Corneal Topography

BAMDAD SH MD
ASSISTANT PROFESSOR OF
OPHTHALMOLOGY
SUMS
Placido-based Topography
Topographic pattern
Corneal topographic pattern
(Rabinowitz et al)

- Round: 21%
- Oval: 25%
- Sup steepening: 4%
- Inf steepening: 11%

- Symmetric bowtie: 22%
  - Symmetric with orthogonal axes: 20%
  - Symmetric with skewed axes: 2%

- Asymmetric bowtie: 11%
  - Asymmetric with sup steepening: 3%
  - Asymmetric with inf steepening: 7%
  - Asymmetric with skewed axes: 1%

- Irregular: 6%
Clinical applications of topography

Pre-keratorefractive surgery evaluation

Post-keratorefractive surgery evaluation
Pre-keratorefractive surgery evaluation

- Rule out subclinical / suspected KCN
- Detect / differentiate normal inferior steepining and FFKCN
- Detect / differentiate of contact lens induced corneal changes with KCN
- Tear film problems / corneal aberration in dry eye
Pre-keratorefractive surgery evaluation

- Rule out subclinical/suspected KCN
Topography scale

Keratoconus — Effect of Scaling

1/4 D Steps

1/2 D Steps

1 D Steps

2 D Steps
Topography scale
keratoconus
inferior steepening
Topography scale
Early keratoconus
inferior steepening
absolute scale display
Topographic scale
upper: absolute scale (1.5D steps)
lower: normalized scale (0.2D steps)
spherical central cornea & much steeper than surrounding cornea
Keratoconus Screening

AK = 46.53 D
AGC = ± 11 D/min
Sn = 0.00 D
Xpi = 0%

Topography not compatible with keratoconus
Keratoconus Screening

AH = 45 mm

AGC = 1.30 D/kmm

SI = -0.13 D

Ksi = 30%

Topography not compatible with keratoconus
Keratoconus Screening

Ax = 48.08 D
AGC = 1.25 D/mm
SI = 0.14 D
Kpl = 29%

Topography not compatible with keratoconus
**Keratoconus Screening**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AK</td>
<td>50.54 D</td>
</tr>
<tr>
<td>AGC</td>
<td>2.18 D/min</td>
</tr>
<tr>
<td>SI</td>
<td>1.18 D</td>
</tr>
<tr>
<td>Kpi</td>
<td>87%</td>
</tr>
</tbody>
</table>

Topography compatible with keratoconus

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6.04 mm²</td>
</tr>
<tr>
<td>D</td>
<td>2.77 mm</td>
</tr>
<tr>
<td>r</td>
<td>0.81 mm; θ = 242°</td>
</tr>
<tr>
<td>RMD</td>
<td>1.75</td>
</tr>
</tbody>
</table>
Keratoconus detection

Topographic pattern findings
Hallmarks of KCN in topography

- Localized steepness
- Overall steepness
- Inferior steepening
- Irregularity of surface (irregular astigmatism)
- Asymmetric Bow –tie
  - Decentered, bended, broken
- Rapid change of power in a specific area
Topographic pattern of keratoconus

Inferior steepening, more prominent temporally

Astigmatic type: Central steepening, with asymmetrical bowtie pattern

Asymmetric bow tie (AB) & skewed radial axes (SRAX)
Localized steepness as asymmetrical bow tie (AB) with inferior steepening (IS)
Localized steepness
asymmetrical bow tie (AB) with superior steepening (SS)
Localized steepness
sup keratoconus
inferior steepening
inferior steepening
inferior steepening
Central steepening
Overall steepness

Central steepening with symmetrical bowtie
Overall steepness

Central steepening with asymmetrical bowtie
asymmetrical bow tie & skewed radial axes (AB/SRAX)
asymmetric bow tie (AB) & skewed radial axes (SRAX)
Decentered, bended

MOSAVINIYA MAHMOOD
OD 19/06/2007

Keratoconus Screening

<table>
<thead>
<tr>
<th>AK</th>
<th>AGC</th>
<th>BI</th>
<th>Kpi</th>
</tr>
</thead>
<tbody>
<tr>
<td>49.75 D</td>
<td>1.31 D/mm</td>
<td>1.71 D</td>
<td>2%</td>
</tr>
</tbody>
</table>

Topography not compatible with keratoconus
In order to complement the information provided by the color map several quantitative indices have proposed.
Surface asymmetry index (SAI)
Inferior-superior index (IS-value)
Keratoconus predication index (KPI)
Surface regularity index (SRI)
Corneal uniformity index (CUI)
Analyzed area (AA)
Coefficient of variation of corneal power (CVP)
Potential VA (PVA)
Predicated corneal acuity (PCA)
Difference in central power between fellow eyes
Irregular Astigmatism index (IAI)
Highest rate of steepening (HRS)
Asphericity
Statistical indices (3)

- Average corneal power (ACP)
- Simulated KR (Simk)
- Effective refractive power (eff RP) or SEP
- Apical curvature or keratometry (AK)
- Apical gradient curvature (ACG)
- Coefficient of variation of corneal power (CVP)
Skewed radial axes (SRAX)

If lines dissecting two lobes appear skewed by more than 30 degree from vertical meridian it is called skewed
Non-orthogonal astigmatism (skewed radial axes)

- **Skewed radial axes (SRAX):**
  
  angle between axes of two halves of bowtie >20°
SRAX measurement

Keratoconus Screening

<table>
<thead>
<tr>
<th>AK</th>
<th>AGC</th>
<th>SI</th>
<th>Kpi</th>
</tr>
</thead>
<tbody>
<tr>
<td>48.36 D</td>
<td>1.06 D/mm</td>
<td>0.45 D</td>
<td>10%</td>
</tr>
</tbody>
</table>

Topography not compatible with keratoconus
Surface Regularity Index (SRI)

- Approach zero for normally smooth corneal surface (<1.0)
- Increases with increasing irregular astigmatism
- High correlation with BSCVA (PVA)
- Can predict the optical performance of a normal given corneal topography
Surface asymmetry Index (SAI)

SAI increases in asymmetry of a specific meridian like keratoconus and decentered ablation
Surface Asymmetry Index (SAI)

- Normal SAI < 0.5
- Indicator of progression of KCN
  - Mild KCN SAI: 1.5 to 2.5
  - Advanced KCN SAI > 5
Surface Asymmetry Index (SAI)

- SAI is zero:
  - A perfect sphere
  - A surface with perfect spherocyl/ Regular astig
- Normal cornea is fairly symmetrical (SAI < 0.50)
- Is sensitive to paracentral K.C
- Part of basis for KCN detection program
Keratoconus screening indices
(modified Rabinowitz values)

- **K value:**
  - Below 47.2D: normal
  - 47.2 to 48.7D: KCN suspect
  - Higher than 48.7D: clinical KCN

- **I-S value:**
  - Below 1.4: Normal
  - 1.4 to 1.9: suspect KCN
  - More than 1.9: clinical KCN
Keratoconus screening indices

- Central corneal power >47.2D
- I-S value>1.2
- Sim-K astigmatism >1.5D
- Skewed radial exes (SRAX) >21 degrees
Keratoconus screening indices Klyce-Maeda indices

- Keratoconus predication index (KPI)
- Multiple regression analysis of indices
  - Simk, SAI, five other indices
- Ranges from 0% to 100%
  - 0% means no keratoconus
  - 100% means severe keratoconus
Advanced keratoconus
KPI=95%
Moderate Keratoconus

KPI = 50\%
Suspected Keratoconus
KPI < 5%
Keratoconus screening indices

TMS-1 Computed Anatomy

Keratoconus Screening Indices

Rapinowitz Indices:
- K values below 4.2 and H values below 1.4 are consistent with normal corneal topography.
- K values between 4.2 and 4.9, or H values between 1.4 and 1.9 represent keratoconus suspect-like patterns.
- Values of K higher than 4.9, or H higher than 1.9 represent definite keratoconus-like patterns.

Kyle Indices:
- KPR (Keratoconus Prediction Index) is obtained by multiple regression analysis of the corneal statistical indices on the following pages. It estimates the presence of keratoconus-like patterns, and ranges from 0% for no keratoconus-like patterns to 100% for severe keratoconus-like patterns.
Keratoconus screening indices

<table>
<thead>
<tr>
<th>Rabinowitz Values</th>
<th>Klyce/Maeda Indices</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>I-S</td>
</tr>
<tr>
<td>51.13</td>
<td>10.58</td>
</tr>
</tbody>
</table>

**Similarity To Keratoconus Detected**

<table>
<thead>
<tr>
<th>Detected Indices</th>
</tr>
</thead>
<tbody>
<tr>
<td>50%+</td>
</tr>
<tr>
<td>75%+</td>
</tr>
<tr>
<td>90%+</td>
</tr>
<tr>
<td>40%+</td>
</tr>
<tr>
<td>50%+</td>
</tr>
<tr>
<td>60%+</td>
</tr>
<tr>
<td>70%+</td>
</tr>
<tr>
<td>80%+</td>
</tr>
<tr>
<td>90%+</td>
</tr>
<tr>
<td>40%+</td>
</tr>
<tr>
<td>50%+</td>
</tr>
<tr>
<td>60%+</td>
</tr>
</tbody>
</table>
Newer KCN detection subprograms

- Neural network approach
  - (Smolek and Klyce)

- KISA % index
  - (Rabinowitz and Rasheed)

To detect keratoconus suspects and grade severity of keratoconus
Keratoconus screening indices
(KISA% index)

This index is product of 4 indices:

- K value
- I-S value
- SRAX value
- Regular astigmatism by KR reading

\[
KISA\% = \frac{(K) \times (I-S) \times (AST) \times (SRAX) \times 100}{300}
\]
Keratoconus screening indices
(KISA% index)

- **K** value < 47.2D = 1, if > 47.2D same number
- **I-S** value < 1D = 1, if > 1D same number
- **SRAX** value
- **Regular astigmatism by KR reading**, if < 1D = 1, if > 1D same number

\[ KISA\% = \frac{(K) \times (I-S) \times (AST) \times (SRAX) \times 100}{300} \]
Keratoconus screening indices (KISA% index)

- Useful longitudinal analysis of suspected keratoconus over time

- Clinically obvious KCN:
  - Cut off point of 100%

- Keratoconus suspect: 60-100%
Based on an artificial intelligence mesh that enable making logic – based decisions , and modification of information in a process simulating human learning , improves its recognition skills as it gains “experience”

Accuracy 96%
Pre-keratorefractive surgery evaluation

- Detect / differentiate of contact lens induced corneal changes with KCN
Differential diagnosis of KCN in topography

Artifact:
- If there is any doubt for subclinical KCN
- re-exam with good fixation and alignment
Pseudokeratoconus in topography

- Ocular misalignment: Sup or inf eye rotation
- Inferior eyeball compression
- Dry spot formation, tear film accumulation
- Contact lens wear (rigid-soft)
- Displaced apex syndrome
Normal inferior steepening

Elevated I-S value:
- Inferior corneal axial power > 1.5D steeper than comparable superior region

No other clinical or topographic aspects of KCN
Normal inferior steepening

Normal topography pattern on elevation based system (Orbscan-Pentacam)

No KCN criteria of some of newer KCN detection subprograms

Normal pachymetry
Orthogonal astigmatism
Stable refraction
BSCVA of 20/20 or better
Good outcome for myopic surgery
Variable outcome for hyperopic surgery
Topographic pattern of KCN-like inferior steepening alone:

• In a patient:
  - More than 30 years of age
  - With stable refraction for 1 year
  - No clinical signs of KCN in either eye
  - No other risks for KCN

Not necessarily a contraindication for PRK
Normal inferior steepening
Normal inferior steepening
keratoconus

Inferior steepening
Pellucid Marginal Degeneration arching bow tie
Pellucid Marginal Degeneration arching bow tie
Pellucid marginal degeneration inferior steepening & against the rule astigmatism PMD -mild
Pellucid marginal degeneration
arching bow tie
PMD -moderate
Pellucid marginal degeneration

generalized steepening of central or inferior PMD

-Severe
Pellucid Marginal Degeneration versus keratoconus
### Keratoconus Screening

<table>
<thead>
<tr>
<th>AK</th>
<th>AGC</th>
<th>SI</th>
<th>KPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>49.75 D</td>
<td>1.31 D/mm</td>
<td>1.71 D</td>
<td>2%</td>
</tr>
</tbody>
</table>

Topography not compatible with keratoconus
Post-keratorefractive surgery evaluation

- Assessment of cornea after refractive surgery (visual problems)
- Planning for possible future surgical strategy
Topographic patterns after PRK
irregular - semicircular
Topographic patterns after PRK
irregular - keyhole
Topographic patterns after PRK
irregular – central island
Topographic patterns after PRK
irregular – central island
Topographic patterns after PRK regular – homogenous PRK overcorrection
Topographic patterns after PRK
PRK regression & haze
Topographic patterns after PRK
Topographic patterns after PRK
Topographic patterns after PRK
Topographic patterns after PRK
Topographic patterns after PRK
Topographic patterns after PRK
Well–centered ablation
Topographic patterns after PRK

PRK decentration
Topographic patterns after PRK

PRK decentration
Topographic patterns after PRK ablation decentration

- **Mild**
- **Gross**
Topographic patterns after Lasik

myopia          hyperopia
Topographic patterns after Lasik
hyperopic astigmatism
Topographic patterns after Lasik
myopic astigmatism
Topographic patterns after Lasik planning for retreatment
- Retrospective, comparative analysis of 37 patients who developed post lasik ectasia out of 148 myopic patients (SE -4 to -8 D)
  (111 no ectasia age/gender matched controls)
- 6 parameters, each given a grade 1 to 3
- Total grade ≤ 7: no ectasia
  8-12: 16/27 (59%) ectasia
  > 12: 21/21 (100%) ectasia
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keratometry</td>
<td>&lt; 45</td>
<td>45-47</td>
<td>&gt;47</td>
</tr>
<tr>
<td>Oblique Cylinder</td>
<td>&lt;0.5</td>
<td>0.5-1.5</td>
<td>&gt;1.5</td>
</tr>
<tr>
<td>Pachymetry</td>
<td>&gt;520</td>
<td>500-520</td>
<td>&lt;500</td>
</tr>
<tr>
<td>Posterior surface elevation</td>
<td>&lt;30</td>
<td>30-40</td>
<td>&gt;40</td>
</tr>
<tr>
<td>I-S difference</td>
<td>&lt;1.0</td>
<td>1.0-1.4</td>
<td>&gt;1.4</td>
</tr>
<tr>
<td>Post /Ant BFS</td>
<td>&lt;1.20</td>
<td>1.20-1.27</td>
<td>&gt;1.27</td>
</tr>
</tbody>
</table>
**Randleman**

**Ectasia Risk Factor Score System**

*Ophthalmology* 2008

<table>
<thead>
<tr>
<th>Parameter</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topography pattern</td>
<td>FFKC</td>
<td>SBRA</td>
<td>460</td>
<td>350</td>
<td>240</td>
<td>140</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RSB thickness (µm)</td>
<td>240</td>
<td>250</td>
<td>260</td>
<td>270</td>
<td>280</td>
<td>290</td>
<td>300</td>
<td>310</td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>18</td>
<td>21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT (µm)</td>
<td>450</td>
<td>480</td>
<td>510</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRSE (1D)</td>
<td>14</td>
<td>12</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

**ART** = asymmetric tomogram; **CT** = preoperative corneal thickness; **1D** = diopters; **FFKC** = femtosecond laser keratoscopy; **MRSE** = preoperative spherical equivalent manifest refraction; **RSB** = residual stromal bed; **SBRA** = skewed radial nas.
<table>
<thead>
<tr>
<th>Cumulative Risk Scale Score</th>
<th>Risk Category</th>
<th>Recommendations</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 2</td>
<td>Low risk</td>
<td>Proceed with LASIK or surface ablation</td>
<td>Consider MRSE stability, degree of astigmatism, preoperative topographic asymmetry, and family history</td>
</tr>
<tr>
<td>3</td>
<td>Moderate risk</td>
<td>Proceed with caution, consider special intervention</td>
<td></td>
</tr>
<tr>
<td>4 or more</td>
<td>High risk</td>
<td>Do not perform LASIK, safety of surface ablation has not been established</td>
<td></td>
</tr>
</tbody>
</table>

MRSE = preoperative spherical equivalent manifest refraction.
Thanks for your attention