Tomography vs. Topography

- Topography: The process for generating a “topograph”, a detailed representation or description of the surface characteristics of a structure.
Tomography vs. Topography

- **Tomography:** The process for generating a “tomogram”, a two-dimensional image of a slice or section through a three-dimensional object.
Placido Topography
Placido Topography, What are the issues?
Tear Film Dependance
Optical axis and visual axis the same

Optical axis and visual axis different
Anterior Segment Tomography

- Schiempflug
- OCT
Pentacam® Comprehensive Analyzer

- High resolution anterior segment images
- Corneal thickness
- Curvature
- Total corneal refractive power
- Elevation
- Corneal Optical Densitometry
- Lens Densitometry and Pentacam Nucleus Staging (PNS) 3D cataract analysis
- Anterior chamber angles, depth, and volume
- Corneal aberrometry – Zernike wavefront analysis
Basic Principles
Rotating Scheimpflug Camera

• The Pentacam® uses a slit beam and Scheimpflug camera to take several cross-sectional images of the anterior segment of the eye.
3D Model

- The individual images are used to construct a 3D model of the eye
- All images go through the central cornea
- Coverage is nearly limbus to limbus
- Measurements are not tear film dependent
Standard Camera

Scheimpflug Technique
Scheimpflug Imaging
Scheimpflug Imaging
Scheimpflug Imaging
Applications of Anterior Segment Tomography

- Angle Closure Glaucoma Screening and IOP Correction
- Detection of Keratoconus
- Screening Refractive Surgery Candidates
- Cataract Assessment
- IOL Selection and Calculations
- Anterior Segment Imaging
Pentacam® Glaucoma Screening
Glaucoma Screening

- Anterior chamber depth
- Anterior chamber angle
- Anterior Chamber Volume
Fast Screening Report/ Indices Report Display

Distribution of pathological findings (red) and normals (green)
Overview Display - IOP Correction

Enter measured IOP (Uncorrected IOP)

Click “Enter IOP” button to enter IOP
Normal Patient
**Fast Screening Report**

Individual Pentacam measurement values are represented in two different ways to accentuate their position within the distribution of healthy and pathological populations. The studies on which the presentation of the particular parameters is based can be viewed by clicking on Literature.

The gray vertical bars represent the normal distribution of healthy eyes, the stepping is 1 standard deviation.

In the colored diagrams the green curve is again the distribution of the healthy population, the red curve is the distribution of a pathological population based on the corresponding study. These indices cannot replace the physician's medical diagnosis. They are only considered as an aid to bring the physician's attention to some displays. The corresponding Pentacam display(s) which might be helpful for the diagnosis are listed in the Quick Navigation Window.
**Fast Screening Report**

Individual Pentacam measurement values are represented in two different ways to accentuate their position within the distribution of healthy and pathologic populations. The studies on which the presentation of the particular parameters is based can be viewed by clicking on "Literature." The grey value bar represents the normal distribution of healthy eyes, the stepping is 1 standard deviation. In the colored diagrams the green curve is again the distribution of the healthy population, the red curve is the distribution of a pathologic population based on the corresponding study. These indices cannot replace the physician’s medical diagnosis. They are only considered as an aid to bring the physician’s attention to some displays. The corresponding Pentacam display(s) which might be helpful for the diagnosis are listed in the Quick Navigation Window.
Primary Closed Angle Glaucoma
Fast Screening Report

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Detection of Keratoconus and Screening for Refractive Surgery
“Keratoconus is a clinical term to describe a condition in which the cornea assumes a conical shape because of thinning and protrusion”
Best Fit Spherical Difference
Radial
Elevation Maps

Spherical Cornea

Astigmatism

Keratoconus
Elevation with Best Fit Sphere

Note the central island of elevation back surface elevation in this case.
Enhanced Reference Shape

Keratoconus fit with Best Fit Sphere vs Keratoconus fit with New Reference Shape

Normal fit with Best Fit Sphere vs Normal fit with New Reference Shape

Courtesy of Dr. Michael Belin
Evaluation of the thickness progression on concentric rings from thinnest spot towards periphery.
Pachymetric Progression

Pachymetric Progression: Corneal Thickness Spatial Profile

Pachymetric Progression: Percentage Thickness Increase
Select the Appropriate Reference Database

Back Surface

Minimum Thickness

Front Surface

Pachy Progression

ART Max

Summary (Final D)
Belin/Ambrosio Enhanced Ectasia

Topometric / KC Staging Display

- **A = Anterior Curvature**
- **B = Posterior Curvature**
- **C = Thinnest Pachymetry**
- **D = Best Corrected Visual Acuity**
Keratoconus
Fast Screening Report

Individual Pentacam measurement values are represented in two different ways to accentuate their position within the distribution of healthy and of pathologic populations. The studies on which the presentation of the particular parameters is based are also visible by clicking on “Literature.”

The grey value bar represents the normal distribution of healthy eyes, the stripping is 1 standard deviation. In the colored diagrams the green curve is again the distribution of the healthy population, the red curve is the distribution a pathologic population based on the corresponding study. These indices cannot replace the physician’s medical diagnosis. They are only considered as an aid to bring the physician’s attention to some displays. The corresponding Pentacam display(s) which might be helpful for the diagnosis are listed in the Quick Navigation Window.

Chamber Angle: 33.3

A. C. Depth (Alt): 2.88

Chamber Volume: 126

Pachym Min: 45.6

Pachy Apex: 47.5

Pachy Prog.-Index Av: 0.84

Pachy Prog.-Index Max: 2.83

K Max (Front): 49.9

Elevation (Front): 2.6

Elevation (Back): 18.2

Cornea Desmito Avg: 17.3

Cornea Desmito Avg: 15.9

BAD D: 3.04

TKC: 0

PNS: 2
### Fast Screening Report

Individual PENTacam measurement values are represented in two different ways to accentuate their position within the distribution of healthy and pathologic populations. The studies on which the presentation of the particular parameters is based can be viewed by clicking on "Literature." The grey value bar represents the normal distribution of healthy eyes; the stepping is 1 standard deviation. In the colored diagrams, the green curve is upon the distribution of the healthy population, the red curve is the distribution of a pathologic population based on the corresponding study. These indices cannot replace the physician's medical diagnosis. They are only considered as an aid to bring the physician's attention to some displays. The corresponding PENTacam display(s) which might be helpful for the diagnosis are listed in the Quick Navigation Window.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chamber Angle</td>
<td>91.1</td>
<td></td>
</tr>
<tr>
<td>Pachy Min.</td>
<td>414</td>
<td>477, 511, 545, 578, 614</td>
</tr>
<tr>
<td>Pachy Apex</td>
<td>436</td>
<td>482, 516, 550, 584, 618</td>
</tr>
<tr>
<td>Pachy Prog.-Index Max.</td>
<td>3.88</td>
<td>0.52, 0.74, 1.18, 1.58, 2.50</td>
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<tr>
<td>Elevation (Back)</td>
<td>64.8</td>
<td>4.1, 8.0, 4.1, 8.2, 12.3</td>
</tr>
<tr>
<td>Comera Densito Avg.</td>
<td>17.9</td>
<td>10.8, 11.2, 12.4, 13.6, 14.8</td>
</tr>
<tr>
<td>DIA:</td>
<td>8.85</td>
<td>4.1, 39.8</td>
</tr>
<tr>
<td>TKC:</td>
<td>2.0</td>
<td></td>
</tr>
</tbody>
</table>
Cataract Assessment
Lens Densitometry (PNS)

Value from 0 to 5 is displayed based on lens opacity.

Field will turn yellow if pupil is not dilated to 4mm as a quality warning.

PNS Button: Pentacam Nucleus Staging

PNS:
The lens density is calculated from the internal 3D model with focus to the lens nucleus.

A grading is performed from PNS 0 to PNS 5 based on a published paper from Donald Niren, MD.

"Preservative cataract grading by Scheimpflug imaging and effect on operative fluidics and phacoemulsification energy.

PNS Quality Specification:
For best reliability, the pupil diameter should be above 4.0mm.
If the pupil diameter is below 4.0mm, the PNS value is highlighted in yellow as a quality warning.
Lens Densitometry (PNS)
IOL Selection and Calculations
Axial/Sagittal Curvature

- Distance between vertex normal and the corneal surface is curvature in millimeters

- *Curvature in Diopters* = \(\frac{(1.3375-1)(1000)}{\text{Curvature in mm}}\)

- Anterior corneal surface only
  - Standard IOL formulas estimate posterior corneal influence based on normal B/F ROC ratio of 0.822 (Gullstrand Ratio)

- No adjustment for spherical aberration
True Net Power

• Anterior and posterior curvature is measured

• \[ \text{True Net Power} = \frac{(1.376-1)(1000)}{\text{Anterior curvature in mm}} + \frac{(1.336-1.376)(1000)}{\text{posterior curvature in mm}} \]

• No adjustment for spherical aberration
| True Net Power, 4.0mm Zone, Apex, Keratometric Mean (Km) |
Total Corneal Refractive Power

• Ray Tracing is used to determine corneal power

• The anterior cornea, posterior cornea, and the refractive effect (i.e. spherical aberration) are considered
Equiv K-Readings 65 (4.5mm Zone)

EKR65 Flat K1: 43.72 D (162.2°)
EKR65 Steep K2: 45.62 D (72.2°)
EKR65 Mean: 44.67 D

Astig EKR65: 1.90 D
Q (6.0mm): -0.17
Total SA [Z(4+6+8,0)]: 0.247 μm
Higher Order Abberations
Spherical Aberration

Ideal Optical System

Spherical Aberration
Cataract Pre-Op Display

- Detection of abnormal corneal shape (Keratoconus, Post LASIK, etc.)
- Evaluation of corneal spherical aberration (Spheric or Aspheric IOL?)
- Evaluation of corneal higher order aberrations
Holladay Report

Pupil Dia: + 3.08 mm  
HWTW: 12.1 mm  
Pachy Min: 543 µm  
A. C. Depth (Ext.): 3.98 mm  
Chord µ: 0.17 mm @ 146°
Operating Procedure
Patient Data Management

Click Pentacam Button To Enter Exam Software

Add New Patient or Search for Existing Patients

Click Save After Entering Patient Info
Click Examination → Scan
New Measurement

• Sanitize the chinrest and forehead rest

• Seat the patient and explain what to expect during the scan

• Have the patient remove their glasses
New Measurement

• Adjust the table height

• Have the patient put chin in rest and forehead against strap

• Adjust the height of the chinrest so eyes are level with black ring
New Measurement

- Turn out lights in room or cloak the patient

- Instruct the patient to **focus on the fixation** target and blink normally

- Move the Pentacam so the crosshairs are in the center of the pupil and the red dot (corneal apex) is on the red line

- Guides will appear to assist with fine adjustments
New Measurement

- Make fine adjustments as directed
- When alignment is close instruct the patient to open eye wide
- Proper alignment is a black cross in the center of the circle with four black bars surrounding it.
- Instruct the patient not to blink and to remain still
- Let the patient know when the scan is complete
Evaluating Scan Quality
Capturing Quality Images

Good Scan

Bad Scan

Too Much Ambient Light
Capturing Quality Images

Good Scan

Questionable Scan

Check Track Alignment and Ensure Proper Fixation
Quality Specifications

Basic exam data
Discussion & Hands On!