HighRes Anterior Segment OCT
CASIA SS-1000
- 
Case Reports

A. Langenbucher, T. Eppig
• Imaging modalities for the anterior eye segment and characterization of the CASIA-OCT
• Measurement samples with the Casia 1000
  – Corneal pathologies
  – Following penetrating keratoplasty + complications
  – Anterior segment analysis
  – Refractive surgery and IOL implantation + complications
• Conclusions
Oculus Pentacam HR
- LED with 475 nm UV-free
- Rotating slit projection
- 100 images in 2 s
- 500 axial points

Zeiss Visante TD-OCT
- SLD mit 1310 nm
- 2000 Scans/s
- Resolution axial/lateral 18/60 µm
- AS scan (16x6 mm) 256 A-scans (.125 s/slice)
- HR cornea scan 512 A-scans (.25 s/slice)

Sonomed UBM
- 35 or 50 MHz
- Resolution (50 MHz) axial/lateral 18/40 µm
- Acquisition time HR/3D 3 s
- No topographic function or image processing

Reichert Reflex UBM
- 35 or 50 MHz
- Resolution (50 MHz) axial/lateral 16/45 µm
- Acquisition time HR/3D 2 s
- No topographic function or image processing

TMS-5 Tomey
- 25 or 31 rings x 256 points
- Acquisition time .5 s (n=4)
- 6400 / 7300 datapoints
- 64 frames in 1.0 s
- 40960 measurement points
- Placido and/or Scheimpflug
- Data merging & motion correction

Ziemer Galilei (Bon Optics)
- Placido-topography+Dual Scheimpflug-Imaging (rotating slit)
- Merging of Placido & Scheimpflug data
Tomey SS Casia 1000 (SS-OCT)

- Light source 1310 nm (NIR)
- Spatial resolution axial 10 µm, lateral 30 µm
- Anterior segment analysis (16x16x6 mm)
- Corneal scan (10x10x3 mm)
- 30,000 A scans/s
- Modalities:
  - 2D/3D measurement and data analysis
  - Corneal topography (anterior and posterior)
  - Anterior segment measurement
  - Pachymetry mapping
  - HR-cornea scan
  - Densitometry map
Optical tomography vs. Ultrasound

- Refractive index of ALL media must be known
  Tissue opacities block light (NIR!!!, e.g. CASIA)
- Deeper structures MUST be corrected by inverse raytracing through superficial structures!!!!
- Error propagation if superficial structures are not measured or analyzed appropriately
  10th order polynomial fit (CASIA) instead of spherical model in Pentacam

- Speed of sound of ALL media must be known
  (especially in pathologic tissue or cataractous lenses unrealistic!!!)
- Refraction at interfaces (e.g. at corneal front surface or vacuoles)
- Error propagation for deeper structures if superficial structures are measured or interpreted incorrectly.
Measurement samples: Measurement with corneal pathologies (e.g. dystrophies and keratoconus)
Stromal corneal dystrophy

Granular stromal dystrophy
Stromal corneal dystrophy
Keratoconus ante perforationem
Overview image: Keratoconus

3D display

Automatic surface detection and characterization
Corneal topography in keratoconus
Dedicated KC screening software

Ectasia Screening
84% Similarity
Clinical Ectasia

Axial Power [Keratometric]
Sph.@6: 48.86 D Reg.@6: 1.73 D
Asy.@6: 4.93 D Hic.@6: 0.41 D

Pachometry
Thinnest: 433 um
X: 0.9 mm
Y: -0.9 mm

Axial Power [Posterior]
Sph.@6: -7.33 D Reg.@6: 0.35 D
Asy.@6: 1.25 D Hic.@6: 0.07 D

Instantaneous Power [Posterior]
Steepest @6: 3.86 mm
X: 1.0 mm
Y: -1.5 mm
Cross sectional view in keratoglobus

Extreme thinning and bulging of the cornea, risk of perforation

„Live“-image
Corneal topography map in keratoglobus

Due to opacification and uncertain reflex, the corneal back surface cannot be detected.
Examination of amniotic membrane in situ
Perforating injury with a steel needle
Descemet detachment and corneal edema in bullous keratopathy
Corneal measurement through a CL
Topography and size of a CL
Measurement samples: Diagnostics after penetrating (PK) or lamellar (LK) keratoplasty + complications
Overview image: following PK
Corneal topography following PK
Graft diameter and CCT profile
Automatic surface recognition following PK
Step formation and flat ACD
Following DSEAK

Measurement of the graft thickness

Descemet stripping endothelial keratoplasty

"Live" image
Measurement w-t-w and graft diameter
Measurement samples: Anterior segment analysis
Anterior chamber depth measurement

OS (Left)

CCT = 715 [um]

ACD [Epi.] = 3.38 [mm]
ACD [Endo.] = 2.66 [mm]

Area = 0.06 [mm^2]
Anterior chamber analysis

Cross section area and volume (integration over 180°)
Angle measurement
Complete and partial anterior synechiae

Situation after PK
Posterior synechia with cyst
Angle closure glaucoma
Severe iris defect and Descemet detachment after ocular trauma

Automatic surface recognition still works!!!
Malignant iris tumor

- Measurement of dimensions and structure
- Therapy monitoring
Peripheral iris cyst
Measurement samples: Refractive surgery and IOL implantation
Corneal topography following LASIK
Evaluation of flap thickness after LASIK
LASIK flap 3D video
Corneal Intacs

Connection between ring segments
Tilted refractive anterior chamber IOL
Extreme keratectasia after LASIK – Corneal topography
Extreme keratectasia after LASIK – Meridional cross section

Automatic surface detection works!!!
Conclusions

• The Casia 1000 is a powerful diagnostic tool which allows for high resolution 2D and 3D-measurements of
  – Cornea (.2-2.4 s image acquisition time)
  – Anterior eye segment
    (distances, chamber angles, areas,…; 1.2 s acquisition time)
  – Crystalline and artificial lens (mainly anterior segment, .5-1.2 s image acquisition time)

• Topography of the anterior and posterior corneal surface including precise full surface pachymetry (0.3 s acquisition time)

• True angles and distances ONLY if superficial surfaces are recognized and corrected properly
  – optical pathway correction with polynomials (n=10)
  – optional manual surface correction
Conclusions

• In measurement precision the Swept-Source-Technology is equivalent with SE-FD-OCT, but allows significantly shorter acquisition times
  – lower risk of movement artifacts (SS vs. TD-OCT: 30000 vs. 2000 scans/s)
• Raw data and processed data can be easily exported and postprocessed externally
• Dedicated keratoconus screening module is available with the new software version
• RGP CL fitting software in preparation (spherical, aspherical, multi-curved or toric CLs)
Experimental Ophthalmology

Saarland University

Thanks for your kind attention

Kirrberger Strasse / Bldg. 22
66421 Homburg/Saar
Germany
Tel.: +49 (0) 6841 / 16-21218
Fax.: +49 (0) 6841 / 16-24400
achim.langenbacher@uks.eu
TMS-5 Anterior segment analyzer
Classical topography map of the anterior corneal surface
Corneal power evaluation of the anterior corneal surface (e.g. CL fitting)
Corneal statistics (qualitative and quantitative)

Klyce Corneal Statistics

SimK: 39.05 @ 97° / 38.15 @ 7°
MinK: 38.10 @ 20°

SAI: 0.64  SRI: 0.22
CYL: 0.90  PVA: 20/15-20/25
CVP: 41.18  ACP: 38.57
SDP: 1.64  CEI: -0.66
IAI: 0.37  AA: 95.84%
EDP: 1.62  EDD: 2.02

SimK: Simulated keratometry is obtained from the greatest power observed in the corneal surface from an average of rings 6-8 along every meridian. The power and axis orthogonal to the highest power are also reported as they are in traditional keratometry. Higher than normal values are often associated with keratoconus, penetrating keratoplasty, and the occasional steep normal. Lower than normal values occur with myopic refractive surgical corrections.
Keratoconus screening based on anterior corneal topography
Corneal quad map
Alternatively with ACD instead of axial power (e.g. in glaucoma screening)
Surface detection with the Scheimpflug AC mode
Measurement of CCT, ACD and w-t-w
Matching of data sets originated from Placido disc and Scheimpflug modes

All optical sections of Scheimpflug image are shifted in x-y-z to be aligned to the Placido disc data set.
Case presentation: Comparison of different anterior segment imaging modalities
Extreme keratoconus with scarring – slit lamp overview
Slit lamp examination – cone profile
Munson sign – side view
Casia imaging – cross section

Extreme cone configuration

Diffuse back surface configuration
Comparison of different anterior segment imaging modalities
Casia imaging – 3D view
Casia imaging – topography map

Realistic values for surface elevation, axial power and pachymetry
**Pentacam HR imaging – topography map**

Realistic values only for axial power, but not for surface elevation or pachymetry
TMS-5 imaging – corneal topography and Klyce statistics

Klyce Corneal Statistics

- SimK: 59.63 @ 122° / 54.96 @ 32°
- MinK: 54.90 @ 27°
- SAI: 2.54
- SRI: 1.99
- CYL: 4.66
- PVA: 20/50-20/60
- CVP: 50.01
- ACP: 56.42
- SDP: 2.82
- CEI: 0.24
- IAI: 0.63
- AA: 78.43%
- EDP: 2.92
- EDD: 4.90

SimK: Simulated keratometry is obtained from the greatest power observed on the corneal surface from an average of rings 5.4° along every meridian. The power and axis orthogonal to the highest power are also reported as they are in traditional keratometry. Higher than normal values are often associated with keratoconus, penetrating keratoplasty, and the occasional steep normal. Lower than normal values occur with myopic refractive surgical corrections.
TMS-5 imaging – corneal topography and Klyce keratoconus screening