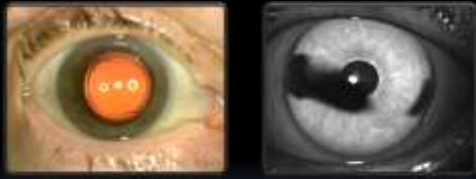


## Anterior Segment Imaging With Retinal Cameras



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



## The Case of the Century!

- Doctor: Can you photograph this amazing fascicoma of the cornea? It's never been reported before and we want to publish it!
- Photographer: The cornea? But we don't have a photo slit-lamp.
- Doctor: What are we paying you for? Why don't you just improvise?



## The Case of the Century!

- Doctor: Can you photograph this amazing fascicoma of the cornea? It's never been reported before and we want to publish it!
- Photographer: The cornea? But we don't have a photo slit-lamp.
- Doctor: What are we paying you for? Why don't you just improvise?



## Why Not Improvise?



www.oxfordjournals.org

### The Phrase Finder

The meaning and origin of the expression: **Necessity is the mother of invention**

Home • Phrase Origins • Word Origins • Necessity is the mother of invention

**Phrase Origins**

**Meaning and origin**

**Origin of the phrase**

**Phrase**

**Meaning**

Difficult situations require ingenious solutions.

**Origin**

The author of this proverbial saying remains unknown. It is sometimes ascribed to Plato and it does appear in translations of Plato's Republic. These translations weren't made until much later than the phrase was in common use in English and are more likely to be the work of the translator than being a direct version of Plato's words. The proverb was known in England by the 16th century, although at that point it must have been known for very long as it was then documented in its Latin form rather than in English. Many well-known proverbs appeared first in Latin and were translated into English by Shakespeare and others, often as helpful tools for later activities.

William Morris, the headmaster of Winchester and Dorset, included the Latin form: *Necessitas mater est inventionis* in his book, a book of aphorisms for the boys of the schools to learn by heart, which he published in 1870.

Roger Ascham came close to an English version of the phrase in his manual on how to use a dictionary, which is by the way the first book ever written about writing. Theophilus, 1540:

"Necessitas, the mother of all goodness."

## Necessity is the Mother of Invention

Build a better mousetrap  
and the world will beat  
a path to your door.

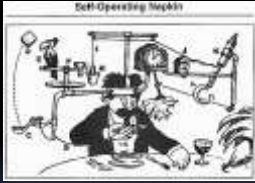
— Ralph Waldo Emerson:  
(1803 - 1883)

**BrainyQuote**

I have not failed. I've just found 10,000 ways that won't work.

— Thomas A. Edison

## Necessity is the Mother of Invention



Professor Butts' Self-Operating Napkin  
Rube Goldberg, ca. 1930

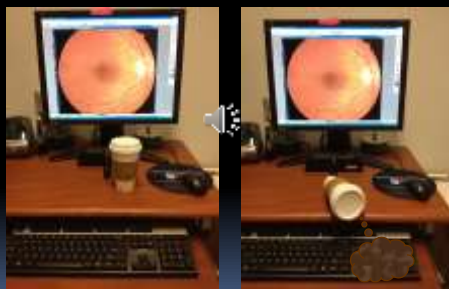


Fluorescein Angiography, Eric Van Rens, MD  
Journal of Ophthalmic Photography, Vol 13(1) 1993

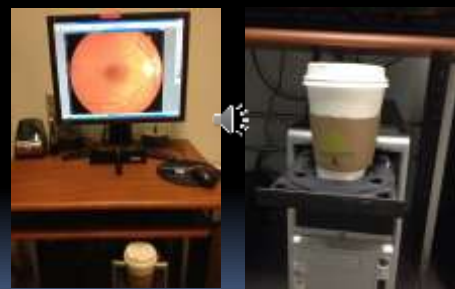
## Necessity is the Mother of Invention

- Instead of inventing something, why not use something you already have at your disposal?

## Why Not Improvise?



## Why Not Improvise?



## Why Not Improvise?



"A paperclip can be a wonderful thing. More times than I can remember one of these has gotten me out of a tight spot..."

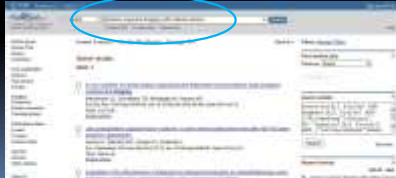
## Why Not Improvise?



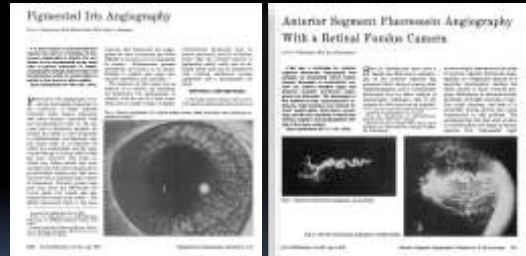
Testing flash synchronization connection between instrument and camera.

## Why Don't You Just Improvise?

- What can you do if you don't have a slit-lamp?
  - Use your iPhone?
  - Maybe there's a better way.
  - Let's look at the literature.



## Literature Search



Arch Ophthalmol -Vol 94, 1976

Arch Ophthalmol -Vol 96, 1978

## Literature Search



BJO, Vol 85:214-218, 2001

## Literature Search



## Literature Search



Journal of Ophthalmic Photography, Vol 36:40-45, 2016

## AS Imaging with Retinal Cameras

- Fundus camera red reflex
- Monochromatic imaging
- RetCam gonio
- Iris/AS angiography
- Corneal staining
- SLO confocal shift
- Autofluorescence
- Meibography
- Pupillography

## Retinal Instruments

- Fundus Camera
  - Red reflex
  - Corneal Staining
  - Iris/AS angiography
  - Autofluorescence
- Handheld Fundus Camera
  - Goniophotography
- cSLO
  - Iris/AS angiography
  - Corneal Staining
  - Autofluorescence
  - Confocal focus-tonal shift
  - IR Meibography
  - IR Pupillography
  - Video recording

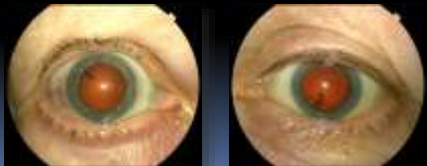
## Retinal Instruments

- Fundus Camera
  - Red reflex
  - Corneal Staining
  - Iris/AS angiography
  - Autofluorescence
- Handheld Fundus Camera
  - Gonio



## Fundus Camera

- Axial illumination/red reflex
- Donut shaped cornea reflex
- Optics designed for concave curved subject
- Edge distortion & shallow depth of field



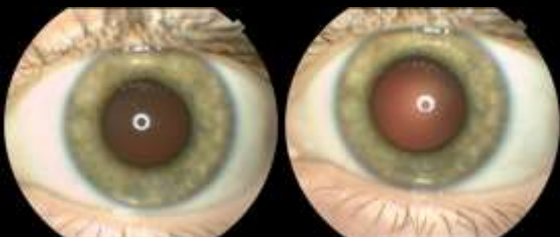
## Fundus Camera

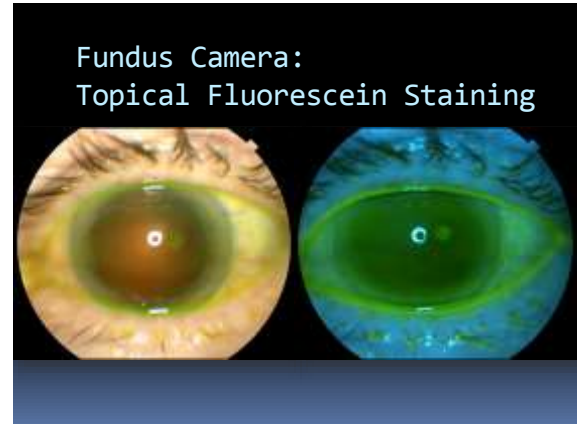
- Plus diopter "+" or "A" setting
  - + setting: lower mag, but less distortion
- Set focus knob all the way forward
- Move joystick to focus



## Fundus Camera

- Align optic disc behind lens to increase brightness of retroillumination





## Exciter and Barrier Filters

- Filters/wavelengths used for fluorescein angiography.
- Built-in to fundus cameras and SLOs.

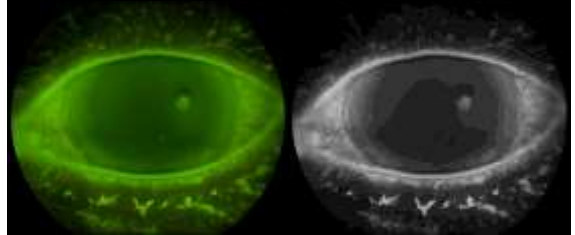


Blue (465-490 nm) excites fluorescence



Barrier (520-540 nm) transmits fluorescence only

Fundus Camera:  
Topical Fluorescein Staining



## Handheld Fundus Camera Goniophotography

- Koeppe Lens
- Reclined/supine position
- Handheld fundus camera (axial illumination)



Wong, D. *Textbook of Ophthalmic Photography*, 1982

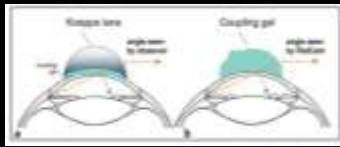
## RetCam Goniophotography



Journal of Ophthalmic Photography 33(2), 2011



## RetCam Goniophotography



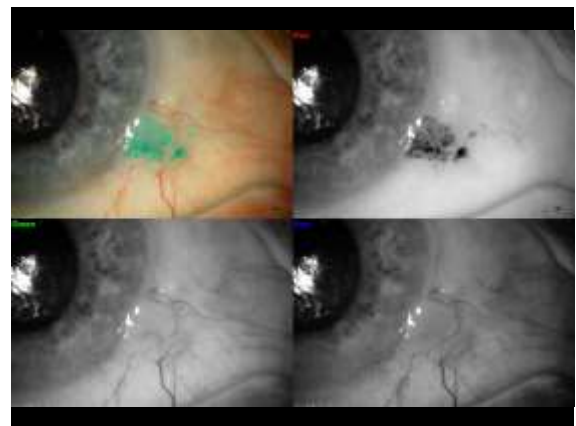
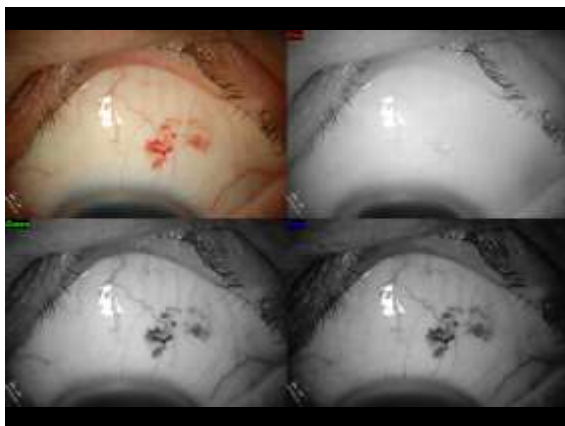
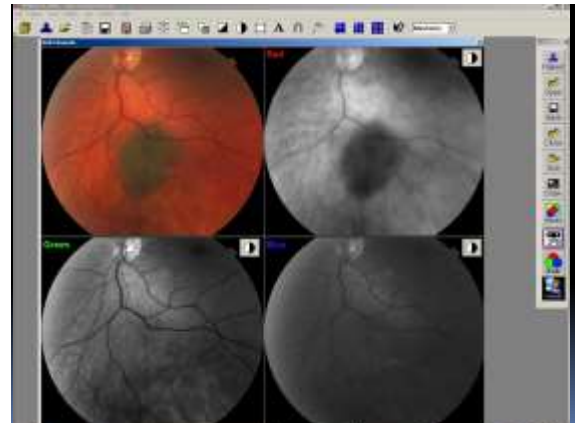
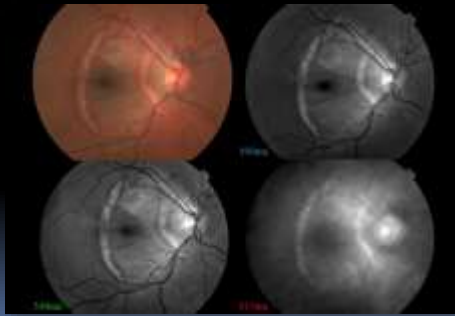
Journal of Ophthalmic Photography 33(2), 2011



## RetCam Goniophotography



## Monochromatic Information



## Retinal Instruments

- cSLO
  - Monochromatic/grayscale imaging
    - IR 820nm
    - Blue reflectance 588nm
  - Corneal Staining
  - Iris/AS angiography
  - Autofluorescence
  - Confocal focus-tonal shift
  - IR Meibography
  - IR Pupillography
  - Video recording

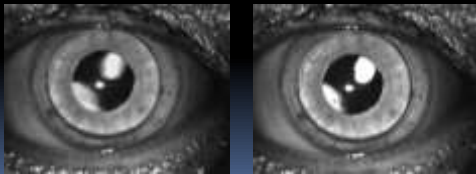
## cSLO - Spectralis HRA

- FA excitation and blue reflectance (red free)
  - 488nm solid state laser
- ICG excitation
  - 790nm diode laser
- IR Reflectance
  - 820nm diode laser



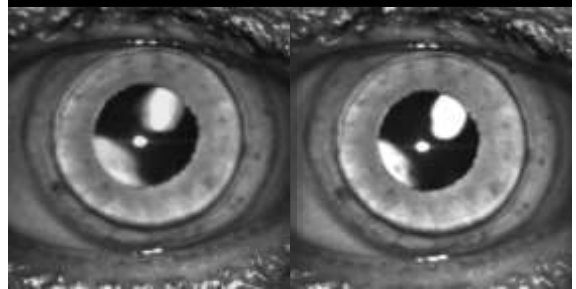
## cSLO - Spectralis HRA

- Normal lens or AS OCT objective
- Set focus to +30D
- Turn ART off (sampling degrades image)



IR Reflectance 820nm

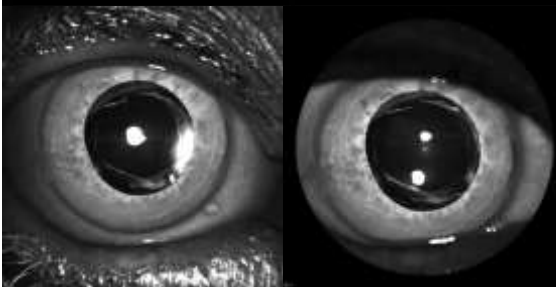
## cSLO - Spectralis HRA



ART on, 9 frames averaged

ART off

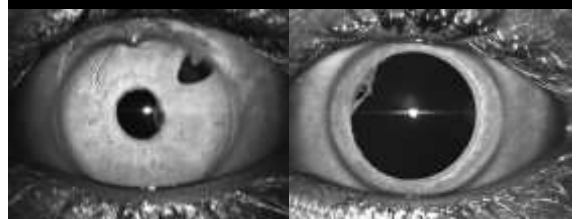
## Spectralis



Standard 30° lens @ 30D

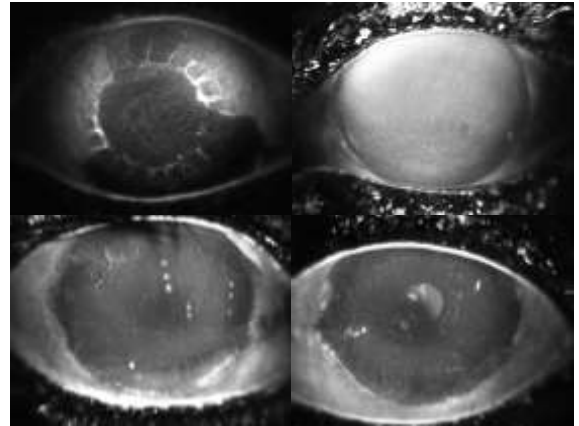
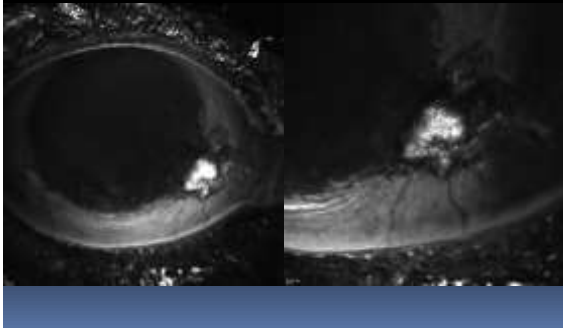
AS-OCT objective @21D

## cSLO - Spectralis HRA



IR Reflectance 820nm

## Topical Fluorescein Staining



## Iris/AS Angiography



Wong, D. Textbook of Ophthalmic Photography, 1982

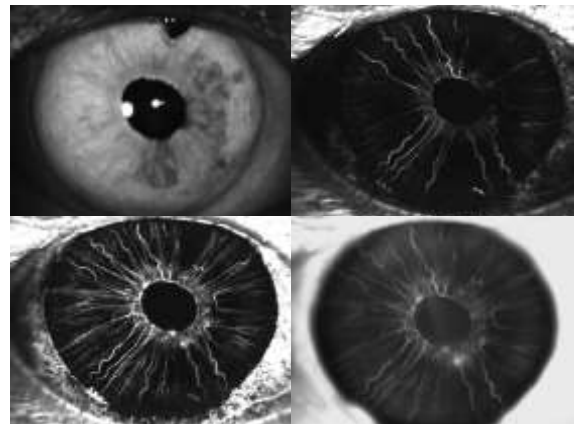
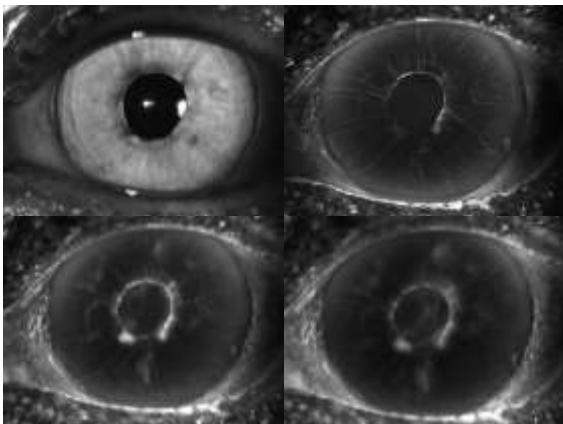
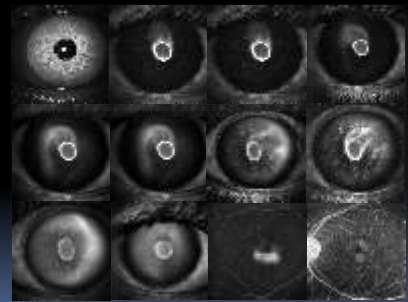


Bergstrom, U, et al. Arch Ophthalmol, 1978

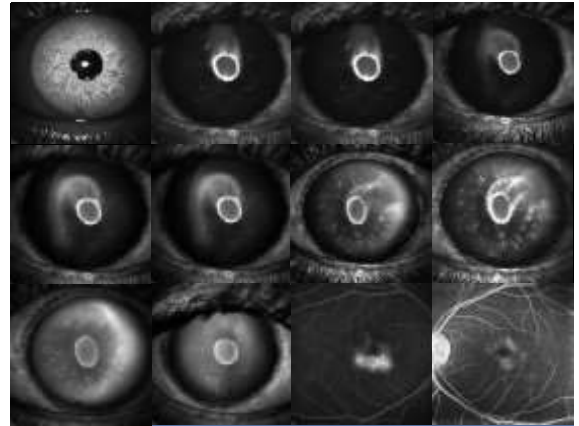
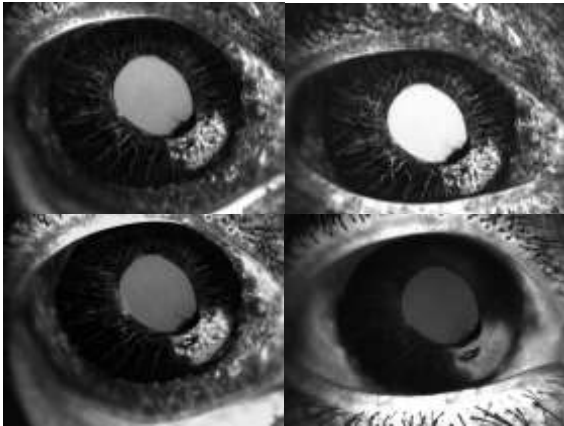


Darmstadter, U, et al. Journal of Ophthalmic Photography, 1982

## cSLO Iris Angiography







## Autofluorescence

- The term "autofluorescence" is used to distinguish fluorescence that can occur naturally vs. fluorescence from dyes.
- Optic nerve drusen, astrocytic hamartomas, and lipofuscin in the RPE can exhibit natural fluorescence.



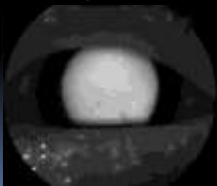
## Fundus Autofluorescence

- Fundus autofluorescence images can be captured with either a cSLO or modified fundus camera.



## Anterior Segment AF?

- Do any anterior segment structures exhibit autofluorescence?
  - Aging crystalline lens
  - Pingueculae



## Anterior Segment AF

- Inspiration from previous versions of this presentation.



Gary Miller, CRA, OCT-C

## Autofluorescence



Br J Ophthalmol 2009;93:396-399.

## AF of Pinguecula



## AF of Pinguecula



## AF of Hemosiderin/Hemoglobin



## cSLO Confocal Tonal Shift



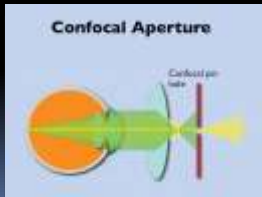
Journal of Ophthalmic Photography 33:17-22, 2016

## Confocal Imaging



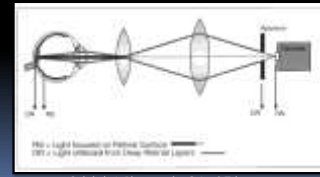
## cSLO Confocal Imaging

- Focused "coherent" laser light source.
- Confocal pinhole/aperture in front of image detector.



## cSLO Confocal Tonal Shift

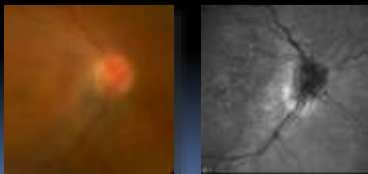
- A confocal aperture positioned conjugate to the focal plane blocks non image-forming (out of focus) light from reaching the sensor to minimize scatter and improve contrast.



Ophthalmic Photography: Saine & Tyler, 2002

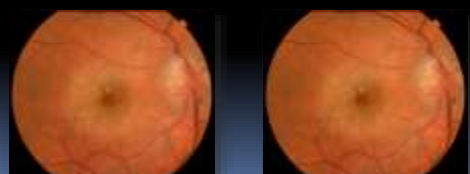
## cSLO Confocal Imaging

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



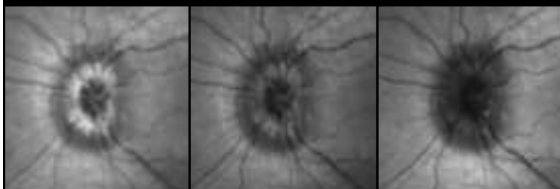
## Focus and Brightness

- With a traditional fundus camera, focus and brightness are independent of one another.
- Adjusting one does not significantly affect the other.



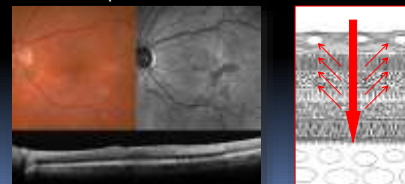
## cSLO Confocal Tonal Shift

- cSLO images are brightest at the plane of focus because of the confocal aperture.



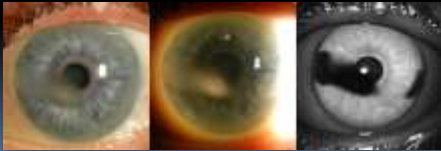
## Scattered Reflection

- Disruption of normally transparent retinal tissue can appear dark. Scattered reflection will be slightly blurred and blocked by the confocal pinhole.



## cSLO Confocal Tonal Shift

- Focus is at the level of the iris with cornea being out-of-focus.
- The confocal pinhole suppresses scattered (out-of-focus) reflection from the cloudy areas of the cornea.



## cSLO Confocal Tonal Shift

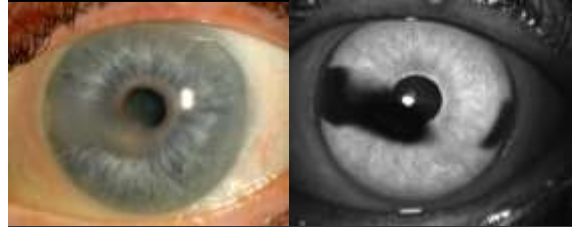


Photo slit lamp

Spectralis cSLO IR 820 nm

## cSLO Confocal Tonal Shift

- Areas of iris atrophy/thinning appear dark.
- The deep out-of-focus areas may represent the confocal tonal shift or reduced IR reflectance from thinning.



## IR Meibography



## IR Meibography

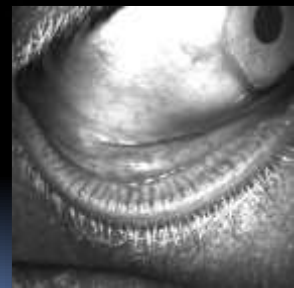


**Normal Eyelid (meibomian) Glands:**  
Meibomian glands produce the oils needed for a healthy tear film.

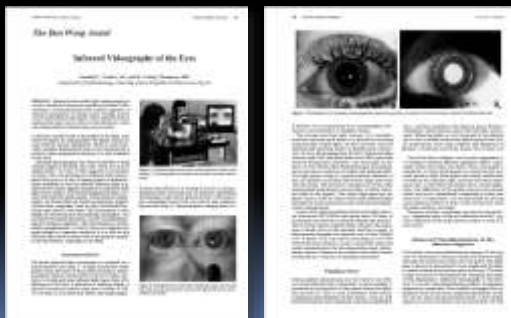


**Gland Islet Onset:**  
MEIS shows when the meibomian glands become pinched. If this blockage is left untreated the glands will drop out entirely.

## IR Meibography



## IR Pupillography



## IR Pupillography



## IR Pupillography



## IR Fundus Reflex

- IR iris transillumination or pupil imaging only works when focus of instrument is at the plane of the retina because of the confocal aperture.
- When focused at iris or pupil margin, the SLO is most light efficient at that level and there is no reflectivity from the fundus to transilluminate.
- In order to backlight iris, patient's head must be moved back from instrument.

## IR Fundus Reflex

- 16 month old with congenital cataract



## IR Fundus Reflex

- 16 month old with congenital cataract
- Axial lighting





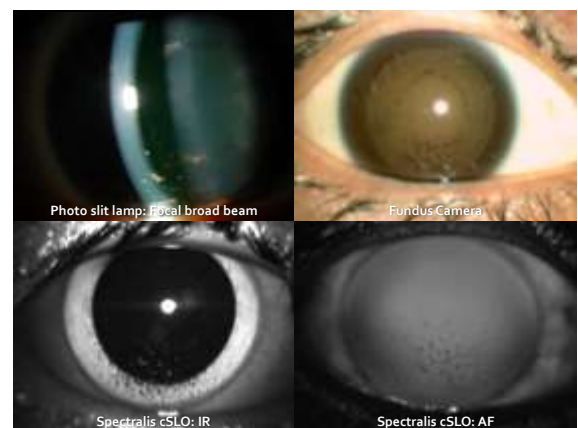
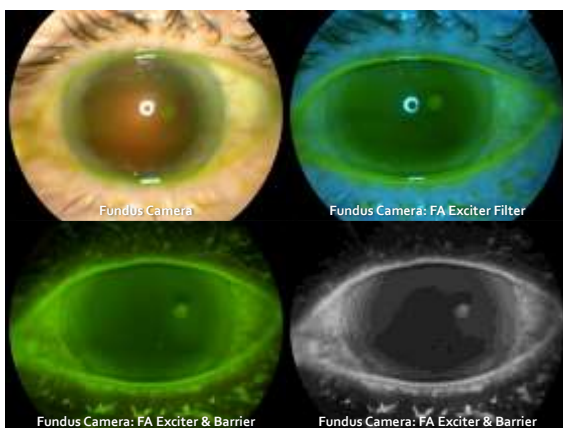
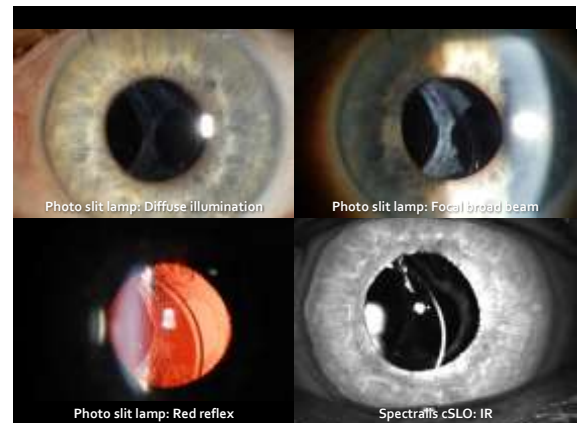
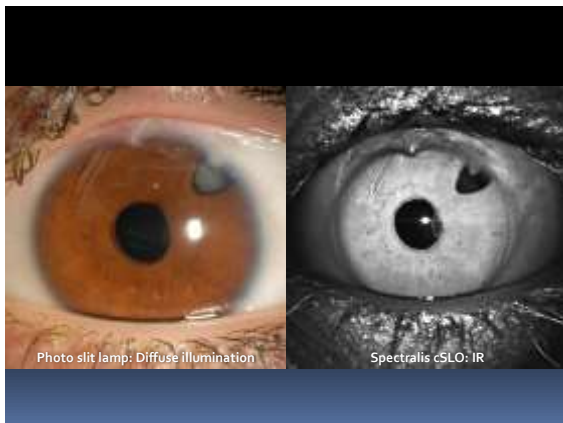
## Anterior Segment Imaging with Retinal Cameras

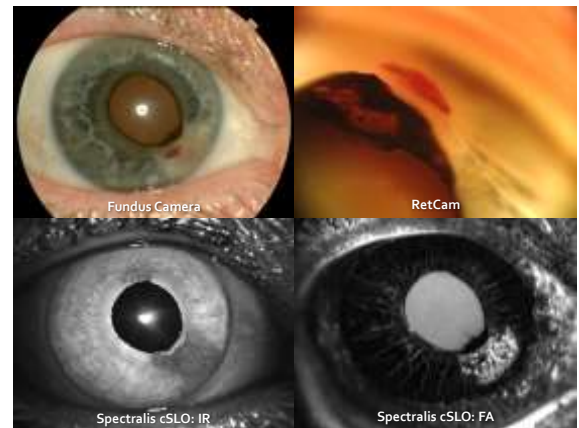
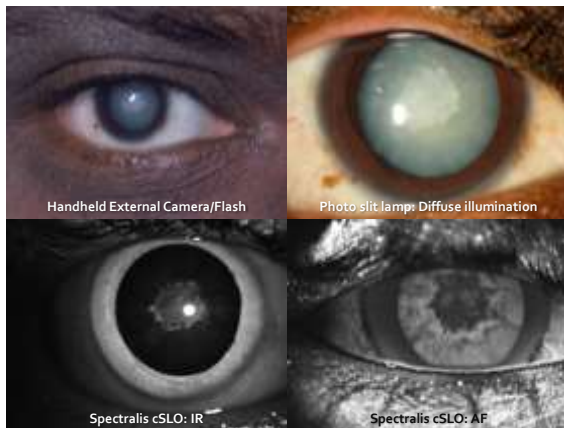
- Why Don't You Just Improvise?



## Anterior Segment Imaging with Retinal Cameras

- Retinal devices provide several modalities that can also be adapted to use in anterior segment imaging.
- Some may be useful in place of, or as an adjunct to, photo slit lamp imaging.





## Questions?

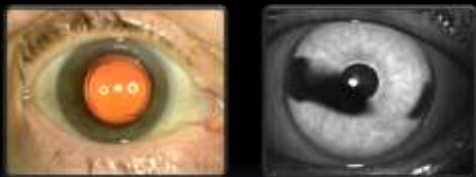
- Email: [timbennett@eye-pix.com](mailto:timbennett@eye-pix.com)
- Web: [www.eye-pix.com](http://www.eye-pix.com)



## Pearls, Tips, & Tactics



## Anterior Segment Imaging With Retinal Cameras



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

