Corneal Imaging

Corneal imaging refers to the study of shape of corneal surfaces.
It is a diagnostic tool that shows the overall architecture of the cornea including surface power, thickness, front and back shape.
Assessment of Corneal Surface

Corneal Slope

- Measurement based on reflected images
- Measured slope used to calculate radius of curvature and power.
- Corneal elevation can’t be calculated from measurements of slope alone.

Corneal Height

- Direct measurement of corneal height
- Measure the elevation and use this to calculate slope, curvature, and power.

Reflection Based

Projection Based
Types of Corneal Topographers

- **Reflection Based Technology**
  1. Keratometer
  2. Keratoscope (Photokeratoscopy & Videokeratoscopy)

- **Projection Based Technology:**
  1. Scanning Slit Technology (Orbscan)
  2. Scheimpflug imaging (pentacam)

Keratometer

- Javal-Schiotz Keratometer
- Bausch & Lomb Keratometer
Keratometer is an objective method for determining curvature (diopteric power) of the cornea.

**Keratometer disadvantages**

- Measures only central 3 mm (6%) of cornea
- Corneal epithelial irregularity → defocussing
- Inaccurate post-refractive surgery readings
Keratoscope
It is an instrument that projects multiple concentric rings (mires) on the cornea.

Keratoscope takes data from the whole cornea.

- Steep cornea $\rightarrow$ narrow mires and close rings.
- Flat cornea $\rightarrow$ broad mires and wide separation.
Keratoscopes

Photo-keratoscope
- Still camera is added to photograph the mires

Video-keratoscope
- Video camera is added

Photo-keratoscope
Placido disc appearing corneas

Normal

Inferior steeping

Irregular cornea

Video-Keratoscopy

- Computerized VideoKeratoscopy
- Capturing the keratoscopic details onto a video and displaying data analysed with multiple algorithms
- Measures larger area with more points (256 circumferential points on each ring are identified)
All of them analyze & visualize anterior corneal surface.
ORBSCAN SYSTEM

- Orbscan I: only slit scan topography
- Orbscan II: the placido disc is added
- Orbscan IIz: with wave front analysis
Orbscan IIz

Combines two principles

- Placido disc
- Scanning slit

Placido disc principle

- The location of the placido rings in relation to the camera is already known.
- The radial slope of the surface at the point of reflection can be determined by ray tracing.

**Used for keratometric analysis**
Scanning slit principle

- It uses a series of light slits (40 slits) passing over the cornea at an angle of about 45° to the camera.

ORBSCAN SYSTEM

- 40 scanning slit beams (20 from the left and 20 from the right) with up to 240 data points per slit, used to scan the cornea and measure independently the X,Y & Z locations
- The central 5 mm area is scanned twice
• The Orbscan has the capability to record 9000 data points of a cornea.
• Each data point is 1 micron.
• As corneas have a diameter of 11 mm, the Orbscan provides a highly accurate map.
• It takes a mere 1.5 seconds to scan one eye.

Interpretation of Orbscan Map
Quad Map

Anterior Elevation Map

Posterior Elevation Map

Curvature Map

Statistics and Data

Pachymetry Map
Elevation Maps

- The computer calculates a hypothetical sphere that matches as close as possible to the actual corneal shape being measured.
- Compares the real surface to the hypothetical sphere showing areas above the surface of the sphere in warm colors and areas below the surface in cool colors.
Color scale for relative elevation

Anterior Elevation Map

Overlays:
- Radial
- Pachymetry
- Circular
- K-Lines
- Pupil
- K-Labels
- Min-Max
- Grid
- Thin Point
- Numerical
- Kappa Absolute
Anterior Elevation Map

Posterior Elevation Map
Posterior Elevation Map

Curvature Map
Color scale for surface curvature

- sharp
- fast bend
- short radius

- flat
- slow bend
- long radius
Corneal thickness (pachymetry) Map

Pachymetry Map

- The orbscan measures thickness from the tear film layer to descemet’s membrane and is thicker than that obtained with ultrasound
- Provides a reading showing the thinnest point of the cornea that may not necessarily be the central reading
Color scale for pachymetry

Max

Min

Blue

Red

• thick

• thin

Pachymetry Map
Pachymetry Map

- Cooler Colors
  - Thicker Areas

- Warmer Colors
  - Thinner Areas

Data measurements

- Sim K (Max. & Min.)
- Mean corneal power
- Astigmatism with its axis (in 3 mm & 5 mm zones)
- White-to-white
- Pupil diameter
- Thinnest corneal thickness
- Ant. Chamber depth
- Angle K

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<th>Parameter</th>
<th>Value 1</th>
<th>Value 2</th>
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<td>Sim K's: Astig</td>
<td>-0.4 D</td>
<td>@ 138 deg</td>
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<td>Max:</td>
<td>46.7 D</td>
<td>@ 48 deg</td>
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<td>Min:</td>
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- White-to-White [mm]: 11.6
- Pupil Diameter [mm]: 4.2
- Thinnest: 504 um @ (0.4, 0.1)
- ACD (Ep): 4.13 mm
- Kappa: 6.42* @ 353.27*
- Kappa Intercept: 0.55, 0.22
Orbscan Cases
Regular Astigmatism

Steep vertical axis, centrally thin cornea, high posterior float

Keratoconus
21 y. female (-2.5 D). Can she undergo lasik?

Normal corneal orbscan

Posterior surface elevation
Relations between 4 Maps

Three step rule

• 1 abnormal map → Caution
• 2 abnormal maps → Concern
• 3 abnormal maps → Contraindication

The posterior highest point correlates with:

• Anterior highest point
• Anterior steepest point
• Thinnest corneal point
Post-LASIK ablation

History of LASIK surgery

Post Lasik Ectasia
Orbscan versus Pentacam

- Both Orbscan IIz & Pentacam Topographic analyze cornea’s front and back surfaces based on the true elevation measurement compared to a derived reference surface.
**Pentacam**
- It uses rotating Scheimpflug camera to take optical cross sections of the anterior segment.

**Orbscan**
- It uses a series of slit imaging

The optical slices used by the pentacam share a common point, allowing for more accurate image registration.

- Intrasystem reliability showed the difference between two consecutive measurements taken by the same machine.
- With the Pentacam, the results showed overall good reproducibility.
- While Orbscan was less reliable with low reproducibility
• Orbscan IIz was incapable of imaging the postoperative cornea accurately
• Edge-detection algorithms (the slit-lamp–based Orbscan IIz) are vulnerable to interference from artifacts introduced by the corneal reshaping

• The Orbscan IIz in particular exaggerates the posterior corneal surface’s contour (locates the surface too anteriorly).
• Orbscan IIz pachymetry reading is too thin
Thank You