Tips and Tactics for Retinal Imaging

Timothy J. Bennett, CRA, OCT-C, FOPS
Penn State Eye Center
Hershey, PA

Retinal Imaging

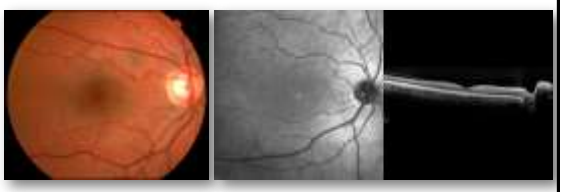
- Fundus camera
- Scanning Laser Ophthalmoscope (cSLO)
- SD-Optical Coherence Tomography

Universal Principles

- Focus
- Uniform illumination
  - Centered in pupil at appropriate working distance.
- Patient fixation
- Centered on known anatomic landmarks
- Centered on pathology

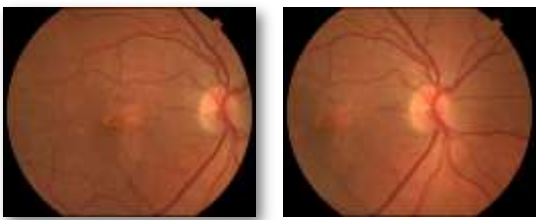
Anatomical Landmarks

- Fovea
- Optic Disc



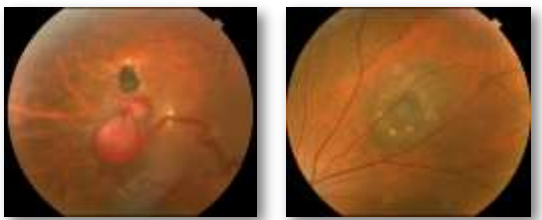
Alignment

- Centered on anatomic landmark



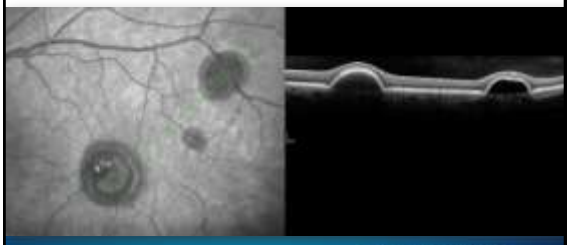
Alignment

- Centered on pathology



Alignment

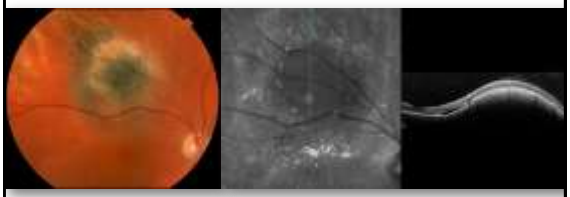
- Centered on pathology



PennState Health
Milton S. Hershey Medical Center

Alignment

- Centered on pathology



PennState Health
Milton S. Hershey Medical Center

Fundus Photography

PennState Health
Milton S. Hershey Medical Center

Fundus Photography

- Fundus photographs are used for clinical documentation, teaching, retinal screening, remote consultation, and clinical trials.
- Some retinal details may be easier to identify in stereoscopic fundus photographs compared with direct examination.
- Serial photographs are commonly used to track disease progression.

PennState Health
Milton S. Hershey Medical Center

Serial Fundus Photography

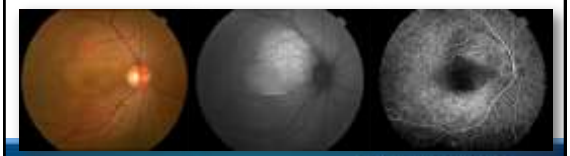
PennState Health
Milton S. Hershey Medical Center

Serial Fundus Photography

PennState Health
Milton S. Hershey Medical Center

Fundus Photography

- Fundus photographs are often used as a baseline to assist in interpretation of other diagnostic imaging procedures such as fluorescein angiography.



Fundus Camera

- The modern fundus camera is a horizontally mounted instrument with an internal electronic flash and an attached 35mm camera or digital sensor.

Fundus Cameras

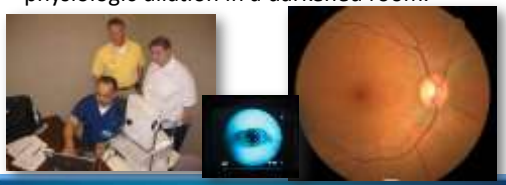
- Traditional (mydriatic)
  - Requires pharmacologic dilation
- Non mydriatic
  - Relies on physiologic dilation in a darkened environment
  - Results are often better WITH pharmacologic dilation

Traditional Fundus Camera

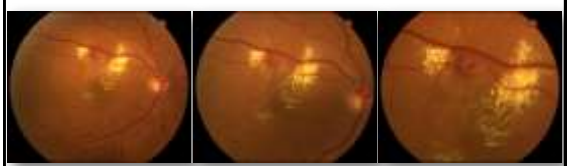
- Requires pharmacologic dilation
- Variable magnification settings
- Best for peripheral imaging
- Easier to shoot stereo photos
- Required for many clinical trials

Non-Mydriatic Fundus Camera

- User-friendly system designed with an infrared video focusing system that promotes physiologic dilation in a darkened room.



Variable Magnification

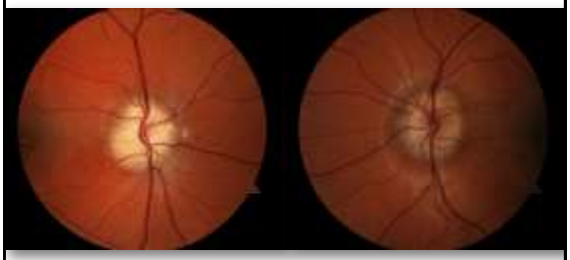


Wide Angle 50º | Normal 35º | High Mag 20º

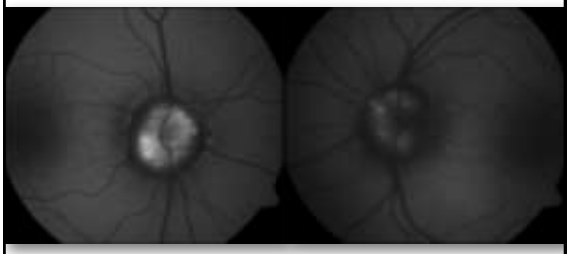
Fundus Camera Illumination

- The optical system of the fundus camera projects a ring of light from the internal strobe axially through the dilated pupil.
- The ring shape allows a separation of the outgoing and incoming illumination.

Dilation



Dilation



Fundus Camera Focus

- Fundus photography relies on the interaction between the optics of the fundus camera and the optics of the subject eye.
- The focus control of the fundus camera is used to compensate for refractive errors in the subject eye.
- Many fundus cameras have additional controls to compensate for refractive conditions such as myopia or astigmatism.

Focus: Setting the Eyepiece

- Fundus cameras employ an aerial image focusing system that relies on a properly set eyepiece reticle before attempting to focus the camera.

Focus: Setting the Eyepiece

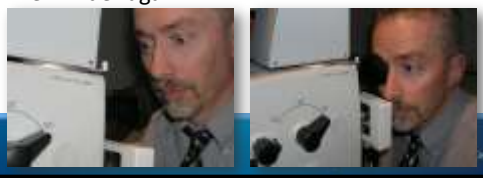
- Correctly adjusting the eyepiece reticle for proper focus is the single most important step in achieving sharp fundus photos.
- The photographer should relax their accommodation at distance to avoid accommodative shift during photography.

Focus: Setting the Eyepiece

- A popular and commonly taught technique involves adjusting the crosshairs at least three successive times, noting the diopter setting each time, and using the average.
- This technique actually promotes unnecessary accommodation and inaccurate settings.

Focus: Setting the Eyepiece

- Each time the photographer looks at the numbers marked on the eyepiece, they accommodate to near, then immediately try to relax at distance before looking through the viewfinder again.

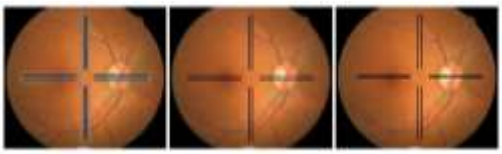


Focus: Setting the Eyepiece

- Repeating these steps multiple times induces accommodative "gymnastics" and subsequent fatigue leading to improper settings when accommodation drifts during a photographic session.

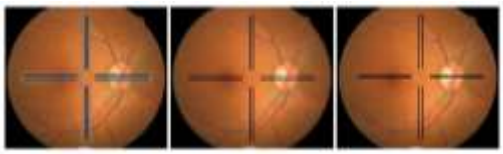
Focus: Setting the Eyepiece

- The best strategy is to ignore the eyepiece numbers, but pay constant attention to the crosshairs and image of the retina.



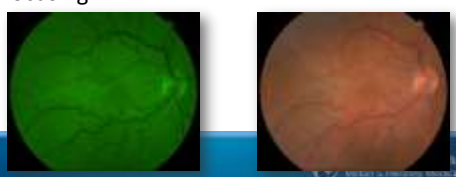
Focus: Setting the Eyepiece

- As long as the crosshairs and the aerial image of the fundus both appear sharp at capture, the focus will be correct.

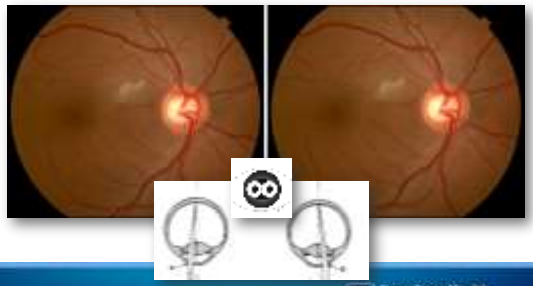


Focus

- Rock focus knob until image is sharp.
- Use myopic or astigmatic control if needed.
- Use green filter to increase contrast while focusing.



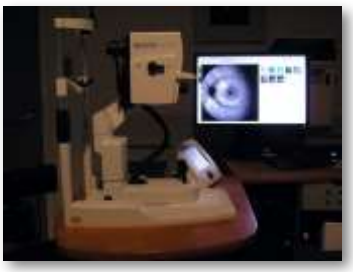
Stereo Technique



FPRC Tutorials

https://www.ophth.wisc.edu/research/fprc/fprc-tutorials/

Scanning Laser Ophthalmoscope

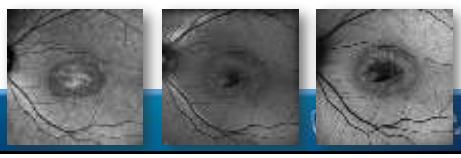


Clinical Confocal Imaging Devices

- Spectralis HRA
- Optos
- Nidek F-10
- Eidon

Scanning Laser Ophthalmoscope

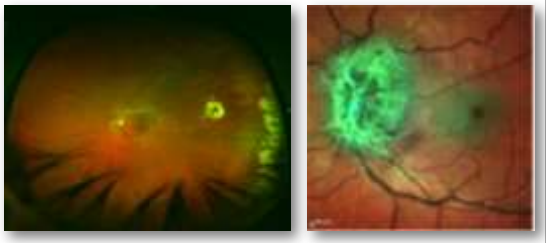
- The confocal scanning laser ophthalmoscope (cSLO) is an instrument that can be used for several retinal imaging modalities including IR, red-free, fluorescein angiography, ICG angiography and fundus autofluorescence.



Scanning Laser Ophthalmoscope

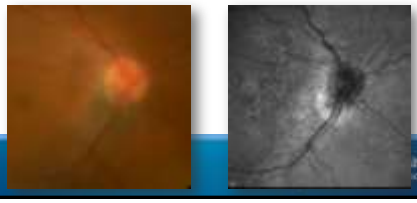
- A monochrome laser scans across the fundus in a raster pattern to illuminate and record successive elements of the retina, point-by-point at speeds up to 24 milliseconds.
- Multiple monochrome laser images taken simultaneously can be combined to create pseudo-color images.

cSLO Pseudo Color



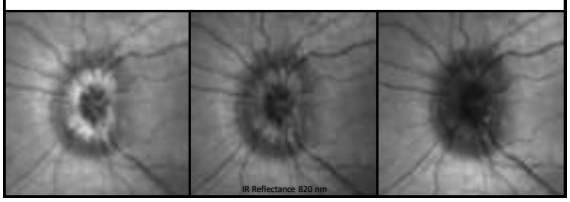
cSLO Confocal Imaging

- A confocal aperture positioned conjugate to the focal plane of the retina blocks non image-forming light from reaching the sensor to minimize scatter and improve contrast.



cSLO Confocal Imaging

- cSLO is most light efficient (brightest) at the plane of focus.
- Secondary effect of the confocal pinhole is a tonal shift when focus is adjusted.



Focusing the Spectralis

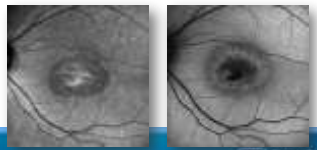
- Manual brightness control: spin gain up to a fairly bright level and shift focus knob until you see speckles.
- Then reduce gain to normal brightness before capturing the fundus image.

Focus/Wavelength

- The angle of refraction changes when switching between light sources/lasers of different wavelengths
- You will need to refocus the SLO when switching between different wavelengths to account for the change in focus.

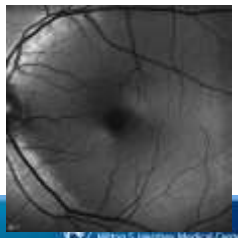
Instrument/Camera Technique

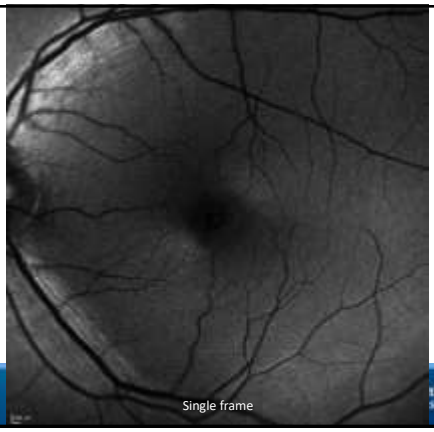
- When switching between the IR (820 nm) and blue laser (488 nm) for FA or FAF, turn the focus knob approximately ¼ turn clockwise.

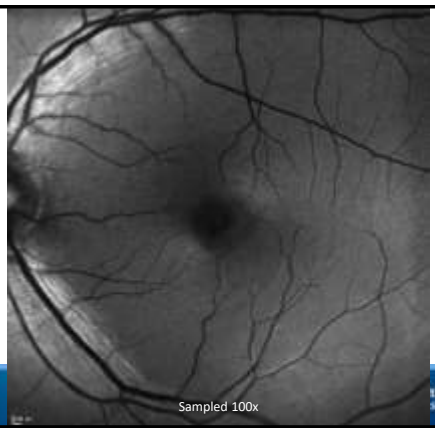


Eye Tracking/Sampling

- Smoothes noise and increases exposure

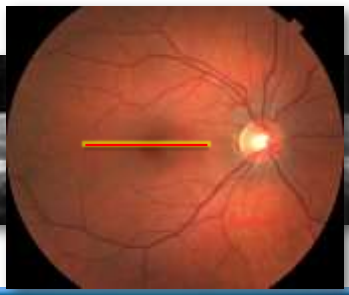






The Eye in Cross-Section

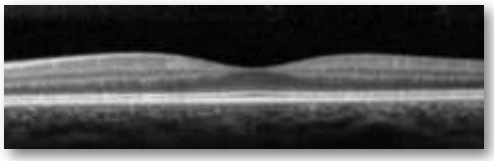
Cross-Sectional Imaging



"Virtual Biopsy"

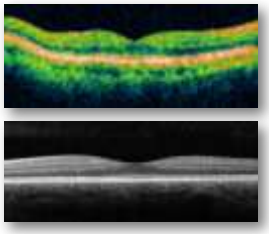
Cross-Sectional Imaging

- Measures both depth/distance and intensity of reflectivity.



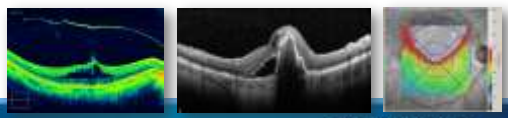
Anatomy of an OCT Scan

- Identifiable layers
  - Posterior hyaloid
  - RNFL
  - Plexiform layers
  - Photoreceptors
  - RPE
  - Choroid



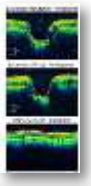
Common/Practical Use

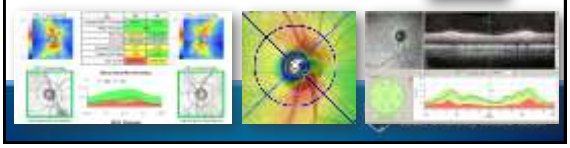
- Line scans for structural changes.
- Line scans for detection of subretinal or intraretinal fluid.
- Volume scans for quantification of thickness or edema.



Common/Practical Use

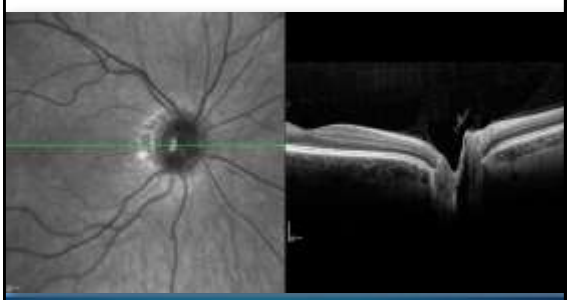
- Optic nerve volume scan
  - Radial lines centered on cup
  - Cube Scan centered on disc
- RNFL scan
  - Circle around disc





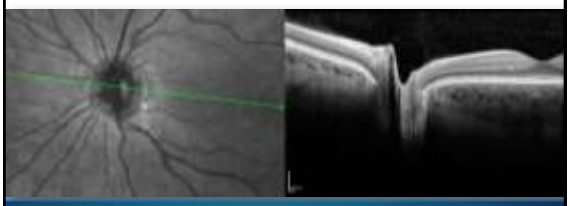
Anatomical Landmarks

Anatomical Landmarks



Anatomical Landmarks

- Anatomically, the fovea sits 5-7 degrees below the midpoint of the disc.



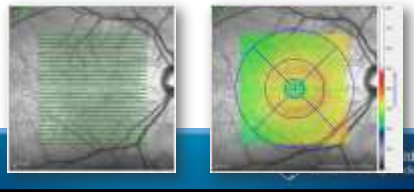
Anatomical Landmarks

Scanning Technique

- Pupils dilated?
- Head/chin straight and square.
- Encourage normal blinking pattern.
- Start with fast scan protocol.
- Optimize polarization.
- Don't forget focus.
- Move joystick (or mouse controls) to maximize signal "sweetspot".

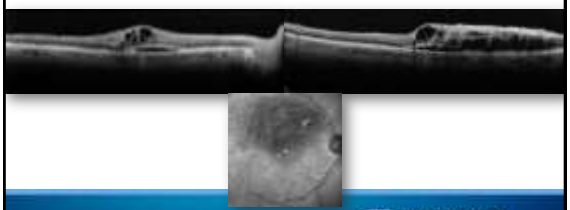
Scanning Strategies

- Start with "Fast" or "HS" volume scans as a quick overview and watch for pathology during acquisition
  - Fast Macular Thickness or Macular Cube Scan



Scanning Strategies

- High-resolution horizontal & vertical single line scans centered on fovea.

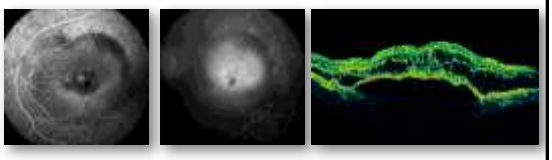


Scanning Strategies

- Free-scan or pan to detect subtle pathology.
- "Anchor" scan on known landmark.
- "Repeat" function restores settings from previous scans for consistency when doing custom scans.

Fixation Issues

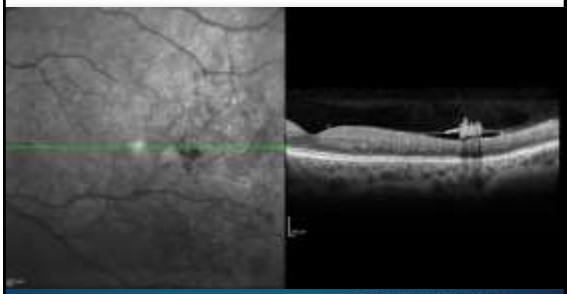
- Macular pathology often makes it difficult for patients to establish or maintain central fixation.



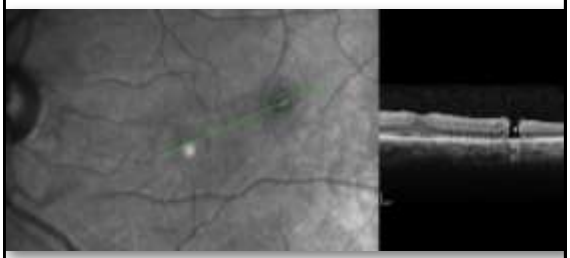
Eccentric Fixation

- Let patient establish fixation.
- Capture scans on fixation first.
- Then try to center scan pattern over fovea or area of pathology & repeat:
  - click and drag the scan pattern over foveal depression (if visible).
  - "Anchor" scan on disc margin if depression isn't identifiable.

"Anchor" Scan



"Anchor" Scan



"Anchor" Scan

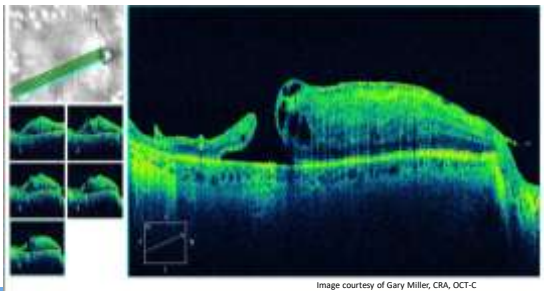
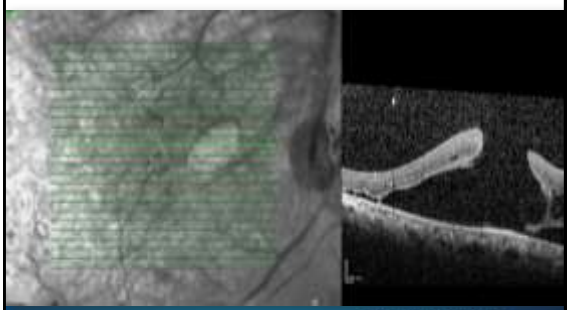
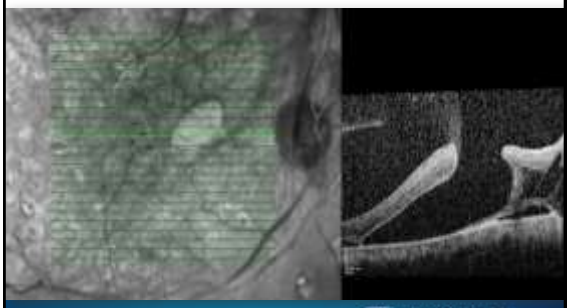


Image courtesy of Gary Miller, CRA, OCT-C

"Anchor" Scan to Disc

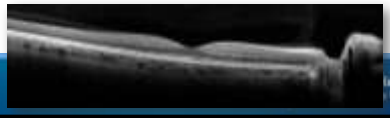


"Anchor" Scan to Disc

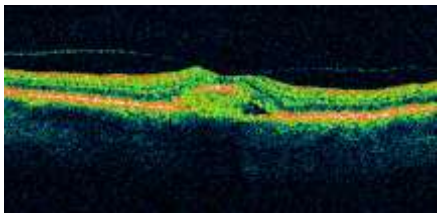


What Defines a Quality Scan?

- Centered on target anatomy/pathology.
- Good edge-to-edge reflectivity.
- Good saturation/signal strength.
- As horizontally level as possible.
- Free from artifacts.



Signal Strength

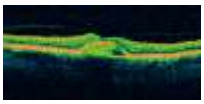


Scan Quality

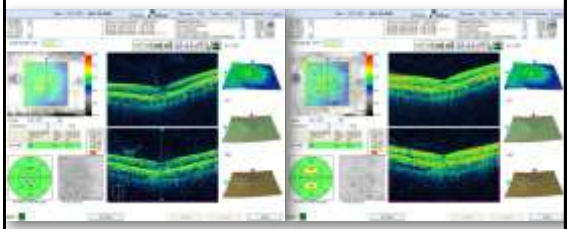
- Scan quality numbers (S/N ratio)
  - Cirrus Signal Strength of >5
  - Spectralis Quality Factor >25
  - Topcon Quality Factor >30-50
  - Optovue SSI >35-50 (different sources)
- Don't be a slave to the numbers!
  - How the image looks is more important than the quality number.

Signal Strength

- Focus
- Polarization
- Z-offset
- Alignment within pupil
- Media opacities
- Tear film disruption
- Dirt/debris on objective

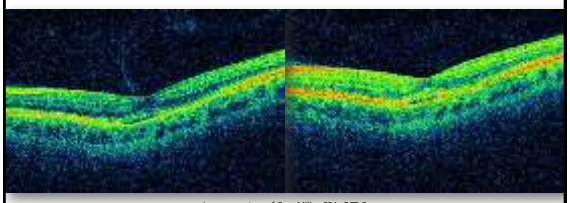


Signal Strength/Focus



Images courtesy of Gary Miller, CRA, OCT-C

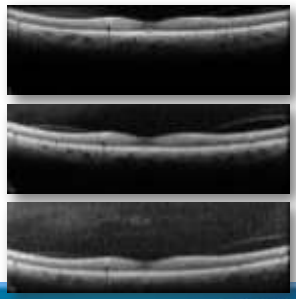
Signal Strength/Focus



Images courtesy of Gary Miller, CRA, OCT-C

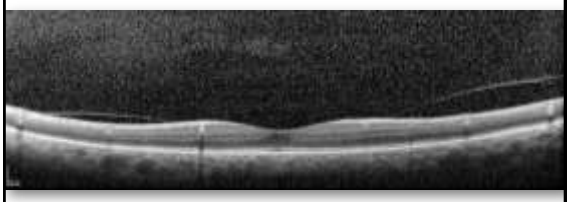
PennState Health Milton S. Hershey Medical Center

Z-Offset/Signal Strength



PennState Health Milton S. Hershey Medical Center

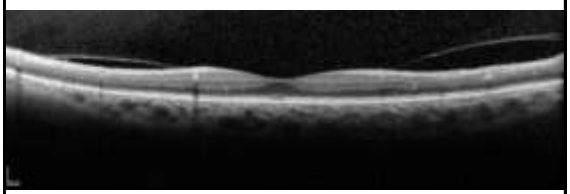
Z-Offset/Signal Strength



ART: 100 frames, Q = 20

PennState Health Milton S. Hershey Medical Center

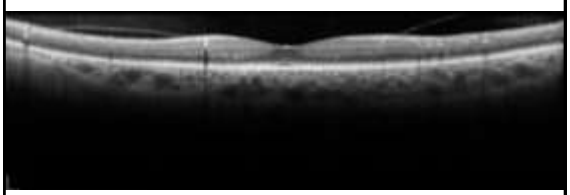
Z-Offset/Signal Strength



ART: 100 frames, Q = 28

PennState Health Milton S. Hershey Medical Center

Z-Offset/Signal Strength



ART: 100 frames, Q = 36

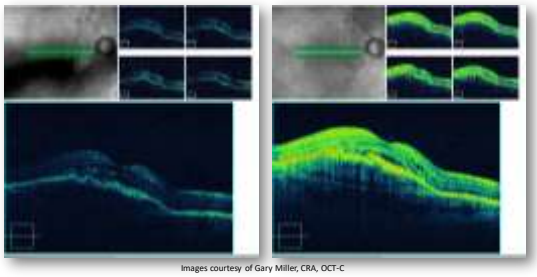
PennState Health Milton S. Hershey Medical Center

Signal Interference

- Signal strength can be adversely affected by several common eye conditions/findings
  - Cataract
  - Corneal opacities
  - Floaters/Asteroids
  - Intraocular blood
  - Astigmatism
  - Poorly centered IOL/small capsulotomy

PennState Health Milton S. Hershey Medical Center

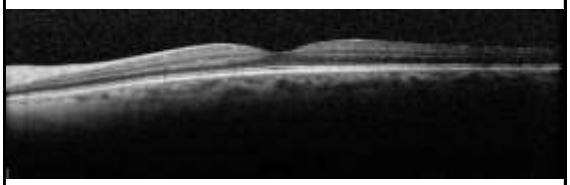
Media Opacities



Images courtesy of Gary Miller, CRA, OCT-C

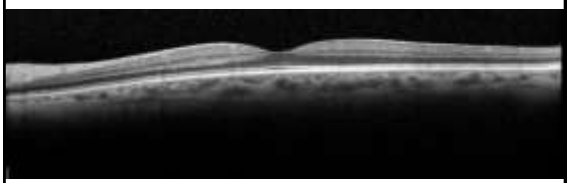
PennState Health
Milton S. Hershey Medical Center

Sample “Painting”



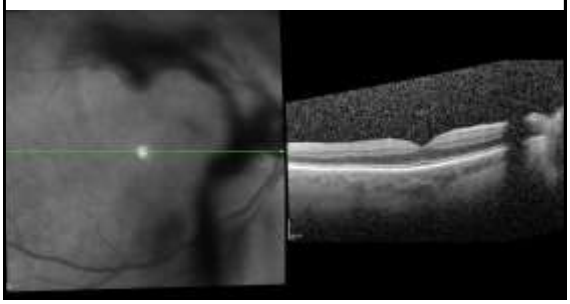
PennState Health
Milton S. Hershey Medical Center

Sample “Painting”

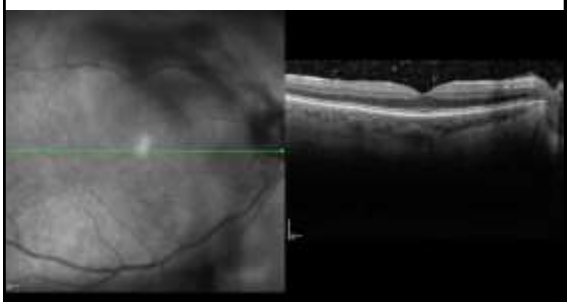


PennState Health
Milton S. Hershey Medical Center

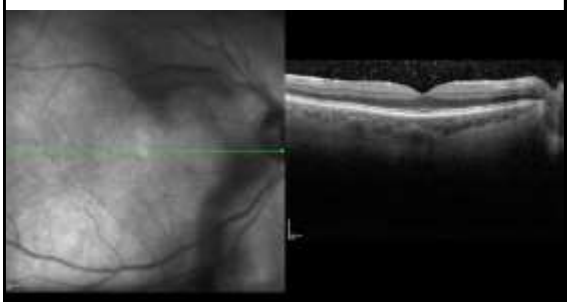
Sample “Painting”



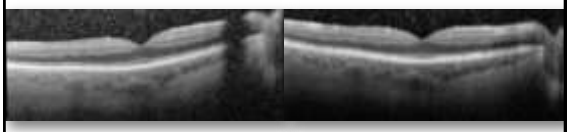
Sample “Painting”



Sample “Painting”



Sample “Painting”

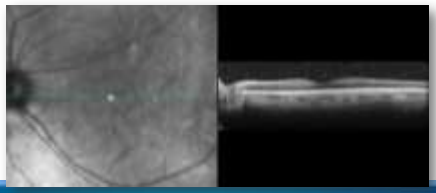


Signal Interference

- A major culprit is dry eye or inadequate tear film.
- Tear film can be disturbed by several routine eye examination procedures:
  - applanation tonometry.
  - diagnostic contact lens exam.
  - gonioscopy.

Signal Interference

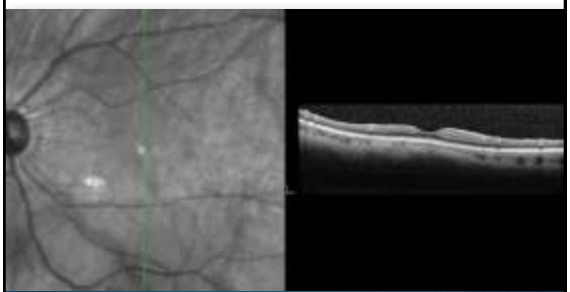
- Whenever possible, perform OCT before any procedures that can compromise integrity of the tear film.



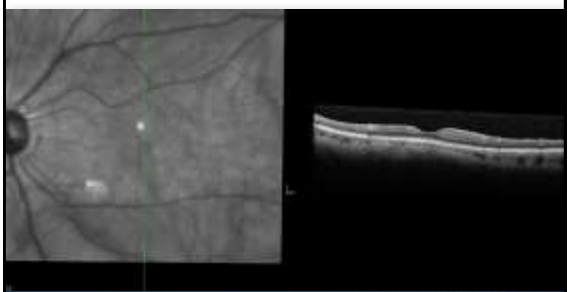
Signal Interference

- Whenever possible, perform OCT before any procedures that can compromise integrity of the tear film.

Before Artificial Tears

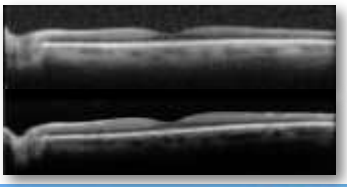


After Artificial Tears

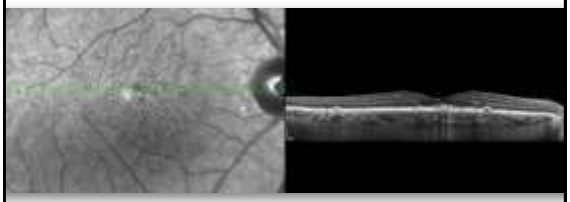


Signal Interference

- Frequent blinking and/or instillation of artificial tears often improves image quality.



Enhanced Depth Imaging (EDI)

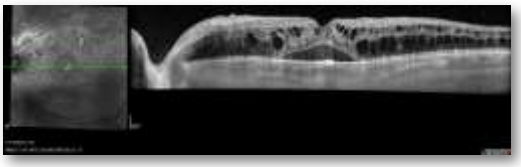


Enhanced Depth Imaging (EDI)

Enhanced Depth Imaging (EDI)

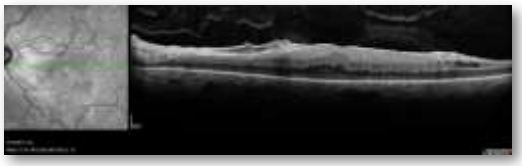
Enhanced Depth Imaging (EDI)

Enhanced Depth Imaging (EDI)



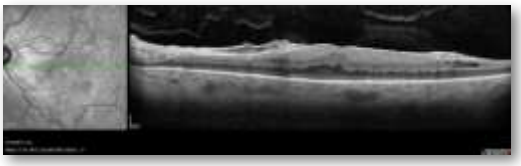
EDI/FDI

- Start sampling image and engage EDI feature about half way through sample.



EDI/FDI

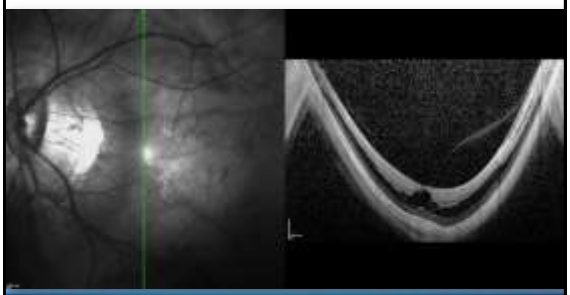
- Start sampling image and engage EDI feature about half way through sample.



Inversion Artifacts

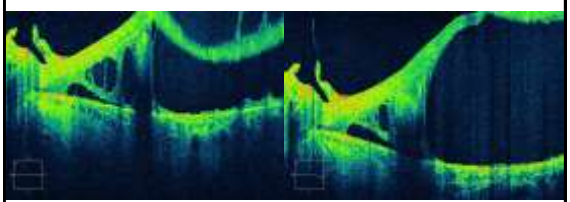
- Pathology is “too tall” for scan window
  - > 2mm
  - High myope, RD, traction, etc.
- Too close to eye/top of scan window.
- Only part of image inverts.
- Image may partially or completely flip for a few frames during sampling.

Inversion Artifacts



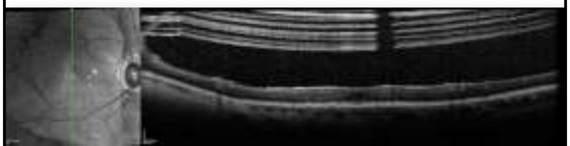
Inversion Artifacts

Inversion Artifacts

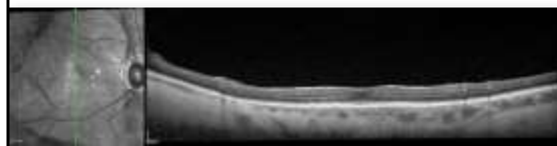


Images courtesy of Bridgette Staffaroni, COT

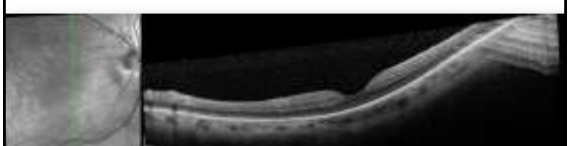
EDI to Eliminate Inversion



EDI to Eliminate Inversion



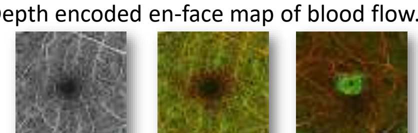
EDI to Eliminate Inversion



EDI to Eliminate Inversion

OCT Angiography (OCT-A)

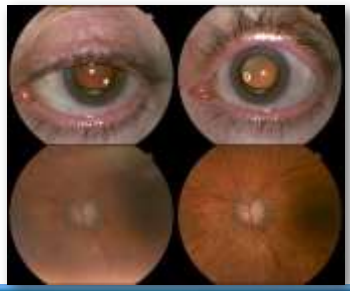
- Samples same area of the retina after correcting for eye movement.
- Detects motion (blood flow).
- Depth encoded en-face map of blood flow.



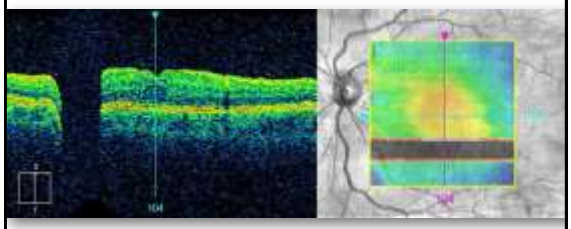
Images courtesy of Darrin Landry, CRA, OCT-C

To Blink or Not to Blink?

To Blink or Not to Blink?

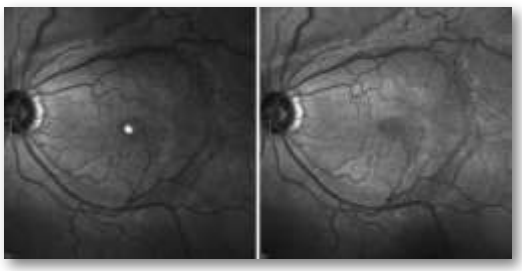


To Blink or Not to Blink?



Oogies on My Lens!

Oogies on My Lens!



Review: Tips for Fundus Photography

- Set the camera eyepiece correctly
  - Ignore the diopter numbers.
  - Relax accommodation to distance.
  - Make sure the reticle and the retina appear sharp at the same time.
- Use green filter to focus on vessels or with photophobic pt.

Review: Tips for Fundus Photography

- Maintain consistent technique from visit to visit with serial imaging.
- Facilitate best possible dilation (mydriatic or non-myd).

Review: Tips for OCT

- Head/chin straight and square
  - Important for consistent alignment of serial scans.
  - Helps proper anatomic alignment when using horizontal scan patterns.
- Encourage normal blinking pattern
  - It's our job to capture images between blinks!
- Use artificial tears on patients with DES or compromised tear film.

Review: Tips for OCT

- "Flirt" with the top of the scan window.
- Look for good edge-to-edge illumination & saturation.
- "Anchor" scans to midpoint or bottom of optic disc margin if unable to detect fovea.
- "Anchor" scans to recognizable anatomy if scanning atypical areas or angles.

Thank You!

- Questions?
  - timbennett@eye-pix.com
- Handouts:

Hands-on Workshop

- Don't be intimidated.
  - Imaging can be fun!
  - Don't be afraid to move the controls.
- Drive it like you stole it!

Tips and Tactics for Retinal Imaging

Timothy J. Bennett, CRA, OCT-C, FOPS
Penn State Eye Center
Hershey, PA