Corneal Topography

Optometry 260A
What is corneal topography?

- Measurement of corneal shape
- AKA videokeratography (VK)
Why do corneal topography?

- Keratoconus diagnosis and monitoring
- Refractive surgery
  - Pre-surgical keratoconus screening
  - Troubleshooting unsatisfactory outcomes
- Contact lens fitting
  - Lens selection
  - Orthokeratology
  - Monitoring corneal warpage
Components of a CT system

- Apparatus for illuminating cornea
  - Placido cone
  - Scanning slit
- Video camera for image capture
- Computer for data analysis
Placido-based systems

- Placido disk consists of concentric rings, reflected off of the cornea
Placido-based systems

• Target may be large or small
Placido-based systems

- Like multiple keratometry mires
- Ring may be center of white or dark/light and light/dark borders
- Curvature calculated from distance between rings for each radial meridian
Scanning section system

- Orbscan (B & L)
- Reconstrucnts height from video of slit scan of cornea
- Combines with Placido data for curvature
Scanning section system
Sources of error

- Tear debris or dry spots
- Lashes or nose blocking mires
- Focus error
- Fixation error
- Distortion
Types of displays

- Color maps
  - Curvature (axial and tangential)
  - Height
  - Refractive power
- Raw image/rings
- Simulated K’s
- Meridional sections
- Numeric
- Irregularity indices
- Contact lens fluorescein pattern simulations
Other features

- Pupil outline
- Grid (rectangular or polar)
- Power displayed for cursor location
- Eccentricity
Reading the basic map

- Curvature maps are most common
  - Axial
  - Tangential

- Curvatures are calculated from data
  - Each instrument has its own algorithm
  - Meridional curvature (from center radially)
  - Radius is converted to diopters using $n=1.3375$, not the index of cornea
Reading the basic map

- Colors represent curvatures
  - Warmer colors (red) = higher curvature
  - Cooler colors (blue) = lower curvature
Features of corneas

• Toricity
  – WTR
  – ATR
  – Oblique
• Asphericity
• Apex location
• Local anomalies
Toricity - WTR

Axial Dioptr
Toricity - ATR

Axial Diopter

- Patient
- ID:
- Examination
  Eye: Left
  Date: 27-Jan-01
  Exam: 1, Center
- Pupil
  Size: 3.35mm
  Position: 0.14mm
  Kappa: 2.0°
- Keratometer
  44.50D @ 6°
  43.50D @ 96°
  Astig: 1.00D
  Eccen: 0.45 @ 96°
- Cursor
  Distance: 9.78mm
  Meridian: 142°

Radius:

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<th>Dual</th>
<th>Multi</th>
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Asphericity

Tangential Diopter

Dpt
40.50
39.00
37.50
36.00
35.25
34.50
33.00
31.50
30.00

35.50D @72°
35.50D @162°
Astig: 0.00D
Eccen: 0.00 @162°

Distance: 5.94mm
Meridian: 90°
Power:
Radius:

Exam: 2, Center

ID: 35436

-Examination-
Eye: Right
Date: 27-Jul-00
Exam: 2, Center
Asphericity

Tangential Diopter
Asphericity
Apex location

- Apex location skews map
Local anomalies

- Tight eyelids
Color scales - absolute

Axial Diopter

Dpt
91.0
86.9
82.9
78.7
74.5
70.4
66.3
62.7
60.1
53.4
56.9
55.6
54.4
53.3
52.1
50.8
49.4
47.6
46.0
41.4
37.3
33.3
29.2
21.1
17.0

-Examination-
Eye: Left
Date: 19 Jan 01
Exam: 4, Center

-Pupil-
Size: 2.87 mm
Position: 0.66 mm
Kappa: 8.3°

-Keratometer-
-4.00 D @ 69°
-41.00 D @ 159°
Astp: 3.00 D
Eccen: 0.67 @ 159°

-Cursor-
Distance: 0.18 mm
Meridian: 8°
Power: 42.3 D
Radius: 7.97 mm
Color scales - relative

Axial Diopter

Dpt
43.75
42.75
41.75
40.75
40.25
39.75
38.75
37.75
36.75

L
Color scales

• Absolute
  – Good for comparing maps
  – Color intervals may vary
  – May hide detail

• Relative (normalized)
  – More detail
  – Better range of color for a given map
  – Color intervals equal
  – May exaggerate detail
Color scales
Color scales

\[ \Delta K = 2.62 \text{ D} \quad \Delta K = 0.75 \text{ D} \]
Types of color maps

- Curvature
  - Axial
  - Tangential
- Height
  - Absolute, or
  - Relative to a reference shape, e.g., sphere
- Refractive power
Curvature maps

• Axial map
  – Less noisy, so smoother
  – Better for overall view
  – Good for monitoring change

• Tangential map
  – Noisier, so more local detail
  – More accurate for curvature
  – More accurate for location
Curvature maps - axial

Axial Diopter

- Patient
  - ID: 
- Examination
  - Eye: Right
  - Date: 22-Jun-99
  - Exam: 2, Center

- Keratometer
  - 48.12D @86°
  - 46.37D @176°
  - Astig: 1.75D
  - Eccen: 0.50 @176°

- Cursor
  - Distance: 8.23mm
  - Meridian: 173°
  - Power: 
  - Radius: 

Legend:
Dpt 48.00 47.50 47.00 46.50 46.25 46.00 45.50 45.00 44.50

R
Curvature maps - tangential
Curvature maps

Axial Dioptr

Tangential Dioptr
Height map - best fit sphere

- Difference from best fit sphere or ellipsoid
- Shows toricity
Parallel light rays striking the corneal surface from infinity are refracted.

Ray C has the greatest refractive power since it crosses the optical axis at the shortest focal distance, c. Rays B and A have longer focal lengths, respectively, (b and a), and therefore have the least refractive power.
Refractive power map

Refractive Diopter

Dpt

- 51.75
- 50.25
- 48.75
- 47.25
- 46.50
- 45.75
- 44.25
- 42.75
- 41.25

R
Color maps - overview
Clinical applications

• Keratoconus
  – Other corneal conditions, detecting irregularity, explaining reduced VA
• Refractive surgery
• Contact lenses
Keratoconus

- Diagnosis of early cases
- Describing size, location, curvature of cone
- Monitoring change
Keratoconus

- Clinical signs
- Methods of detecting with topography
  - Tangential power (peak > 49 D)
  - Difference between 2 eyes at apex
  - Progression
  - Statistical indices
Keratoconus
Keratoconus

- Tangential map best for peak power, location
Keratoconus

- Axial map underestimates peak power, overestimates distance to apex
Keratoconus

Condition
CIM (Corneal Irregularity Measurement)
SF (Shape Factor)
TKM (Mean Toric Keratometry)
Keratoconus
Refractive surgery

- Pre-surgical keratoconus screening
- Troubleshooting unsatisfactory outcomes
Refractive surgery

- Tangential map best for power, location
Refractive surgery
Refractive surgery

Tangential Diopter

Dpt
48.00
46.00
44.00
42.00
41.00
40.00
38.00
36.00
34.00

L
Contact lenses

- Lens selection
- Orthokeratology
- Monitoring corneal warpage (distortion)
Lens selection

Lens Position From Vertex:
0.01 mm Nasal  0.01 mm Superior

Recommended Lens - OD
Menicon - SFP{1}

Power: 45.5 D
Radius: 7.42 mm

From vertex:
Distance 3.41 mm
Sagittal 270°

From pupil:
Distance 3.60 mm
Sagittal 272°

SimK Values:
46.120 @100
42.350 @10

Base Curve
7.94 mm
Curve 42.50 D
Power -0.25

Lens Diameter
9.20 mm
Optical Zone
6.60 mm
Secondary Curve
11.51 mm
Width 0.60 mm
Peripheral Curve
12.52 mm
Width 0.70 mm

Options

©1993-1997 HUMPHREY SYSTEMS MASTREVUE ULTRA Version A8x17 Extrapolated 1 mm
Lens selection
Orthokeratology
Orthokeratology
Corneal distortion

• Differentiating keratoconus from CL distortion
  – CL distortion follows lens decentration
  – CL distortion usually has smile pattern
Corneal distortion

Despite red cone-like topography pattern, the corneal curvature is only 45 diopters at the highest point.

Although CIM is quite abnormal, both Shape Factor and Mean Toric K’s are in the normal range, eliminating the diagnosis of keratoconus.
Corneal distortion