The Future of Retinal Imaging Has Arrived!

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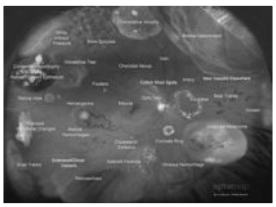
Financial Disclosure

- Pizzimenti:
- Honoraria
  - Kemin
  - Nicox
  - Review of Optometry
  - Optometric Management
  - VSP
- Scientific Advisory Boards
  - Zeavision
  - Zeiss
  - Thrombogenics
- Pelino: nothing to disclose

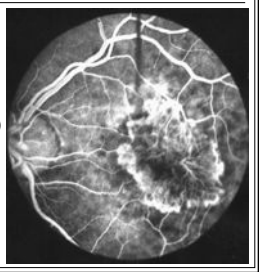
Goals of this Course

- To provide a broad overview of Post Seg Imaging
- Past, Present, and …
- Clinical Applications and Interpretation



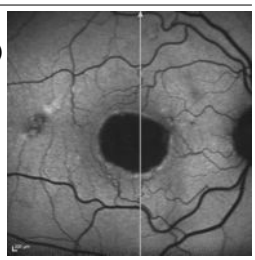
Imaging Technologies

- Fundus photography
- Wide-field/panoramic
- Angiography
  - Fluorescein (FA)
  - Indocyanine Green (ICGA)
- Scanning lasers
  - OCT
    - En face
    - Enhanced depth
    - OCTAng



Imaging Technologies

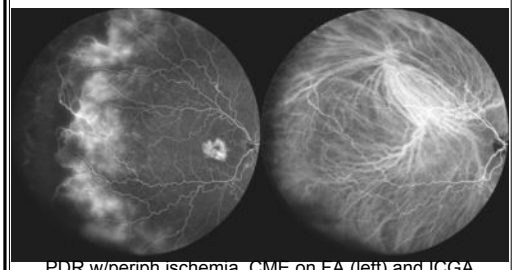
- Fundus Autofluorescence (FAF)
- A/B Scan Ultrasound (Echography)
- Multi-spectral imaging
- Adaptive optics



Questions and Comments?

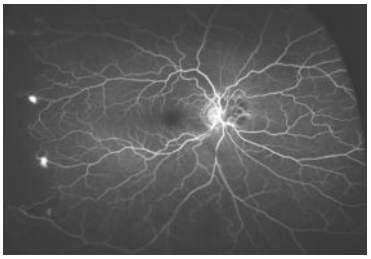
"Most major advances in the understanding of retinal diseases have been preceded by advances in imaging."

Richard Spaide, MD
NY Retina Consultants



PDR w/periph ischemia, CME on FA (left) and ICGA

Optos Wide-Field Angiography



Digital retinal imaging does

not

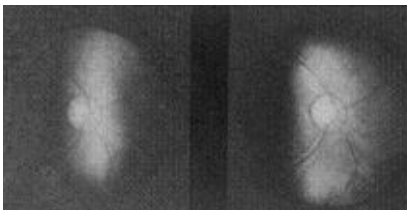
replace a dilated retinal examination.

Fundus Biomicroscopy and BIO

Milestones in Retinal Imaging

- Fundus Photography 1920s
- Fluorescein Angiography 1950s
- B-Scan Ultrasound 1970s
- ICG Angiography (Digital) 1980s
- CSLO (HRT), SLP (GDX) 1990s
- OCT first demonstrated 1991
  - High-res OCT 2001
- Fourier (Spectral) Domain OCT 2007

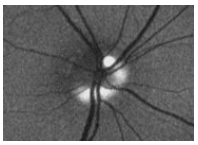
Milestones in Retinal Imaging



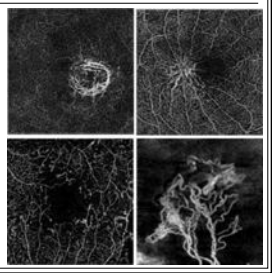
1909-Thorner's Stereo Photos

2016

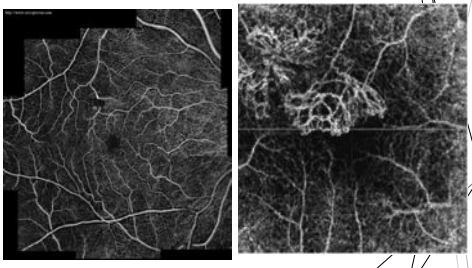
En face OCT angiograms



FAF of ON Drusen



OCT Angiography



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Which one is right for my practice

- Factors to consider when purchasing new technology:
- _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____

The Critical Question

Will this technology improve patient care?

How can imaging technologies help me grow my practice?

Benefits of Post Seg Imaging

- Provide a higher level of care for our patients
  - Less referrals to sub-specialists (Dry AMD, CSC, Nevus)
  - Keep care in-house, keep revenues in house
- Use our new technology as a marketing tool to attract new patients: A/B-scan, OCT, FAF, wide retinal field imaging
  - These important tests also generate revenue
- I get referrals from many local ODs. You can too.
  - Become a recognized expert by reading and using the right tools.

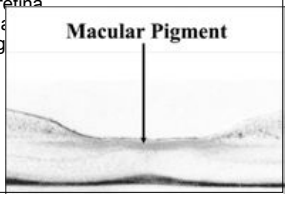
There are many treatments, but….

Macular Pigment Optical Density (MPOD)

Heterochromatic Flicker Photometry

The Importance of Macular Pigment

- Filters blue light
- Acts as an antioxidant by quenching free radicals
- Provides support to sensory retina
- MPOD is a biomarker of retina and systemic health (DM, cog

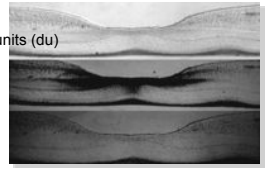


MPOD

Measurement of Macular Pig Optical Density (MPOD)

HFP works on the principle that:

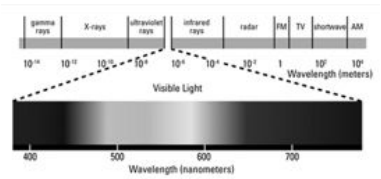
- Macular pigment absorbs blue light (not green light)
- Dense or thicker macular pigment = longer time to see the target begin to flicker
- Results are quantified in density units (du) via software



What is Multicolor Imaging (MCI)?

- Simultaneous imaging with multiple laser colors.
- MCI selectively captures diagnostic information originating from different posterior segment structures and layers within a single scan.
- Delivers high contrast, detailed images and en face slices.
- A simultaneous SD-OCT image can be obtained for multi-modal analysis.

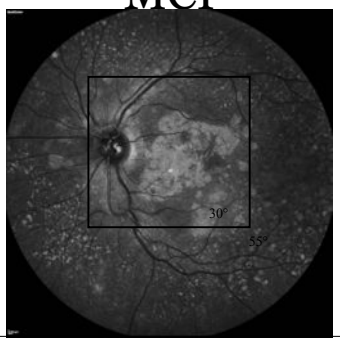
How does MCI work?



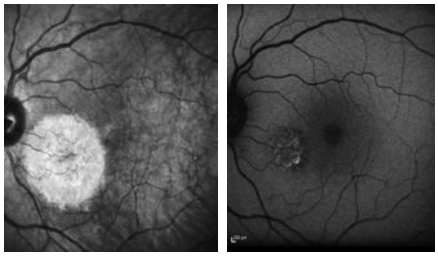
MCI is achieved using the principle of confocal scanning laser ophthalmoscopy (cSLO).

Multicolor images are illuminated with three select color wavelengths: infrared, green, and blue.

Wide Field Imaging- MCI



MCI and FAF on Choroidal Mass

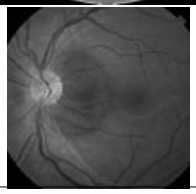


Multiple drusen appear well delineated in the Multi Color Image on right. Simultaneous SD-OCT confirms the confluent drusen pattern.

What is Multispectral Imaging (MSI) ?

- The use of several non-overlapping discrete spectral bands, or slices, to highlight certain features within the field of view.
- Produces discrete en face slices of posterior segment tissue.
- FAF possible.

MSI



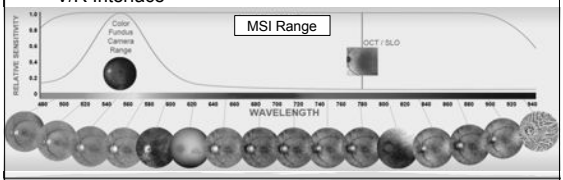
How does MSI work?

- MSI uses discrete light emitting diodes (LEDs) across a wavelength range from 520 nm (green) to 940 nm (infrared).
- Progressively images the layers of the sensory retina, RPE, and choroid.
- Longer wavelengths penetrate deeper into the tissues.

Multi-spectral Imaging

V/R Interface

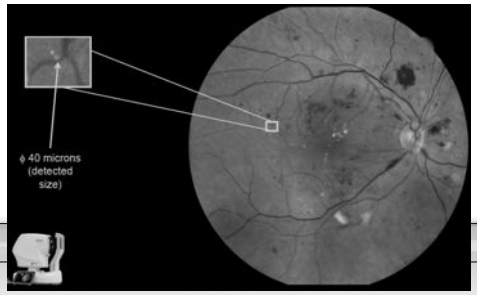
Choroid



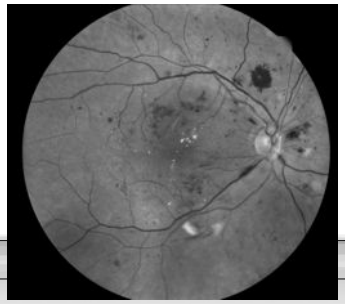
Confocal Scanning

- In TrueColor confocal fundus photography white light is flashed onto the retina and gets reflected back to the sensor
- **Image quality is NOT affected by cataract and other media opacities** because light reflected by other layers crossed (cornea, aqueous, lens, vitreous) is filtered and does NOT contributes to image formation
- Image quality is less affected by **pupil size (min 2.5 mm)**
- FAF possible

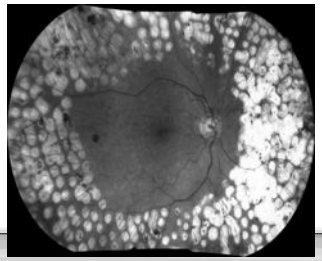
Confocal Scanner Images



Red-free

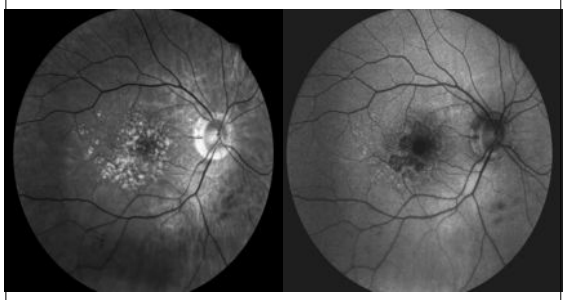


100° mosaic image (up to 150° with manual mode)



Dry AMD-GA

True-Color Confocal Image



Images courtesy of SriniVas R. Sadda, MD

Scanning Laser Match Game

Instruments	Technologies
■ OCT	■ Confocal scanning laser ophthalmoscopy (CLSO)
■ HRT 3	■ Scanning laser polarimetry (SLP)
■ GDX	■ Low Coherence Interferometry

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Scanning Laser Match Game

- OCT
- HRT 3
- GDX

- Low Coherence Interferometry
- Confocal scanning laser ophthalmoscopy (CLSO)
- Scanning laser polarimetry (SLP)

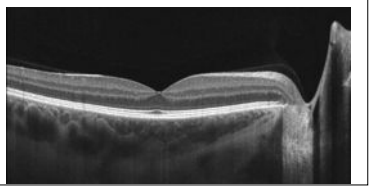
OCT: The Big Dog in PS Imaging

Optical Coherence Tomography

Unlike FA, OCT is non-invasive.

Posterior Segment Applications

- Vitreous/Vitreoretinal Interface
- Neurosensory retina, RPE/Bruch's
- Choriocapillaris/Deeper Choroid (EDI)
- Optic Nerve/NFLA



Coverage for OCT

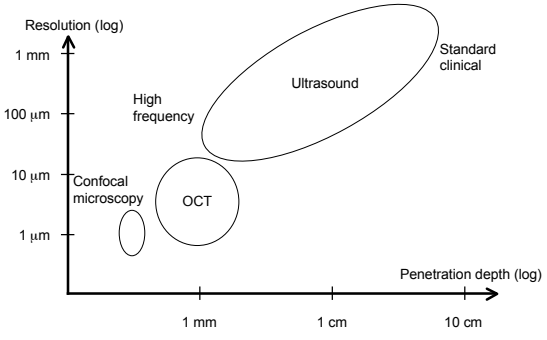
- Anterior Seg 92132
- Glaucoma/ON 92133
- Retina 92134

Coding Caveats

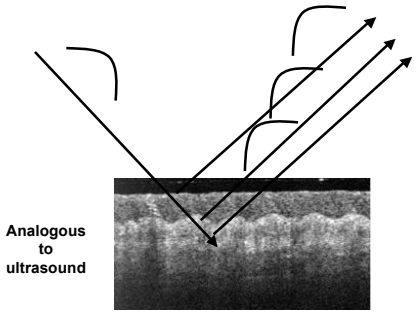
- These codes are only billed once, whether you scan both eyes or just one.
- 92133 and 92134 are mutually exclusive, so they cannot be billed on same day, regardless of diagnosis.
- In many areas, 92132 is also considered to be inappropriate to bill on the same day with either of the posterior segment procedures.
- Check your local LCD.

Questions and Comments?

OCT vs. Other Imaging



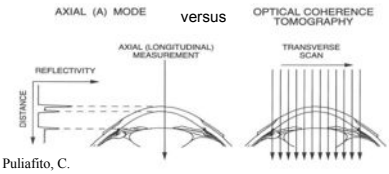
Optical Coherence Tomography



Analogous to ultrasound

TOMography: *cut/cross-section*
CAT, MRI, OCT, B-Scan

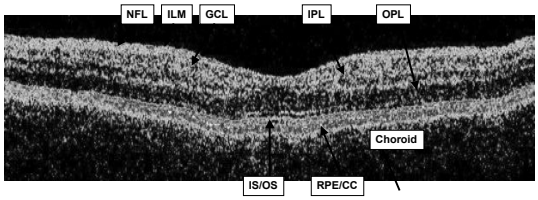
TOPography: *relief/mapping*
Corneal Top



Puliafito, C.

- Scan of the reflectivity of a sample as a function of depth is referred to as an A-scan.
- A cross-sectional tomograph is achieved by laterally combining a series of A-scans.
- Two-dimensional data sets are digitized by a computer and presented as a gray-scale or false-color image.

Identification of Retinal Layers-TD



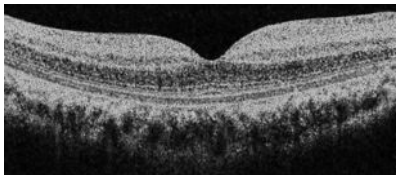
NFL: Nerve Fiber Layer
ILM: Inner Limiting Membrane
GCL: Ganglion Cell Layer

IS/OS: Junction of inner and outer photoreceptor segments
RPE: Retinal Pigment Epithelium
CC: Choriocapillaris

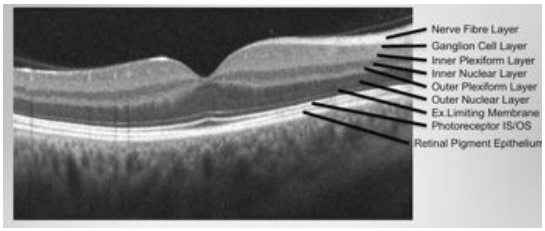
IPL: Inner Plexiform Layer
OPL: Outer Plexiform

Cross-sectional image of live tissue; a "virtual biopsy"

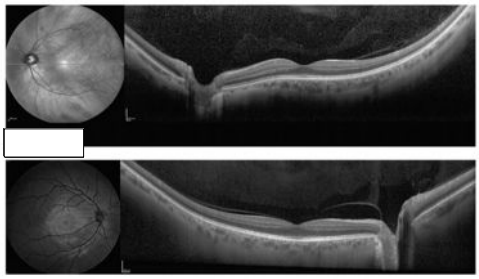
SD-OCT Healthy Macula



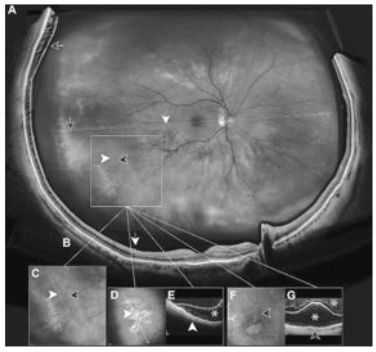
SD-OCT Healthy Macula w/Layers



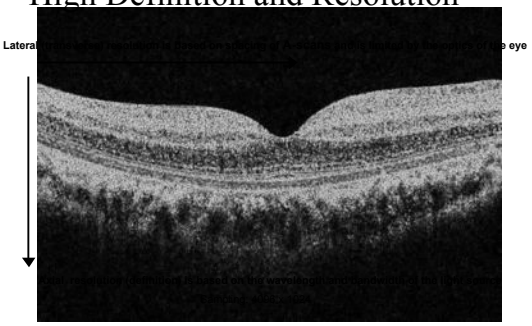
Wide Field OCT--VMA



Coming Soon…



High Definition and Resolution



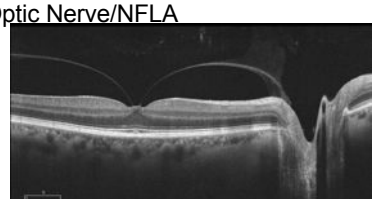
OCT Interpretation: In Order of Increasing Reflectivity (brightness)

- Black = Vitreous, Cystic/Ser. Fluid, Blood
- Blue/Green: Vitreous Debris
- Green/Yellow = Retina, Choroid
- Red = NV, Dense Tissue
- Red/White = NFL, RPE, Scar Tissue
- White = Silicone Oil, Scar Tissue

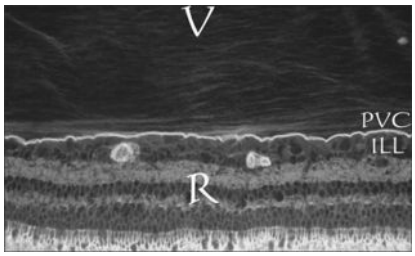
Bright colors = High reflectivity

Posterior Segment Applications

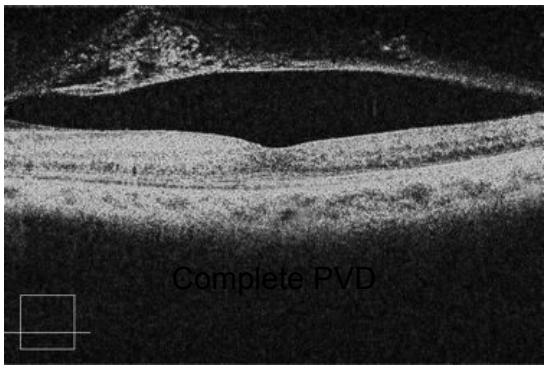
- Vitreous/Vitreoretinal Interface
- Neurosensory retina, RPE
- Choriocapillaris
- Optic Nerve/NFLA



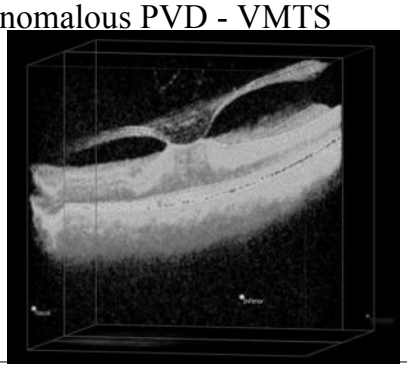
The Vitreoretinal Interface



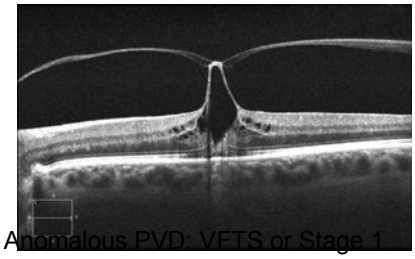
retinalphysician.com



Anomalous PVD - VMTS



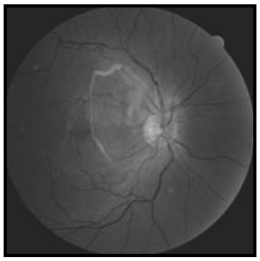
Case: 58 y/o WM
Gradual blur, VA 20/60



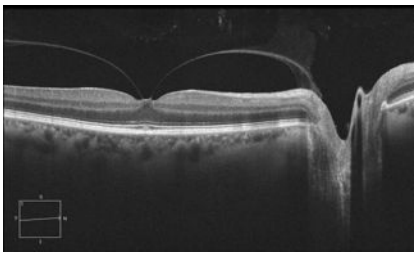
Anomalous PVD: VFTS or Stage 1 Macular Hole

Is this patient a candidate for

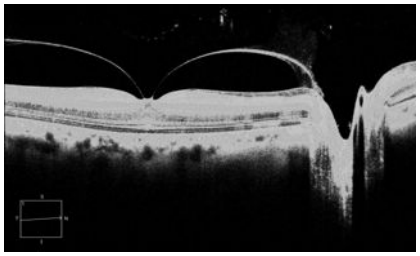
Vitreoretinal Interface



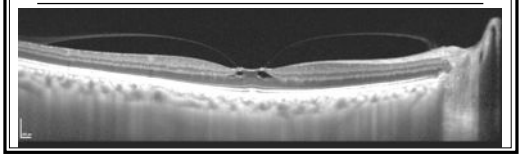
The Vitreous



The Vitreous



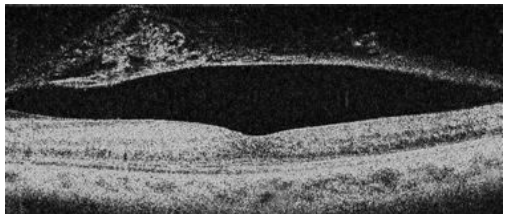
Chemical Vitrectomy for Vitreomacular Adhesions (VMA)



MIVI-TRUST Program

- Microplasmin for IntraVitreous Injection-Traction Release withoUt Surgical Treatment
- Two randomized, placebo controlled, double-masked, multi-center trials (Phase III)
  - single-dose 125-µg intravitreal Ocriplasmin (ThromboGenics) v. placebo for symptomatic VMA.
- Primary endpoint of both trials was resolution of VMA one month after injection.
- Over 650 patients were enrolled
- 90 centers in 7 countries.

Goal: Complete PVD



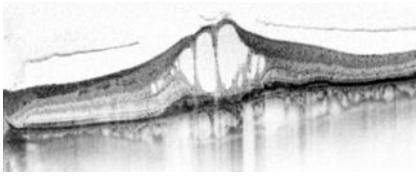
Results

- At 28 days, VMA resolved in 29.8% of 464 eyes treated with Ocriplasmin and 7.7% of 188 eyes given placebo.
- Total posterior detachment occurred in 17% of treated eyes.
- Moreover, 25.5% of treated eyes gained two or more lines of acuity at 6 months.
- At 6 months, 40.6% of treated eyes achieved full-thickness macular hole closure, compared with only 17% of placebo eyes.

Questions and Comments?

Vitreomacular Adhesion in AMD

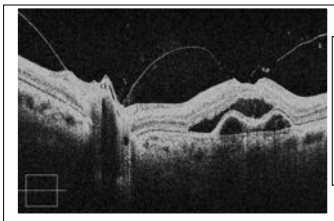
- May hasten the AMD process.



The Posterior Hyaloid in AMD

- If microplasmin can successfully produce a PVD, there may be some future therapeutic benefit in the prevention of progression to wet AMD.

  - Sebag J, Binder S. Posterior hyaloid adhesion is significantly increased in NV AMD. Program and abstracts of the 40th Annual Scientific Meeting of the Retina Society; September 27-30, 2007; Boston, Massachusetts.

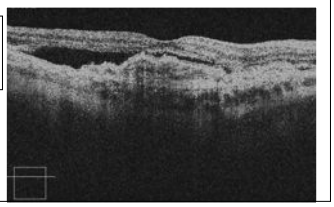


Multiple conditions:

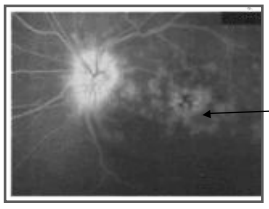
VMTS
VPTS
Subretinal fluid (Serous RD)
Sub-RPE fluid

Wet AMD

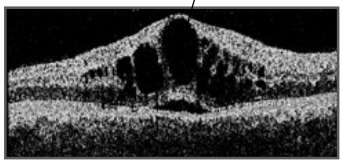
With serous RD



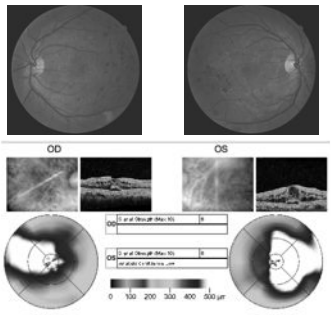
VMA may precipitate Macular Edema in DR, RVO



Macular Edema is #1 cause of vision loss in CRVO

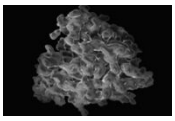


Diabetic Retinopathy--ME may occur at ANY stage!



Status of Ocriplasmin Pharmacologic Vitreolysis

- ThromboGenics gained FDA approval and brought Ocriplasmin to market in the U.S. in January 2013.
- New unique ICD-9-CM disease code approved specifically for vitreomacular adhesion (VMA).
- ICD-9 = 379.27



Indication

JETREA® (ocriplasmin) Intravitreal Injection, 2.5 mg/mL, is a proteolytic enzyme indicated for the treatment of symptomatic vitreomacular adhesion.

Good Candidates for Jetrea

- Small VMA area
  - <1,500 microns
- No ERM
- Stage 2 MH
- Younger
  - < 65 y/o
- Phakic

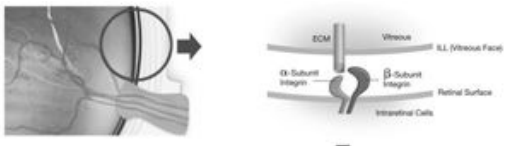
Poor Candidates for Jetrea

- Eyes w/multiple VMAs
- High myopia (greater than 8.00D)
- Hx of prior RD
- Macular hole greater than 400µm
- ERM
- Ischemic retinal disease

S/P Jetrea

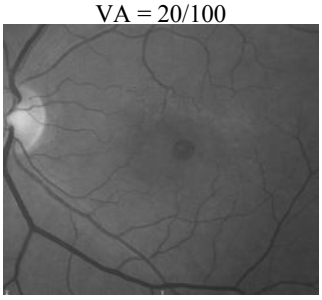
Most patients experience worsening of symptoms, i.e., flashes, floaters and/or reduced vision, before they improve.

Anti-Integrin Peptide for VMA

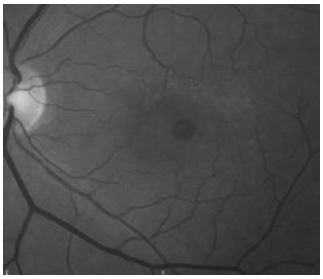


- Phase II study of anti-integrin oligopeptide (ALG-1001) in patients with vitreomacular traction (VMT).
- Also treats CNV.
  - David Boyer, MD

Case: 72 y/o WF
Gradual central blur OS
VA = 20/100



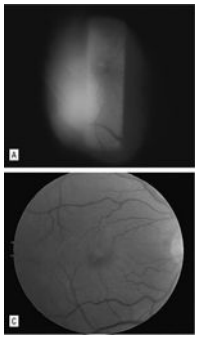
Stage 3 Macular Hole



Macular Hole

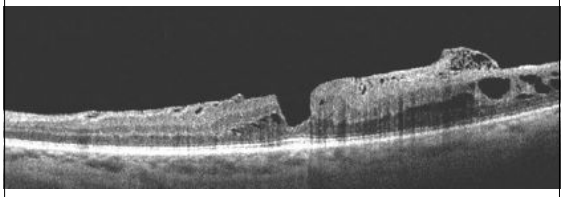
Watzke-Allen Test

- Subjective
- Purpose: identify full-thickness v. lamellar
- Fundus lens at SL
- Vertical beam
- Central break indicates full-thickness
- Maddox rod, direct scope

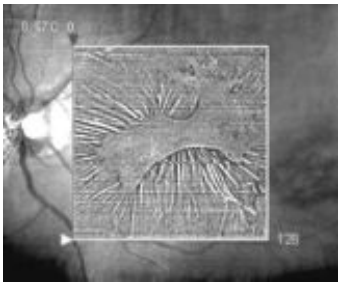


Macular Hole (Stage 4)

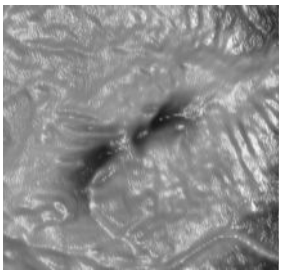
ERM With Mac Pucker, Pseudohole



ERM en Face (Slab Analysis)

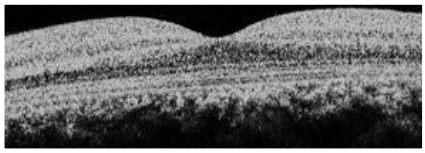


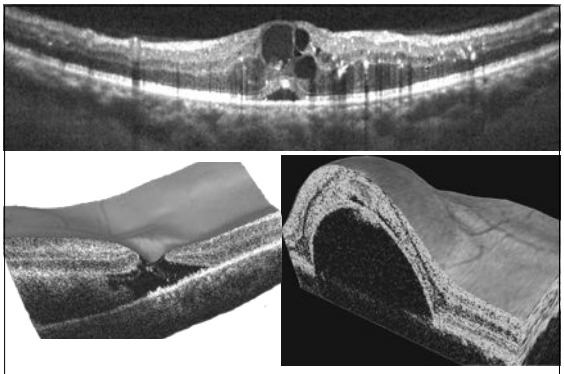
ERM 3-D

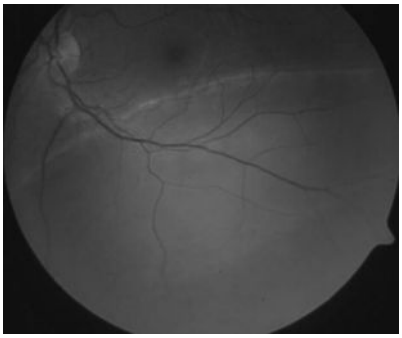


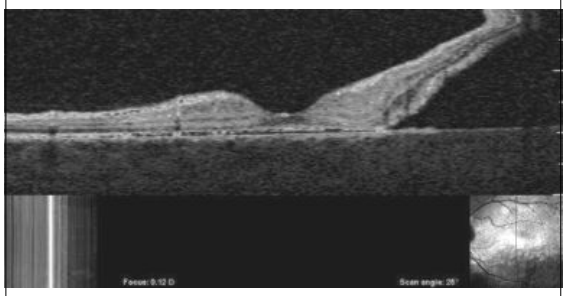
Posterior Segment Applications

- Vitreous/Vitreoretinal Interface
- Neurosensory retina, RPE/Bruch's
- Choriocapillaris
- Optic Nerve/NFLA



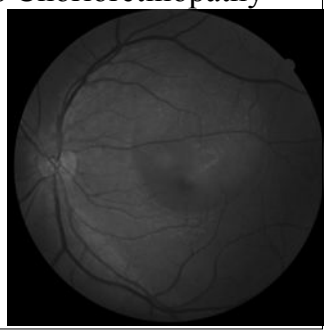


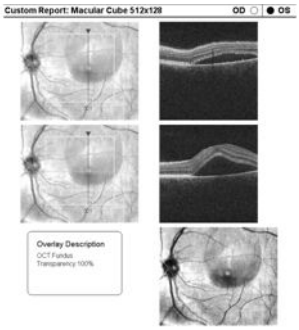




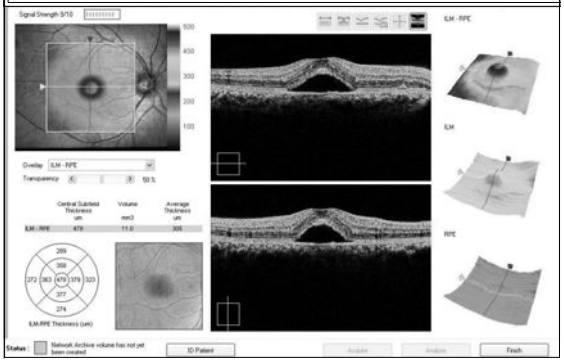
Central Serous Chorioretinopathy

- 36 y/o WM
- CC: Sudden central blur OS
- VA OD 20/20
- VA OS 20/200



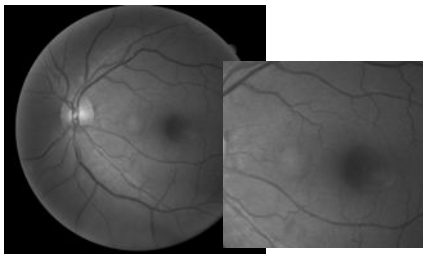


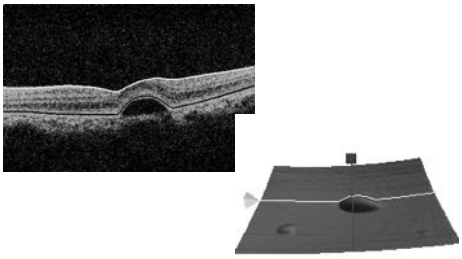
Central Serous Chorioretinopathy



RPE Detachment

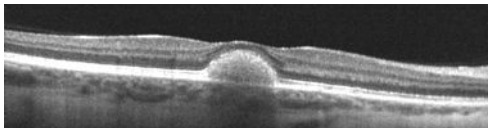
48 yo BF
VA 20/20



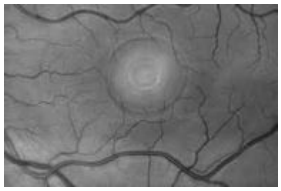


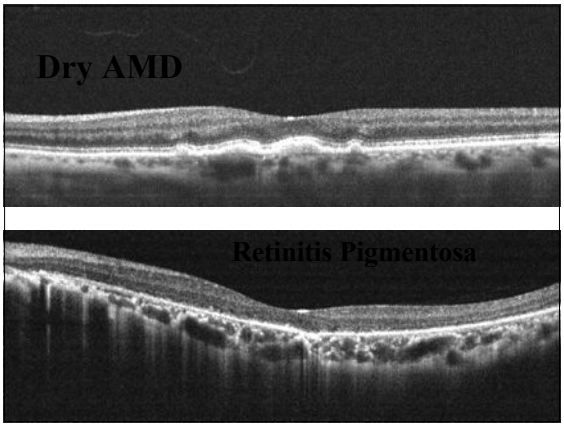
Pigment Epithelial Detachment

18 yo BF 20/80
Bests Disease-confirm with EOG



18 yo BF Best's Disease

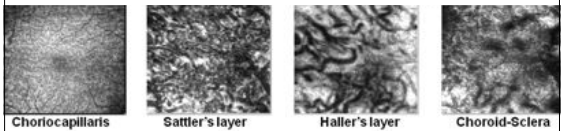




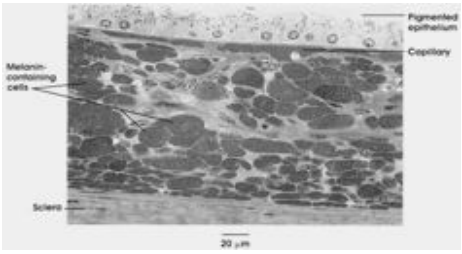
Questions and Comments?

Posterior Segment Applications

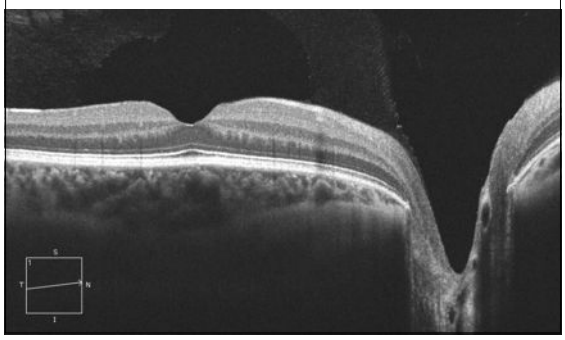
- Vitreous/Vitreoretinal Interface
- Neurosensory retina, RPE/Bruch's
- Choroid
- Optic Nerve/NFLA

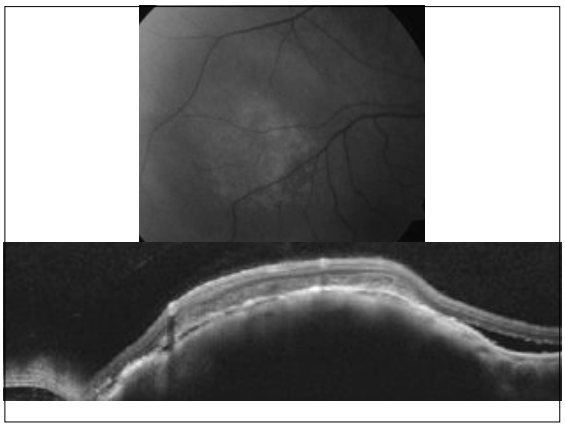


Choroid Microstructure



Vascular Layers of the Choroid





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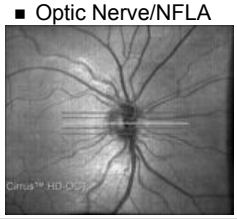
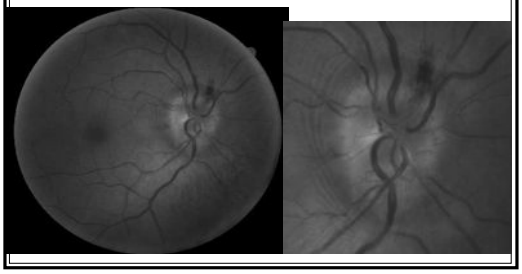
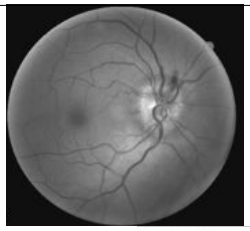
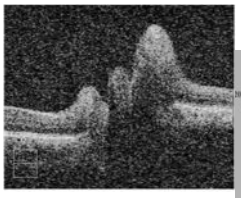
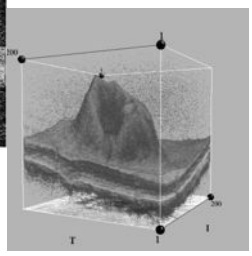


A 58-year-old male: chronic ONH edema

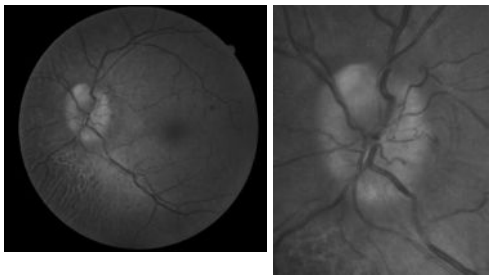


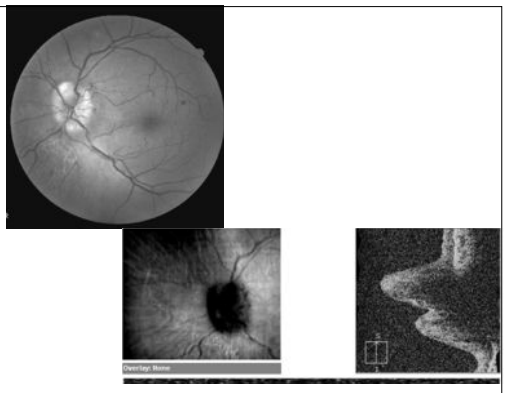


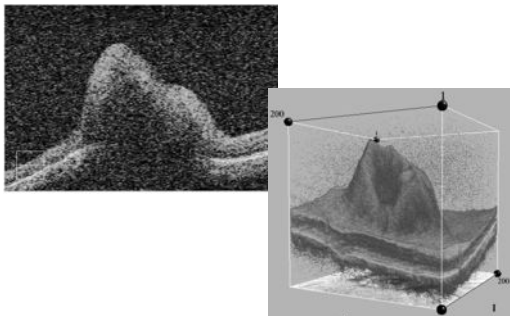




DFE OS





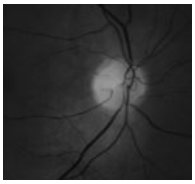


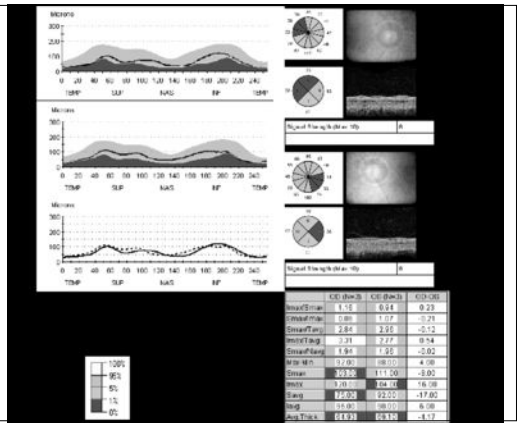
Demyelinating Optic Neuopathy

58 y/o WF w/MS

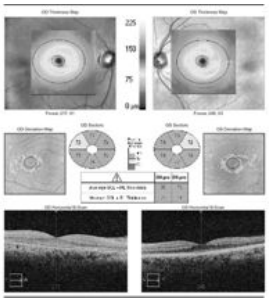
VA 20/25
OD/OS

APD -





Ganglion cell analysis in MS



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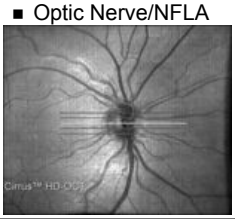
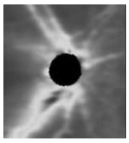


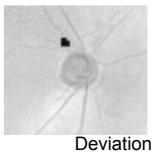
SD-OCT Glaucoma in HD

Laser Image



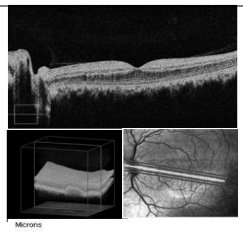
Thickness Map

Cross-section

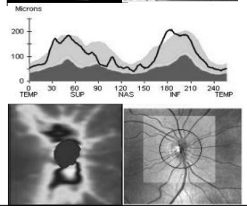


Deviation Map

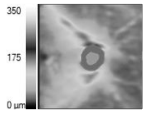
2-D and 3-D volumetric data cubes



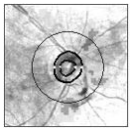
TSNIT w/comparison



Analysis Elements



RNFL thickness and deviation maps with cup and disc



	OD	OS
Average RNFL Thickness	73 µm	61 µm
RNFL Symmetry	55%	
Rim Area	1.12 mm²	0.70 mm²
Disc Area	1.58 mm²	1.68 mm²
Average C/D Ratio	0.53	0.75
Vertical C/D Ratio	0.49	0.75
Cup Volume	0.036 mm³	0.201 mm³

Optic Nerve Head calculations are presented in a combined report with RNFL thickness data. Key parameters are displayed in table format

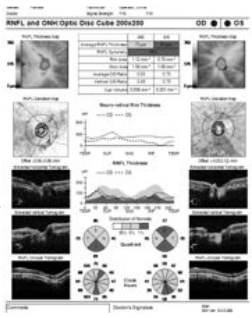
Cirrus RNFL + ON OU Analysis 50 Year Old BF

RNFL THICKNESS MAP

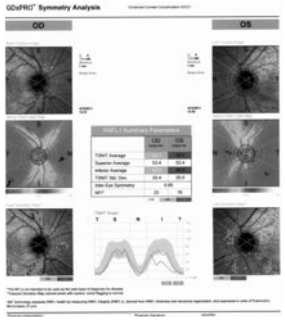
RNFL DEVIATION MAP, overlaid on the OCT fundus image

RNFL thickness and comparison to normative data is shown in circle, quadrants and clock hour display

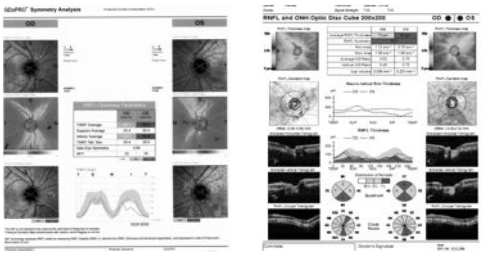
TSNIT RNFL thickness along the calculation circle is displayed in graphic format and compared to age-matched normative data



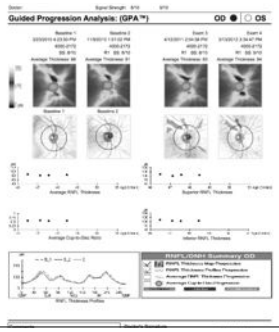
GDx RNFL OU Analysis 50 Year Old BF



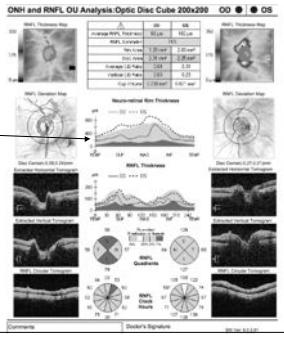
GDx vs. Cirrus OCT Analysis



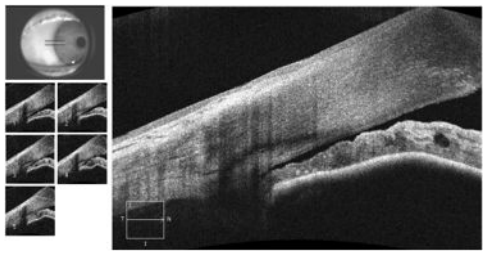
Cirrus OCT Progression Analysis
50 Year Old BF



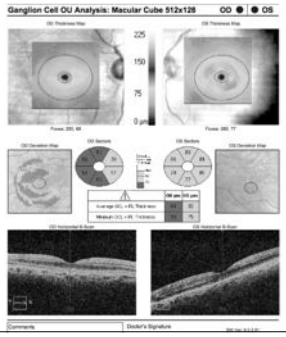
Cirrus OCT RNFL + ON Analysis
75 Year Old WM Plateau Iris Syndrome



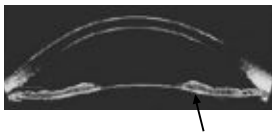
Plateau Iris Syndrome



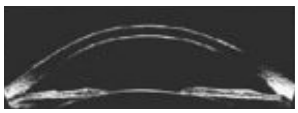
Cirrus Ganglion Cell OU Analysis
75 Year Old WM Plateau Iris Syndrome



Pigmentary GLC Pre/Post LPI



Note “back-bowing” of the iris



Questions and Comments?

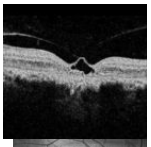
Advanced Visualization Analysis

Manipulation of Images on OCT

Advanced Visualization

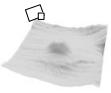
HD Cross Sectional Image

Vitreomacular Traction



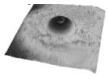
HD Layer Map of ILM

Central Serous Chorioretinopathy



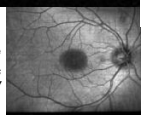
HD Thickness Map

Central Serous Chorioretinopathy



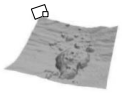
HD Fundus Image

Central Serous Chorioretinopathy



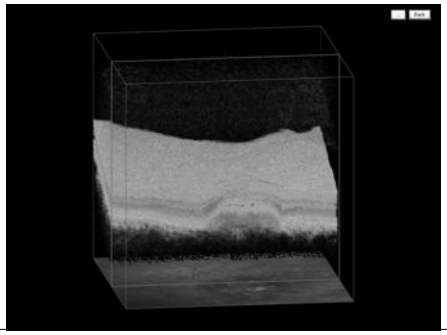
HD Layer Map of RPE

Age Related Macular Degeneration



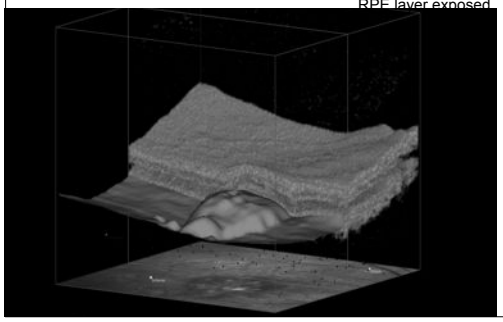
Advanced Visualization

3D Volume Rendering

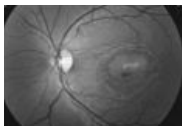


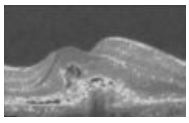
Advanced Visualization

3D Volume Rendering with RPE layer exposed



Choroidal Neovascular Membranes (CNVM)

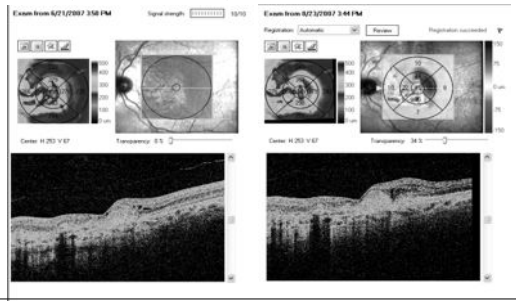




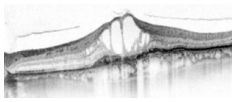
OCT shows increased retinal thickness due to leakage.

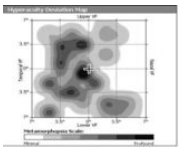
Macular Change Analysis

Provides visual and quantitative comparison of two exams.
Post-acquisition registration and the unique Fovea Finder function allows the accuracy and precise repeatability of macular thickness measurements.



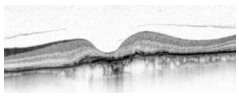
Pre and Post Avastin Treatment

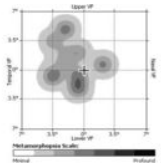




VA 55 L

VA 78 L





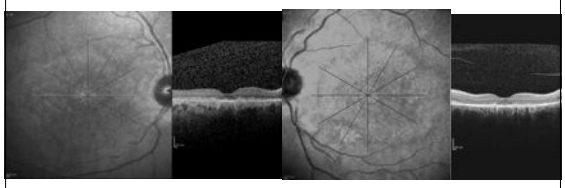
Case

- 65 Year old Female
- Comes in with complaints of blurred and dimmed vision
- PMH: Rheumatoid Arthritis x 15 years
- OcHx: S/P CE and IOL OU

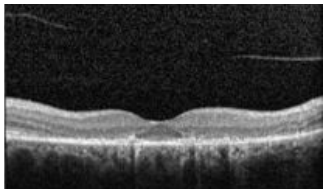
Ophthalmic Exam

- VA:
  - OD: 20/40 OS: 20/40
- IOP
  - OD: 14 OS: 13
- SLE:
  - OD: PCIOL OS: PCIOL
- DFE:

DFE/OCT

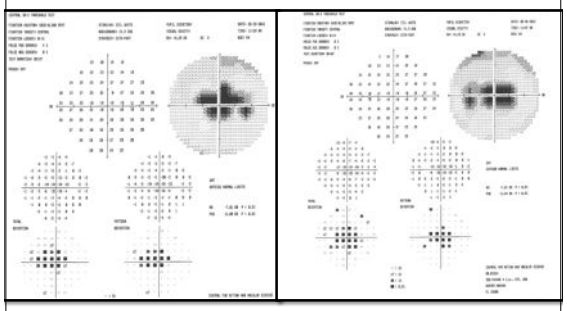


OS



Additional Testing?

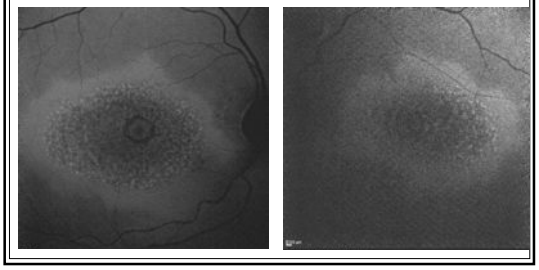
Visual Fields



Fundus Autofluorescence

While Angiography images BRB integrity, FAF captures metabolic activity.

Auto Fluorescence



Likely Diagnosis?

Plaquenil Maculopathy

- Co-management team includes eye care provider, rheumatology
- Testing guidelines for patients on Plaquenil
- Repeat testing

Fundus Autofluorescence

While Angiography images BRB integrity, FAF captures metabolic activity.

Imaging Technologies: FAF

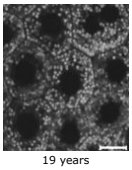
Hyper-AF

Hypo-AF

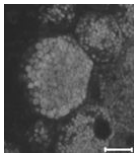
Imaging Technologies: FAF

What is autofluorescence in the retina?

- It is the fluorescence of the lipofuscin molecule within the RPE cell layer that fluoresces with a certain wavelength.



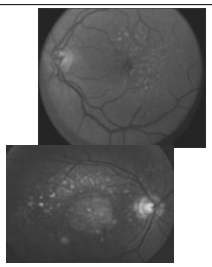
19 years



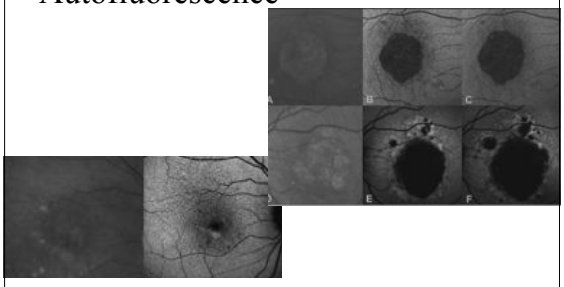
64 years

Autofluorescence (FAF)

- Principle
  - When stimulated with light in the blue range, lipofuscin granules emit yellow fluorescence.
  - Patterns of fundus autofluorescence may predict which eyes will progress more quickly.

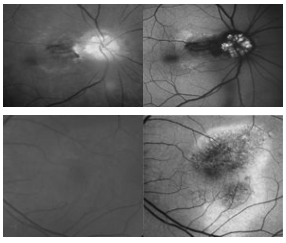


Autofluorescence



Autofluorescence (FAF)

- Early ID of disease.
  - ON drusen
  - CSC
- Predictive marker
  - increased FAF signal precedes dry AMD progression.
- Monitor Dx.
- Functional correlation.

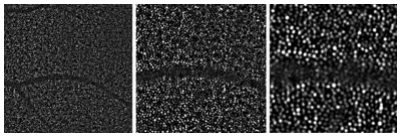


FUTURE HORIZONS
in PS Imaging

Adaptive Optics

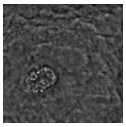
Multimodal Imaging

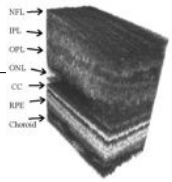
What is the future?

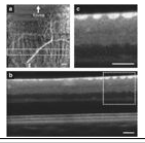


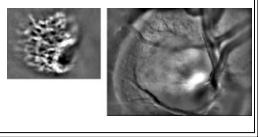
- Adaptive optics
- An instrument capable of compensating for the large aberrations present in the human eye.
- Visualize the retina at the cellular scale.
  - Cones, nerve fiber bundles, capillaries, lamina cribrosa

Adaptive Optics

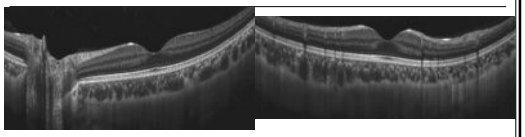






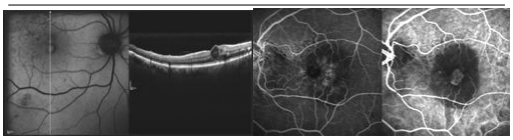


Swept Source OCT



- 1,050nm wavelength
- 100,000 A-scans/sec
- Allows deeper imaging of choroid, sclera, intra-orbital ON

Multi-modal Imaging

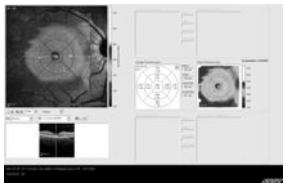


- e.g. Spectralis SD-OCT w/Blue Peak AF, FA/ICGA
- mf-ERG + OCT
- Adaptive optics retinal camera/SD-OCT

Multi-modal Imaging

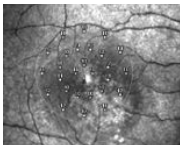
- SD-OCT
- Color digital imaging
- FAF

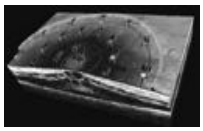
Blue Peak FAF + OCT



Geographic Atrophy

Multi-modal Imaging



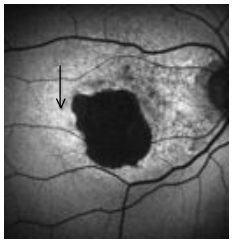


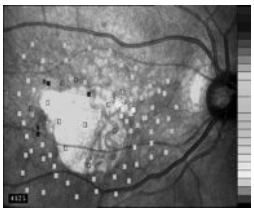
- e.g. Optos SD-OCT w/microperimetry

FAF + Microperimetry

Geographic Atrophy

Atrophy associated with hypo-AF (GA) correlates to severe VFD

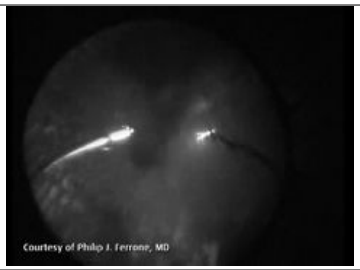




Images courtesy of Frank Holz MD, University of Bonn

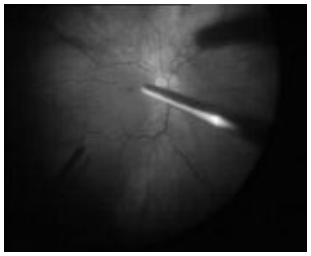
Digital Video Imaging

PDR w/Vitreous Heme



ERM Surgery

Macular Hole Sx. ILM Peel

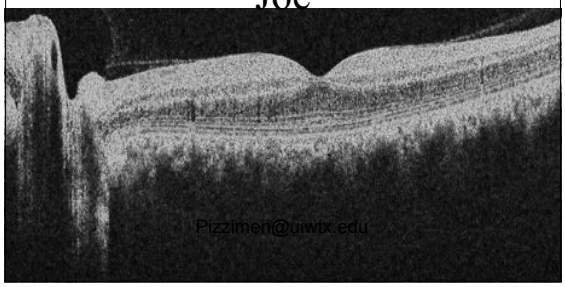


Summary and Conclusions

- No imaging technology replaces the skills of a good historian, diagnostician, clinician.
- Clinicians are better equipped than ever to detect and characterize sight-threatening posterior segment disease early.
- Timely treatment with more effective therapies enhance the potential for improved visual outcomes.

Thank you!

Joe



Pizzimen@uiwtx.edu