy

ABMD can induce “acquired” irregular astigmatism and affects keratometry readings. May require treatment prior to cataract surgery.
ABMD Case

- 70yo WM c/o “blurry vision” OU, no h/o RES
- POH: POAG x 18yrs well-controlled on timolol 0.5% bid
- BSCVA:
  - OD: -3.00 – 0.75 x 100 20/60
  - OS: -3.00 – 0.50 x 90 20/50-
- SLE:
  - Cornea: 3+ MDF changes OU with 1+ central guttae
  - Lens: NO2NC3 OU
  - c/d ratio 0.70 OU
- ? Cause of vision loss
ABMD Case

Maps and dots on SLE and negative fluorescein staining
ABMD Case: Corneal topography

Right and Left eyes with axial and tangential maps Demonstrating irregular astigmatism OU
ABMD Case

- **Treatment:** Superficial keratectomy OU
- **Post Super K BSCVA**
  - OD: -1.75 -1.25 x 80 20/20+ (20/60 preop)
  - OS: -1.00 – 1.75 x 30 20/20 (20/50- preop)
- **Preop K’s**
  - OD: 46.55/48.91@107 Central power: 52.31
  - OS: 46.68/47.31@43 Central power: 50.49
- **Postop K’s**
  - OD: 47.07/47.40@88 Central power: 47.23
  - OS: 46.55/47.20@43 Central power: 46.77
ABMD Case

Improved corneal topography after Super K OU with regular symmetric astigmatism. No cataract surgery required.
Refraactive Cataract Case: Toric IOL

- 76yo retired Dean of Univ, reads ancient manuscripts
- MRx:
  - OD: -2.00 -3.00 x 90 20/50-2
  - OS: -3.75 -3.00 x 87 20/80-2
- Ks
  - OD: 43.25/45.75@ 5 2.5D
  - OS: 43.50/46/00@ 177 2.5D
- Orbscan demonstrated ATR OU
Refractive Cataract Case

Regular symmetric ATR astigmatism OU

Surgery recommended with:
OD: SN60T5 +16.50D @ 180 (target -0.50)
OS: SN60T5 +17.0D @ 180 (target -1.00)
Refractive Cataract Case

- 1 month: patient very happy, can read with good light
- UCDVA
  - OD: 20/25+3
  - OS: 20/30
- OD: +0.25 – 0.75 x 99 20/20 (95-4 degrees) (aim -0.50)
- OS: plano – 1.00 x 85 20/20 (87-2 degrees) (aim -1.00)

Not actual patient
Cataract Topography Example

- 59yo engineer, seen for LVC, c/o difficulty with night driving, road signs and halos
- MRx:
  - OD: -5.75 -0.75 x 090 20/25 (slow) BAT 20/40
  - OS: -8.00 -1.00 x 180 20/20-2 (slow) BAT 20/30-
- Ks:
  - OD: 41.75/43.25@ 118  1.5D
  - OS: 42.50/43.50@ 93   1D
- ?+ Vogt striae OD, Central PSC OU, temporal lattice OU
Corneal Topography/ Cataract Surgery

Right Eye: inferior steepening and increased posterior float
Cataract Topography/ Cataract Surgery

Left Eye: slight asymmetric astigmatism
Cataract Topography Example

- Based on Pentacam images and numbers,
- Surgery
- OD: SN60WF +10.5D (target -1.00)
- OS: SN60T3 +9.5D (target -0.50)

- 6 weeks after surgery, UCVA
- OD: 20/25+1 (+0.25 – 1.00 x 64)
- OS: 20/20 (plano -0.25 x 113)
Postrefractive IOL Calculations

- RK and LVC alters cornea configuration
- Affects ability to calculate corneal power
- Placido-based topographers assume:
  - Radius of posterior corneal surface 82% of anterior corneal surface, and cannot read the central cornea, leading to a potential 25% error
- Pentacam has “true net power” maps and Holladay EKR Report for accurate K readings
IOL Calculations Postrefractive Surgery: The Problem is Keratometry

- Post Myopic LVC: Measured K steeper than actual K (42D vs 40D)
  - Result: IOL choice too weak, hyperopic overcorrection
- Post Hyperopic LVC: Measured K flatter than actual K (43D vs 45D)
  - Result: IOL choice too strong, myopic correction
- Two classic methods to determine true corneal power
  - Corneal power calculation (Clinical history method)
  - HCL method
- Seitz et al. Ophthalmology 1999;106:693-702 (24%)
Pentacam Holladay Report and Holladay EKR Report (2 displays)

- 6 map format: refractive power, tangential, pachymetry, relative pachymetry, ant and post elevation
- Equivalent K readings (EKR)
  - IOL formulas reduce K readings by 2% to compensate for “true net power”
  - True net power is 2% less (0.75D) than K readings
  - Pentacam measures “true net power”
  - EKR adjusts K readings and compensates for back surface power
- Combination of maps help to detect ectasia
Holladay EKR Report Post LASIK
Post Radial Keratotomy IOL Calculation Case

- 51yo WM had RK for -3D OU 30 years ago c/o progressive decrease in vision/unable to use CLs
- MRx
  - OD: +9.75 -3.75 x 075 20/20-
  - OS: +8.25 -0.50 x 010 20/30
- Greene Lasso suture performed OS with only moderate effect +6.00-2.50 x 75 20/30, and removed after 6 mo for RLE
- IOL Master: AL OD: 25.91, OS: 26.05
- Ks: OD: 29.25/34.25@151 OS: 28.30/33.40@36
  - Ave IOL Master Ks: OD: 31.75D OS: 30.60D (2.5mm)
  - Ave Auto K’s: OD: 34.75D OS: 35.50D (2.8mm)
Post RK IOL Surgical Case

Right Eye
4 Refractive map
Post RK IOL Surgical Case

Left Eye
4 Refractive map
Post Refractive Surgery Case

OCULUS - PENTACAM

Equivalent K Readings (D) calculated in zones centered on pupil center (Halifax)

<table>
<thead>
<tr>
<th>Zone Diameter</th>
<th>1.0 mm</th>
<th>2.0 mm</th>
<th>3.0 mm</th>
<th>4.0 mm</th>
<th>4.5 mm</th>
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<tr>
<td>EKR K1</td>
<td>30.6</td>
<td>29.4</td>
<td>29.2</td>
<td>29.1</td>
<td>30.5</td>
<td>31.3</td>
<td>33.2</td>
<td>35.2</td>
<td>39.1</td>
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<tr>
<td>EKR K2</td>
<td>31.8</td>
<td>31.5</td>
<td>31.4</td>
<td>31.2</td>
<td>33.7</td>
<td>34.5</td>
<td>36.1</td>
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<td>Mean Zonal EKR</td>
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<td>30.0</td>
<td>30.3</td>
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<td>32.1</td>
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<td>34.6</td>
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<td>Zonal Std Dev</td>
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<td>0.022</td>
<td>0.015</td>
<td>0.013</td>
<td>0.013</td>
<td>0.014</td>
<td>0.014</td>
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<td>10069</td>
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<td>42111</td>
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<td>75236</td>
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Equivalent K Reading Power
Post Refractive Surgery Case

Equivalent K-Readings (D) calculated in zones centered on pupil center (Holladay)

<table>
<thead>
<tr>
<th>Zone Diameter</th>
<th>1.0 mm</th>
<th>2.0 mm</th>
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<th>4.0 mm</th>
<th>4.5 mm</th>
<th>5.0 mm</th>
<th>6.0 mm</th>
<th>7.0 mm</th>
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<tbody>
<tr>
<td>EKR K1</td>
<td>30.6 (45°)</td>
<td>29.4 (49°)</td>
<td>29.2 (73°)</td>
<td>29.9 (75°)</td>
<td>30.5 (74°)</td>
<td>31.3 (73°)</td>
<td>33.2 (70°)</td>
<td>35.2 (65°)</td>
</tr>
<tr>
<td>EKR K2</td>
<td>31.8 (135°)</td>
<td>30.5 (139°)</td>
<td>31.4 (163°)</td>
<td>32.9 (165°)</td>
<td>33.7 (164°)</td>
<td>34.5 (163°)</td>
<td>36.1 (160°)</td>
<td>37.8 (155°)</td>
</tr>
<tr>
<td>Mean Zonal EKR Km</td>
<td>31.2</td>
<td>30.0</td>
<td>30.3</td>
<td>31.4</td>
<td>32.1</td>
<td>32.9</td>
<td>34.6</td>
<td>36.5</td>
</tr>
<tr>
<td>Zonal Std Dev</td>
<td>1.22</td>
<td>2.04</td>
<td>2.08</td>
<td>2.36</td>
<td>2.64</td>
<td>2.97</td>
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<td>4.63</td>
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<td>0.015</td>
<td>0.013</td>
<td>0.013</td>
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<td>0.014</td>
<td>0.014</td>
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<tr>
<td>Zonal Samples (N)</td>
<td>1953</td>
<td>8200</td>
<td>18667</td>
<td>33327</td>
<td>42211</td>
<td>52180</td>
<td>75235</td>
<td>102483</td>
</tr>
</tbody>
</table>

Distribution of EKR in Actual Zone

Equivalent K-Readings in Actual Zone

- K1: 30.5 (74°)
- K2: 33.7 (164°)
- Km: 32.1 D
- Peak: 31.9 D
- 65% Mean: 32.4 D

RIGHT EYE
### Post Refractive Surgery Case

**Equivalent K-Readings (D) calculated in zones centered on pupil center (Holladay)**

<table>
<thead>
<tr>
<th>Zone Diameter</th>
<th>1.0 mm</th>
<th>2.0 mm</th>
<th>3.0 mm</th>
<th>4.0 mm</th>
<th>4.5 mm</th>
<th>5.0 mm</th>
<th>6.0 mm</th>
<th>7.0 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>EKR K1</td>
<td>23.6 (102°)</td>
<td>26.2 (82°)</td>
<td>27.2 (88°)</td>
<td>28.7 (91°)</td>
<td>29.6 (92°)</td>
<td>30.6 (93°)</td>
<td>32.8 (88°)</td>
<td>34.8 (31°)</td>
</tr>
<tr>
<td>EKR K2</td>
<td>24.6 (12°)</td>
<td>27.1 (172°)</td>
<td>29.1 (178°)</td>
<td>30.5 (1°)</td>
<td>31.2 (2°)</td>
<td>31.9 (3°)</td>
<td>33.3 (178°)</td>
<td>35.3 (121°)</td>
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<tr>
<td>Mean Zonal EKR Km</td>
<td>24.1</td>
<td>26.6</td>
<td>28.2</td>
<td>29.6</td>
<td>30.4</td>
<td>31.2</td>
<td>33.0</td>
<td>35.0</td>
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<tr>
<td>Zonal Std Dev</td>
<td>1.32</td>
<td>3.77</td>
<td>4.54</td>
<td>5.09</td>
<td>5.39</td>
<td>5.71</td>
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<tr>
<td>Zonal Std Error of Mean</td>
<td>0.030</td>
<td>0.042</td>
<td>0.033</td>
<td>0.028</td>
<td>0.026</td>
<td>0.025</td>
<td>0.023</td>
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</tr>
</tbody>
</table>

**Distribution of EKR in Actual Zone**

**Equivalent K-Readings in Actual Zone**

- K1: 29.6 (92°)
- K2: 31.2 (2°)
- Km: 30.4 D
- Peak: 22.5 D
- 65%Mean: 27.0 D
Post Refractive Surgery Case

- After viewing Pentacam EKR choose average K’s
  - OD: 30.00D
    - IOL Master K 31.75D and AutoKs 34.75D
  - OS: 27.00D
    - IOL Master K 30.60D and AutoKs 35.50D
- Aim -1.00 OU using SRK/T formula in the IOL Master
- Cataract Surgery with phaco uneventful
  - Scleral tunnel used
Post Refractive Surgery Case

- 8 wks Postoperatively Pt thrilled!
  - UCVA: OD: 20/40+, OS: 20/50-
  - MRx:
    - OD: -1.00 -1.25 x 67  20/25
    - SE -1.62 (target -1.00)
    - OS: +2.50 – 5.00 x 110 20/40
    - SE plano (target -1.00)
Post RK IOL Calculations

- ASCRS Post Keratorefractive IOL Calculator
- Prior case ASCRS calc
  - OD: 32.0D IOL (30.0D)
  - OS: 32.0D IOL (27.0D)

Right Eye previous RK pt data
Intraoperative aberrometry (WaveTec Vision ORA, Alcon Verifeye)

- Attaches to microscope and uses wavefront technology using “Talbot-Moire” interferometry
- Potentially eliminates need for preop biometry and keratometry for IOL power
- Intraoperative aphakic measurement allows surgeon to select IOL power on the table
- May allow more accurate use for toric IOLs, post refractive IOL calcs
Post Cataract Surgery Topography

- 72yo Chinese man experienced complicated CCI cataract surgery OS with anterior vitrectomy and sulcus PCIOL with BSCVA 20/70 2.5 months postop
- MRx:
  - OD: +0.75 -1.50 x55  20/40- (cataract)
  - OS: +1.00 –6.00 x55  20/70 (sulcus PCIOL)
- Ks:
  - OD: 41.50/43/00@165  (1.5D)  CCT 605
  - OS: 37.00/50.50 @38  (13.5D)  CCT 700
- SLE: OS, Terrien-like appearance with superior CCI paracentral internal entry at 10:30 position with ? DM tear/folds and local corneal edema
Post Cataract Surgery Topography

- Pentacam used to evaluated situation
Post Cataract Surgery Topography

- 5 months after CE, 2 months after last exam, BSCVA improved 20/40+2
- MRx OS: +1.00 – 4.25 x 107
- K’s: 39.75/48.00@ 37 (8.25D vs 13.5D, same axis)
- Decreased central K edema, 700 to 673 (pentacam)
Post Cataract Surgery Topography

OCULUS - PENTACAM

List Name: CHIN
First Name: RING
ID: 790569
Date of Birth: 01/31/1955
Examination Date: 04/17/2008
Examination Time: 10:02:24

Cornea Front:
- K1: 41.3 D
- K2: 47.0 D
- Rm: 43.3 D
- Axis: 120.0°

Cornea Back:
- K1: 41.1 D
- K2: 55.9 D
- Rm: 49.9 D
- Axis: 105.1°

Pupil Center:
- Pupil Center (mm): +0.57

Pachymetry:
- Corneal Thickness: 574 μm
- Change: +0.22

Asteroid:
- A: 46°
- B: 46°
- C: 46°
- D: 46°

Chamber Volume:
- Volume: 110 mm³
- Angle: 38.3°
Although topography/tomography is NOT necessary for routine cataract surgery with monofocal IOLs, corneal topography adds valuable information when performing LRIs, and using multifocal or toric IOLs.

- Corneal topography can help rule out significant corneal pathology when evaluating cataracts (irreg astigmatism).
- Elevation based topography/tomography and software provides relatively accurate data for keratometry readings after refractive surgery and corneal transplantation (Holladay EKR).
- When in doubt, perform corneal topography!
Thank you for your attention

QUESTIONS???????????????????????