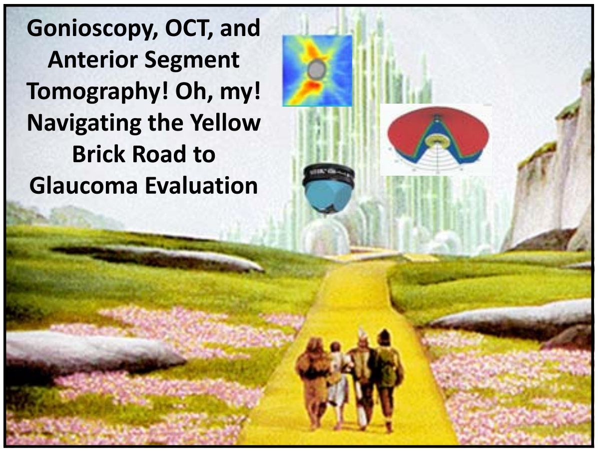
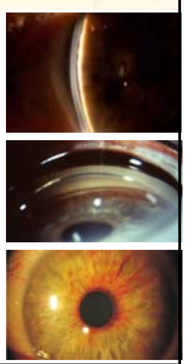
Gonioscopy, OCT, and Anterior Segment Tomography! Oh, my! Navigating the Yellow Brick Road to Glaucoma Evaluation



No disclosures or conflicts of interest

Indications for Gonioscopy

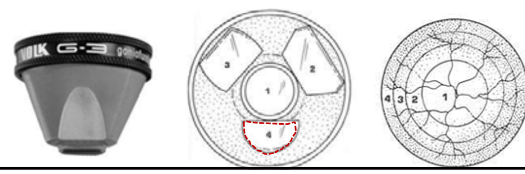
- **Glaucoma and glaucoma suspects**
- **Narrow angles**
  - **Gonioscopy is the "gold standard" for assessment of risk for angle-closure (ACG)**
- Elevated IOP
- History of blunt trauma
- Eyes at risk for developing iris or angle neovascularization secondary to an ischemic posterior segment disease (CRVO, OIS, DR, etc.)
- Suspicious iris or ciliary body lesions/masses



Gonioprism Design

Goldmann 3-mirror design

1. Central lens – 64 D
2. Equatorial/trapazoidal mirror (73°)-used to examine the equatorial retina
3. Peripheral mirror (67°)- used to examine the peripheral retina
4. **Thumb nail/D mirror (59°)- used primarily for gonioscopy**, can also be used to view the ora seratta/pars plana



Gonioprism Design

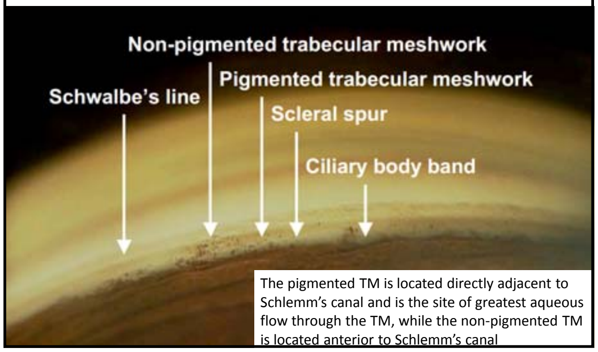
Zeiss 4-mirror design

- **4 mirrors are tilted at 64 degrees**
- Available with (**Posner design**) or without (**Sussman design**) a handle
- More suitable for small palpebral apertures
- No flange
- Can perform indentation

Gonioscopy Interpretation

- What is the anatomy?
  - What is the deepest visible structure
  - Are there any anatomic abnormalities?
- What is the geometry?
  - What is the angle?
  - What is the iris contour?

Gonioscopy Interpretation

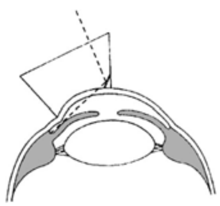


The pigmented TM is located directly adjacent to Schlemm's canal and is the site of greatest aqueous flow through the TM, while the non-pigmented TM is located anterior to Schlemm's canal

Normal Angle

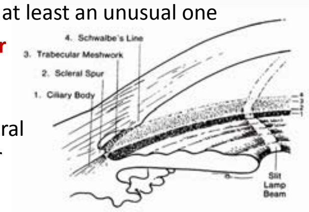
Gonioscopy Interpretation

- Accurately **identify the most posterior visible angle structure** in each quadrant
  - Tilt lens and/or modify patient's direction of gaze as needed to assess angle depth
  - **Inferior is usually deepest, superior is usually shallowest**
  - Find the scleral spur
  - Use **corneal wedge** as needed to aid identification of Schwalbe's line

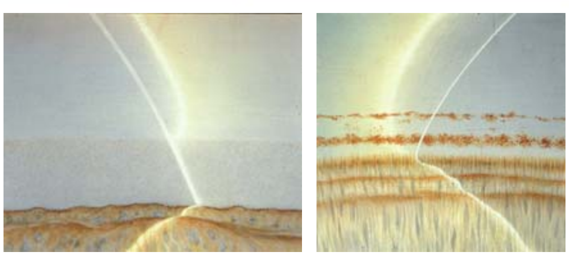


Gonioscopy Interpretation

- ACA orientation
  - The **scleral spur is the visual landmark with maximum angle orientation**
  - If the scleral spur is not located, suspect an abnormal angle, or at least an unusual one
  - All **outflow anterior to the spur is trabecular** and the remaining uveoscleral outflow is posterior



Corneal Wedge



Left: Corneal wedge in nonpigmented open angle

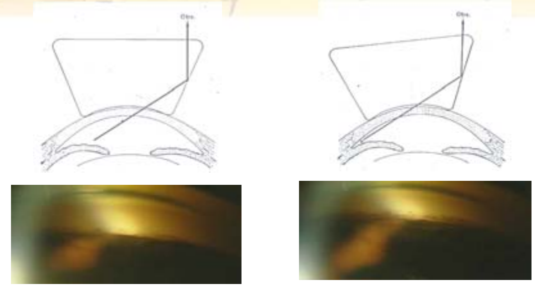
Right: Corneal wedge in pigmented closed angle

Corneal Wedge

Narrow Angle Evaluation

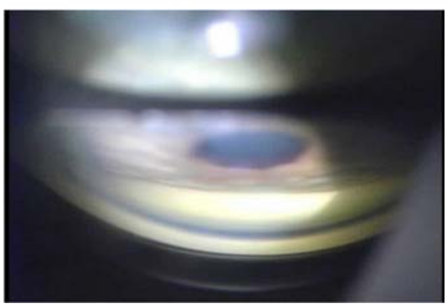
- Two techniques for evaluation of narrow angles
  - Look “over the hill” – lens tilting
  - Push the iris back – indentation

Look Over The Hill



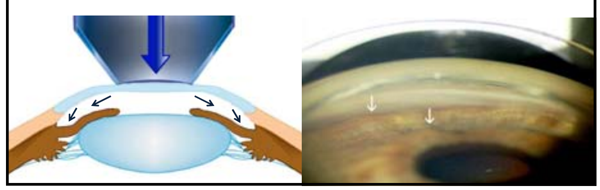
Have patient look into the mirror
or
tilt lens away from mirror

Look Over The Hill



Compression Gonioscopy

- Apply direct pressure to the cornea to force aqueous into the angle to deepen it and push the iris posteriorly
- Allows differentiation between **appositional and synechial closure**
- May help you identify angle structures in some situations



Compression Gonioscopy

- Can only use a lens with a contact surface that is smaller than the cornea
  - i.e. Zeiss/Volk 4 mirror, Posner, and Sussman lenses

Indentation Gonioscopy

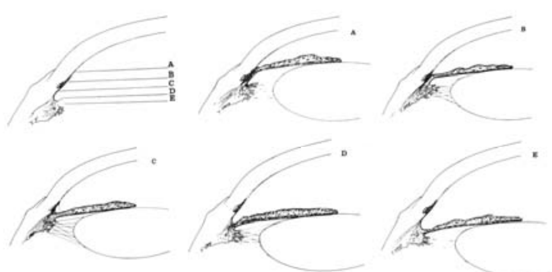
Gonioscopic Grading Systems

- Gonioscopic evaluation of the anterior chamber angle
  - **Assessment of angle anatomy**
    - Identify anatomic landmarks
    - Identify deepest visible structure
  - **Assessment of angle geometry**
    - Estimate the geometric angle formed by the angle recess
    - Assess width between Schwalbe's line and nearest part of the iris

Gonioscopic Grading System

- Spaeth System
  - **Insertion of iris root (deepest visible structure)**
    - A = Anterior to Schwalbe's line
    - B = Behind Schwalbe's line
    - C = sCleral spur
    - D = Deep into ciliary body band
    - E = Extremely deep
  - Effect of indentation
    - The apparent (pre-indentation) insertion is recorded first in parenthesis
    - The actual (indentation) insertion in recorded next without parenthesis

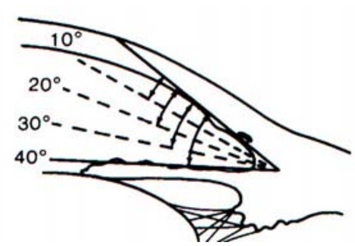
Gonioscopic Grading Systems



(Apparent) & actual insertion of iris root is graded as part of the Spaeth system

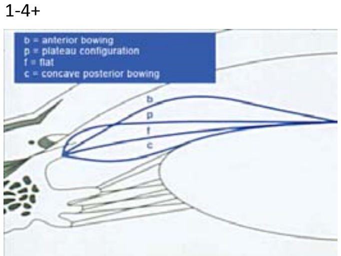
Gonioscopic Grading Systems

- Spaeth System (cont)
  - **Angle geometry**
    - 0º to 40º



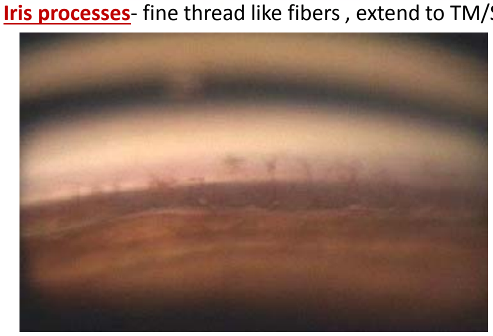
Gonioscopic Grading Systems

- Spaeth System (cont)
  - **Iris contour**
    - b = bow, grade 1-4+
    - f = flat
    - c = concave
    - p = plateau



Gonioscopy Findings

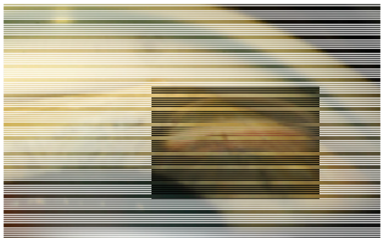
Iris processes- fine thread like fibers , extend to TM/SS



Gonioscopy Findings

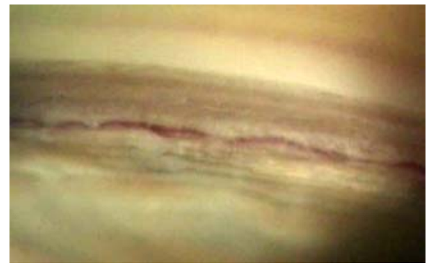
Peripheral Anterior Synechiae- broad, tented-up portions of the iris root which are attached to the TM

- Inflammation, neovascularization, angle closure



Gonioscopy Findings

Normal iris vasculature- radial orientation, large caliber, non-branching, do not cross SS



Gonioscopy Findings

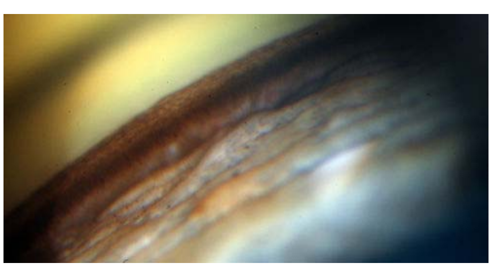
Neovascularization- Fine vessels that branch and run ant-post to cross the SS

Gonioscopy Findings

Angle Recession- Following blunt trauma

Gonioscopy Findings

Pigment Dispersion Syndrome



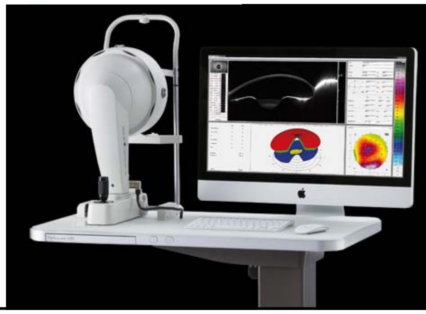
Gonioscopy Findings

Blood in schlemm's canal

- Without indentation- cavernous sinus fistula, sturge-weber

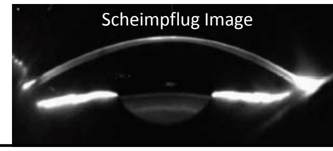
Anterior Segment Tomography

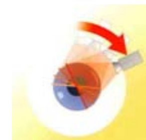
Pentacam®



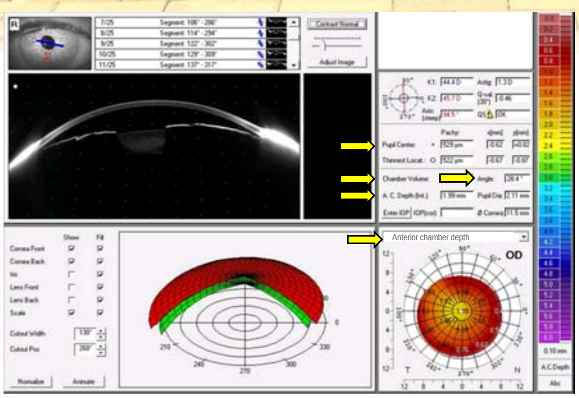
Pentacam®

- Combination of a slit illumination system and a camera that rotates around the eye to create a series of radial, cross sectional images (Scheimpflug images)





Pentacam®



Pre/Post LPI

Li S, Wang H, Mu D, et al. **Prospective evaluation of changes in anterior segment morphology after laser iridotomy in Chinese eyes by rotating Scheimpflug camera imaging.** Clin Experiment Ophthalmol. 2010 Jan;38(1):10-4.

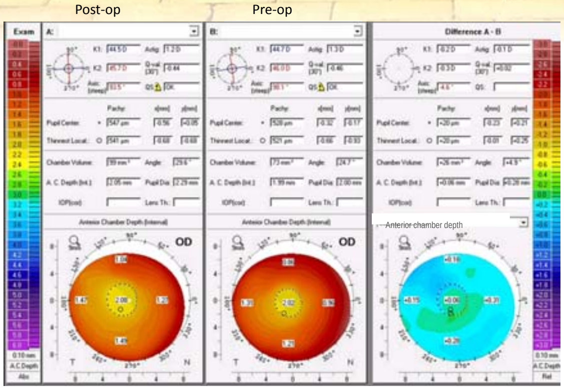
Table 2. Data summary of anterior chamber configuration changes before and after laser iridotomy ($n = 25$, eyes = 37)

	Before LPI	Post LPI	*P*
CCT (μm)	537.92 ± 27.92	541.49 ± 27.85	0.074
CACD (mm)	1.72 ± 0.27	1.70 ± 0.24	0.337
PACD (mm)	0.89 ± 0.26	1.14 ± 0.26	0.000
ACV (mm^3)	55.54 ± 14.25	82.65 ± 17.63	0.000
ACA – 9 o'clock	25.51 ± 5.66	28.11 ± 5.67	0.005
ACA – 3 o'clock	25.77 ± 5.15	27.91 ± 4.87	0.020
PD (mm)	1.72 ± 0.42	1.63 ± 0.46	0.228

ACA, anterior chamber angle; ACV, anterior chamber volume; CACD, central anterior chamber depth; CCT, central corneal thickness; LPI, laser peripheral iridotomy; PACD, peripheral anterior chamber depth; PD, pupil diameter.

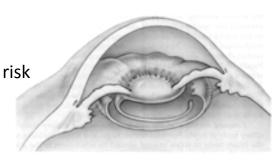
Pre/Post LPI

Post-op   Pre-op



Narrow Anterior Chamber Angle

- Evaluation of the narrow-angled eye
  - History
    - Transient episodes of visual blur, halos, or pain
    - ACG in fellow eye?
    - Family history of ACG?
  - Refraction
    - Hyperopia is a significant risk factor for ACG
  - Slit lamp examination
    - Van Herick estimation
    - Synechia (posterior or peripheral)
    - Glaucomflecken



Narrow Anterior Chamber Angle

- Should the narrow-angled patient be monitored or treated?
  - **Indications for iridotomy**
    - Occludable angle on gonioscopy
    - ACG in fellow eye
    - Any indication of glaucoma (IOP, cupping, VF)
    - Symptoms or signs of prior closure (PAS, halos)
    - Inability to be evaluated promptly if acute ACG develops
    - Significant patient anxiety about the risk of spontaneous angle closure

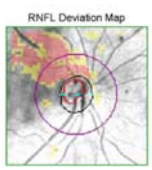
OCT IN THE DIAGNOSIS OF GLAUCOMA

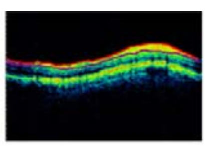
- **OCT Detection of Glaucoma**
  - Retinal Nerve Fiber Layer (RNFL)
  - Optic Nerve Head (ONH) Topography
  - Macular Thickness
- **Factors Affecting OCT Detection of Glaucoma**
  - Disease severity
  - ONH size
  - Others

OCT Detection of Glaucoma

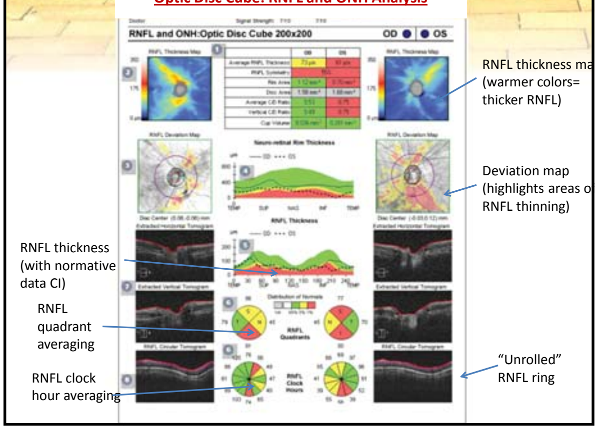
Method #1: Retinal Nerve Fiber Layer Thickness

- **3.4mm diameter measurement circle**
  - Make sure disc is centered in measurement circle
- **Segmentation** of RNFL from other layers
  - Accuracy dependent upon signal strength





Optic Disc Cube: RNFL and ONH Analysis



OCT Detection of Glaucoma

- Performance of RNFL analysis
  - **"Good" detection** of early glaucomatous optic neuropathy (per likelihood ratio tests)
    - **Avg and inferior most often affected in early glc**
    - Average thickness of fellow eyes should be within 10µm
  - Superior to general ophthalmologists' and equivalent to glaucoma specialists' interpretation of stereo disc photos

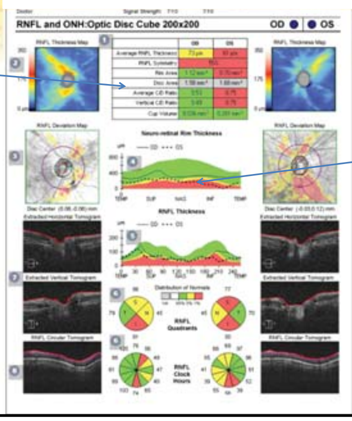
OCT Detection of Glaucoma

Method #2: Optic Disc Morphology

- Compare **cup and rim parameters** to normals
- Automated detection of disc & cup margins (Cirrus)
  - ONH margin defined as the termination of Bruch's
  - Analyzed at 255 points around the ONH circumference
  - The shortest perpendicular distance to ILM is the cup margin

Optic Disc Cube: RNFL and ONH Analysis

Key parameters table



Neuro retinal rim thickness (with normative data CI)

Cirrus ONH Parameters

	OD	OS
Average RNFL Thickness	73 µm	61 µm
RNFL Symmetry	55%	
Rim Area	1.12 mm²	0.72 mm²
Disc Area	1.58 mm²	1.72 mm²
Average C/D Ratio	0.53	0.75
Vertical C/D Ratio	0.49	0.77
Cup Volume	0.036 mm³	0.220 mm³

ONH morphology

Always gray b/c it's not compared to normals!

1mm² = sm
2mm² = med
3mm² = lg

NOTE: Asymmetric size may account for asymmetry in CDR and RNFL

OCT Detection of Glaucoma

- Performance of ONH morphology
  - **Not well established**. Conflicting reports
  - Best parameters for glaucoma detection: **Rim area, vertical CDR**

	OD	OS
Average RNFL Thickness	73 µm	61 µm
RNFL Symmetry	55%	
Rim Area	1.12 mm²	0.72 mm²
Disc Area	1.58 mm²	1.72 mm²
Average C/D Ratio	0.53	0.75
Vertical C/D Ratio	0.49	0.77
Cup Volume	0.036 mm³	0.220 mm³

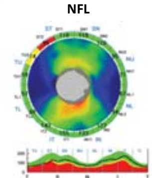
- **Poorer performance with smaller optic discs**
  - Smaller optic discs may be damaged but still appear normal (**small "pseudonormal" disc**)

OCT Detection of Glaucoma

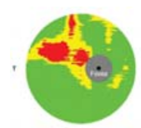
Method #3: Macular Thickness

- Death of ganglion cells leads to **macular thinning**
  - Localized &/or diffuse loss
  - Localized loss can be correlated with changes in RNFL and VF
- Measurements
  - **Ganglion Cell Complex (GCC)**
  - Macular retinal thickness

NFL



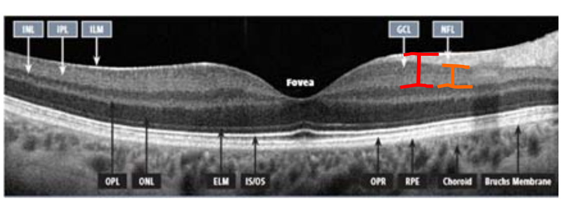
GCC



Ganglion Cell Complex

RTVue = RNFL + Ganglion cells + Inner plexiform layer

Cirrus = Ganglion cells + Inner plexiform layer

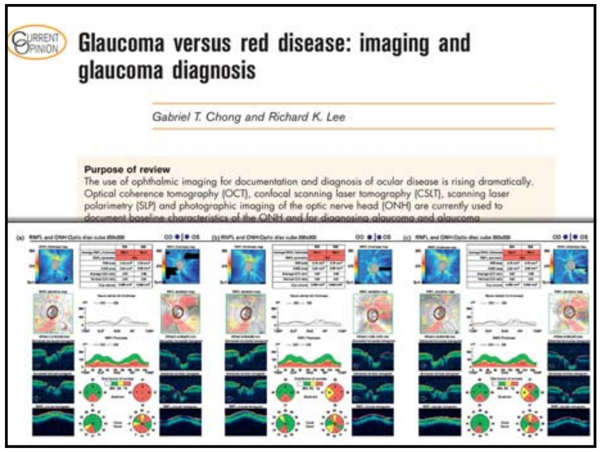


OCT Detection of Glaucoma

- GCC Thickness Data Presentation
  - Average and Regional thickness values
  - **Global Loss Volume** (GLV): "total deviation"
  - **Focal Loss Volume** (FLV): "pattern deviation"
  - Thickness, Deviation & **Significance maps**
  - Horizontal and vertical scans

OCT Detection of Glaucoma

- Performance of GCC analysis
  - **As good as RNFL** analysis for early glaucoma
  - **Performance improved when GCC is combined with RNFL analysis**
  - Less anatomic variability than peripapillary RNFL
  - Confounded by presence of **macular disease** (drusen, AMD, macular edema, epiretinal gliosis)



Glaucoma versus red disease: imaging and glaucoma diagnosis

Gabriel T. Chong and Richard K. Lee

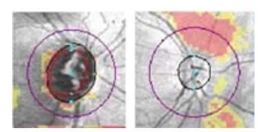
Purpose of review
The use of ophthalmic imaging for documentation and diagnosis of ocular disease is rising dramatically. Optical coherence tomography (OCT), confocal scanning laser tomography (CSLT), scanning laser polarimetry (SLP) and photographic imaging of the optic nerve head (ONH) are currently used to document baseline characteristics of the ONH and for diagnosing glaucoma and glaucoma

Factors Affecting Glaucoma Detection

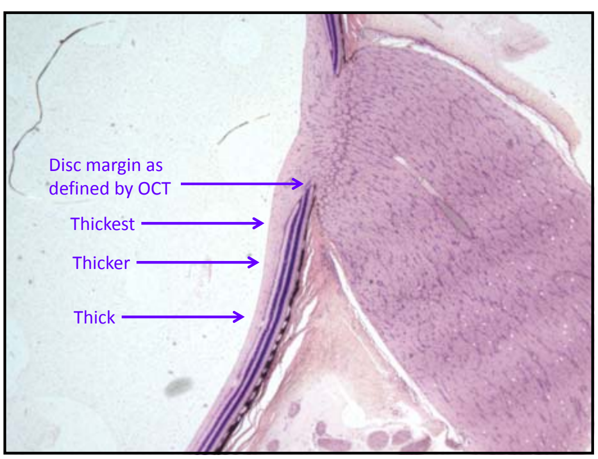
1. Optic disc size / Large physiologic cup
2. Signal strength / Errors
3. Artifacts / Ocular anomalies
4. Axial length
5. Blood vessel position

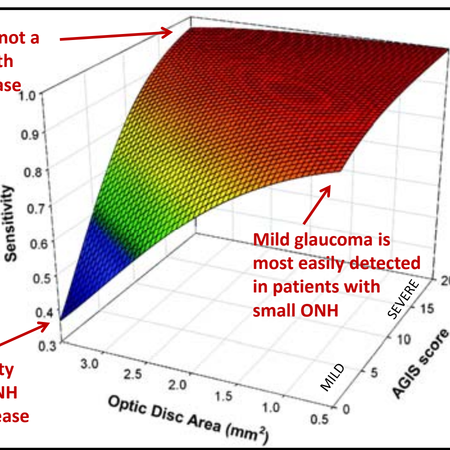
Factors Affecting Glaucoma Detection

- Optic Disc Size
  - **Larger discs have thicker RNFL measurements**
    - May contain more fibers
    - May be an artifact of fixed measurement circle



  - **Larger discs have lower sensitivity for early glaucoma detection**
    - Because larger discs start with thicker RNFL measurements, they must suffer more damage before registering as abnormal on OCT





Factors Affecting Glaucoma Detection

- **Smaller Disc Size Associated with OCT False Positives**
  - Cirrus OCT performed on 149 normal eyes
  - False positive rate: 26.2%!
  - Smaller optic disc size was significantly associated with increased risk of false positive results
  - Mean disc area: 2.74±0.49mm^2
    - **Large: >3mm^2 ➔False negatives**
    - **Small: <2mm^2 ➔ False positives**

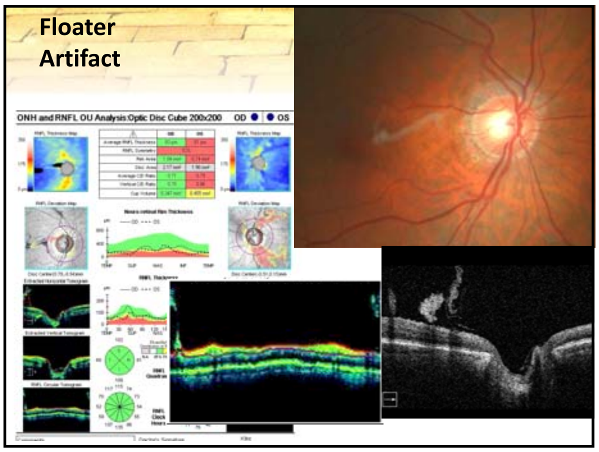
Factors Affecting Glaucoma Detection

- Signal Strength
  - Scan quality affects OCT performance, **even when within manufacturer recommended limits**
    - Effect greater on RNFL than ONH and GCC
  - Pupil dilation does not affect signal strength, RNFL measurement or reproducibility in normal eyes
    - Minimum 2mm pupil required
  - **Technical errors**
    - Disc centration, Blinks & eye movements, Vignetting

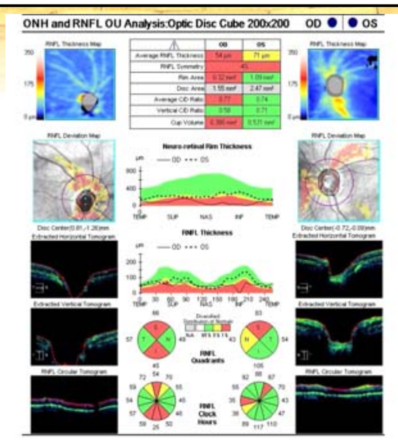
Factors Affecting Glaucoma Detection

- Artifacts & Ocular Anomalies
  - **Cataracts cause underestimation of RNFL**
    - Reproducibility can be improved with pupil dilation
  - Epiretinal membrane is a common artifact on RNFL and GCC scans
    - **ERM may inflate RNFL and macular thickness measurements**
  - Partial PVD will also inflate the thickness measurements until full detachment occurs

Floater Artifact

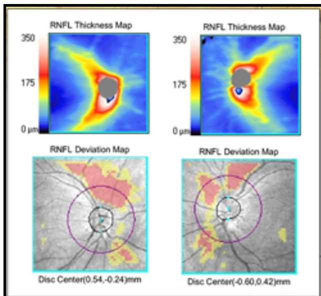


Decentration Error

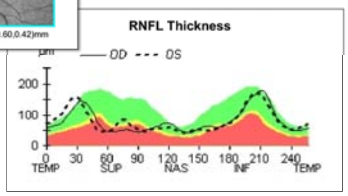


Factors Affecting Glaucoma Detection

- Axial Length
  - RNFL thickness is associated with axial length—**the longer the eye, the thinner the mean RNFL**
    - Every 1mm ↑axial length = 2.2µm ↓RNFL thickness
  - High myopes often have **lateral shifts in the contour of the RNFL thickness profile**
  - Longer axial length associated with significantly higher risk of OCT **false positive**

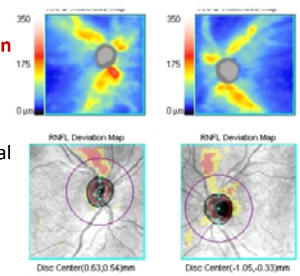


An example of how shifted RNFL bundles can create a false positive OCT abnormality



Factors Affecting Glaucoma Detection

- Blood Vessel Position
  - **Variations in normal RNFL profiles are often due to variation in blood vessel location**
  - **Split bundles**: When the RNFL bundles traveling with the nasal and temporal arcades are distinctly separated. May simulate a wedge defect



Thank you!!