1

Learning objectives:

- **After completing this course, the participant will be able to:**
  - Describe the pathobiology of Glaucoma, dry/wet AMD, RVO, and DR.
  - Discuss the clinical features of common retinal conditions.
  - Properly diagnose and manage/co-manage Glaucoma, dry AMD, wet AMD, RVO, and DR using various imaging and other diagnostic modalities.
  - Describe the contemporary treatment options for posterior segment diseases.

2

Learning objectives continued

- Discuss the emerging roles of OCTA, enhanced-depth OCT, and fundus autofluorescence.
- Accurately interpret and apply the findings obtained with these imaging methods.
- Understand the principles of OCTA and how it can be utilized in the clinical care of patients with AMD, diabetic retinopathy, and glaucoma.
- Evaluate FAF imaging for retinal abnormalities
- Describe how OCT ganglion cell analysis and central visual field testing can aid in the early detection of glaucomatous damage

3

Financial Disclosures

ALL REFERENCES TO COMMERCIALLY-AVAILABLE PRODUCTS ARE INTENDED TO BE NONBIASED AND FOR EDUCATIONAL PURPOSES.

WE HAVE NO RELEVANT FINANCIAL OR NON-FINANCIAL RELATIONSHIPS TO DISCLOSE.

4

Clinical Examination of the Posterior Segment

A. BIOMICROSCOPY
   i. View the anterior segment, lens, anterior and mid-vitreous
B. FUNDOSCOPY
C. DIRECT OPHTHALMOSCOPY
D. BINOCULAR INDIRECT OPHTHALMOSCOPY
   i. Scleral indentation to expand the reach of BIO
   ii. Multiple condensing lenses for wider field of view
D. FUNDUS BIOMICROSCOPY
   i. Contact fundus lenses
   ii. Goldmann 3-mirror
   iii. Non-contact fundus lenses

5

History of Posterior Segment Imaging Techniques

- FUNDUS PHOTOGRAPHY 1920S
- FLUORESCEIN ANGIOGRAPHY 1950S
- B-SCAN ULTRASOUND 1970S
- ICG ANGIOGRAPHY (DIGITAL) 1980S
- SLO (HRT), SLP (GDX) 1990S
- DIGITAL PHOTOGRAPHY 1990S
- OCT FIRST DEMONSTRATED 1991
- WIDE FIELD SLO 2000
- HIGH-RES TD-OCT 2001
- FOURIER DOMAIN SD-OCT 2007
- OCT ANGIOGRAPHY 2015
- SWEPT-SOURCE OCT 2016

6

Swept-Source OCT

I. TWICE AS FAST (TWICE AS MANY A-SCANS / SECOND) AS SD OCT

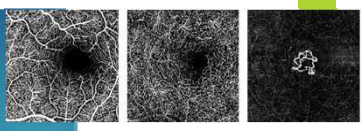
II. ALLOWS FOR WIDE FIELD IMAGING (12MM VS. 6-9 MM). EASILY GETS ONH AND MACULA IN THE SAME SCAN

III. LONGER WAVELENGTH OF LIGHT, SO CAN IMAGE MUCH MORE EFFECTIVELY THROUGH MEDIA OPACITIES, AND PENETRATES MUCH BETTER IN TO THE CHOROID (2.6 MM DEPTH V 2.3MM)

7

OCT Angiography (OCTA):

A review and clinical update



https://eyewire.news/articles/heidelberg-engineering-oct-angiography-module-now-available-in-the-united-states/

8

OCT Technology: A timeline

First in vitro 1991 → First in vivo 1993 → TD-OCT 1996 → SD-OCT 2006 → OCTA 2015 → SS-OCT 2016

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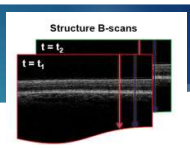
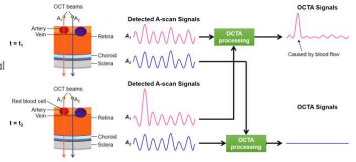
How does OCTA work?



- *Motion Contrast Imaging*
  - Successive B-scans of the same area
    - Retinal tissue remains unchanged
    - Movement (flow) of erythrocytes through the retinal vasculature is detected
  - Many different algorithms exist to compute blood flow and formulate a three-dimensional image
    - Vessel density
    - Flow index

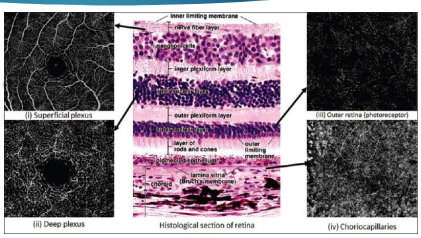


Kashani A, Chen C, Gahm J, et al. Optical coherence tomography angiography: A comprehensive review of current methods and clinical applications. *PROGRESS IN RETINAL AND EYE RESEARCH*. 2017;60:66-100.

10

Three distinct retinal vascular layers

- Three capillary networks within the retina:
  - Radial peripapillary capillaries (NFL)
  - Inner/superficial capillary network (GCL)
  - Outer/deep capillary network (INL)



11

OCT Angiography

- Pros
  - *Convenience, safety*
  - *High-resolution visualization of vessel architecture, **ischemia***
  - *Isolation of specific layers for precise localization (3-D)*
  - *Ability to monitor ischemia, vessel regression with subsequent scans*
- Cons
  - *Small area analyzed*
  - *Prone to artifacts*
  - *Snapshot in time*

Fluorescein Angiography

- Pros
  - *Blood flow over time (early/late, pooling, leaking)*
  - *Better visualization in cases of very high or low flow (MA's)*
  - *Gold standard*
- Cons
  - *Potential adverse affects*
  - *Poor visualization of 2 of the 3 vascular networks (Spaide 2015)*
    - FA mainly shows the inner capillary network
    - Little to no visualization of the radial peripapillary network, deep capillary network

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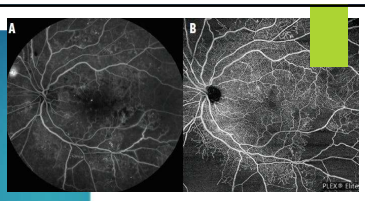
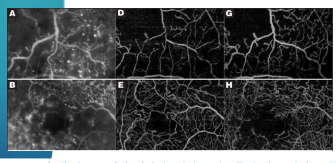
FA vs OCTA

- MA's → FA
- Capillary detail, nonperfusion → OCTA





From: Kuehlewein L, et al. Imaging areas of retinal nonperfusion in ischemic branch retinal vein occlusion with swept-source OCT microangiography. Ophthalmic Surgery, Lasers and Imaging Retina. 2015;46(2):249-252.

13

Various OCTA platforms

- Visionix AngioVue
- Zeiss AngioPlex
- Heidelberg Spectralis
- Topcon Maestro 2/Triton
- Nidek, Canon
- New SS-OCTA technology
  - Expanded Field, Widefield, Ultra Widefield
  - Intalight DREAM OCT system

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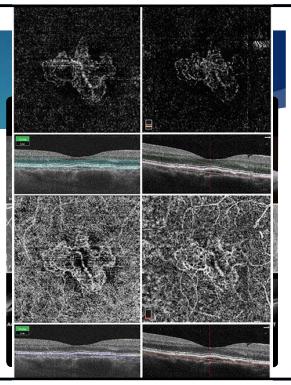
Which system is best?

- Spectral Domain vs. Swept Source
  - SD → Higher resolution
  - SS → Faster acquisition time; $$$
- Software considerations
  - AngioAnalytics (Optovue)
  - AngioPlex (Zeiss)
- Consider multimodal imaging



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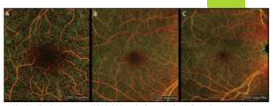
Performing OCTA

- Choose scan size
  - 3x3, 6x6, 8x8, 12x12 mm
  - Widefield
- Angiography Analysis
  - Two en face analyses
    - **AngioPlex**
    - **Structure**
  - Cross-sectional "flow" image (raster scan)



http://retinatoday.com/2017/03/a-role-for-octa-in-daily-retina-practice

https://retinatoday.com/articles/2021-sept/clinical-utility-of-oct-angiography-for-retinal-and-choroidal-vascular-diseases

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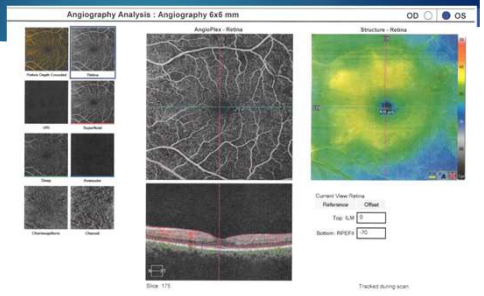
OCT-Angiography Analysis

- Macula 6x6 mm



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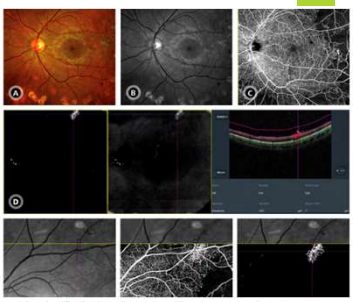
Multimodal Imaging Example

- Refractory PDR



"OCTA Simplified", Zeiss, United States Edition. Content contributed by Ricardo Luz Leitão Gueiros MD, MSc, FICO

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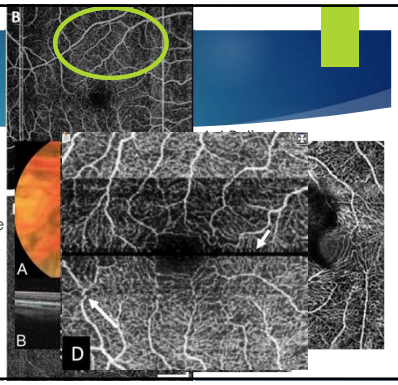
Artifacts

- Image artifacts
  - Media opacities
- Projection Artifacts
  - Vessels from above
- Motion artifacts
  - White lines
- Blink artifacts
  - Black lines



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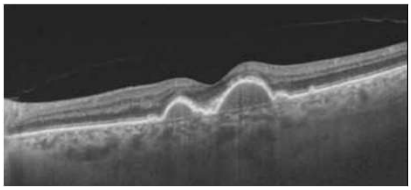
Questions



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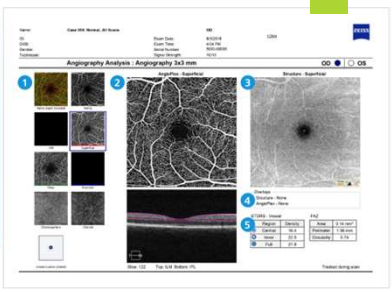
OCTA metrics

- Vessel
  - Vessel Density (VD)
- Macula
  - Foveal avascular zone (FAZ)



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Clinical use of OCTA

DIABETIC RETINOPATHY
AMD
RVO
RAO

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Diabetes evaluation & monitoring

- Vascular changes may be visualized earlier than on fundus exam
- High-resolution analysis of diabetic microangiopathy
  - Capillary nonperfusion, IRMA, neovascularization
- Monitoring of disease
  - Increased FAZ
  - Macular capillary perfusion density

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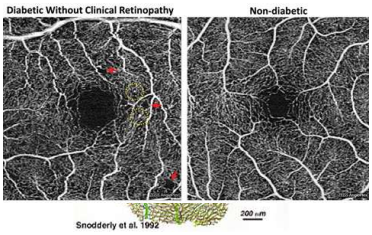
Foveal Avascular Zone (FAZ)

- Denotes the vascular-free fovea
- 400-700 µm in diameter
- Hussain *et al.*
  - 660 µm (Superficial)
  - 914 µm (Deep)
- Previously only visible with fluorescein angiography
- Enlarged in microvascular ischemic disease (ex. diabetes)



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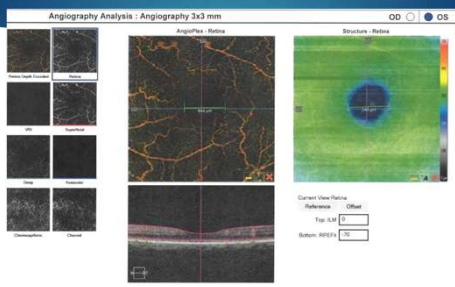
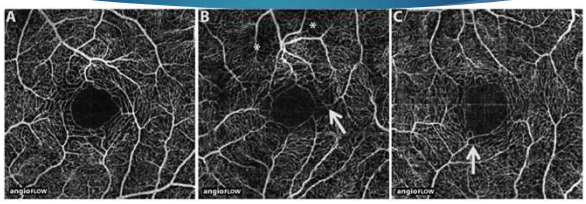
FAZ measurement



26

FAZ enlargement and vascular remodeling in a diabetic patient

From: de Carlo TE, Chin AT, Bonini Filho MA, et al. Detection of microvascular changes in eyes of patients with diabetes but not clinical diabetic retinopathy using optical coherence tomography angiography. *Retina*. 2015;35:2364-2370.



Healthy FAZ

Diabetic eye with capillary nonperfusion (arrow, asterisks)

Diabetic eye with enlarged FAZ, vascular remodeling (arrow)

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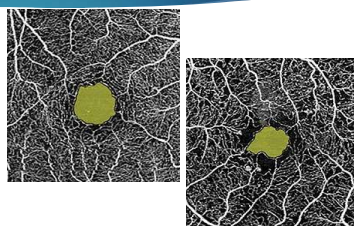
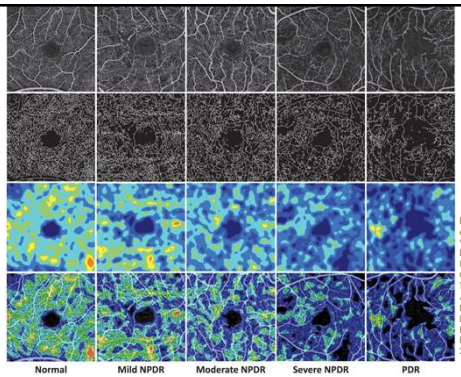
Quantifying microvascular change

- **AngioPlex Metrix™**
- **Identify** patients progressing in disease.
  Evaluate central microvascular perfusion changes.
  Assess changes over time.
  Visualize changes in FAZ size and geometry.



https://www.zeiss.com

28



From: Agemy SA, et al. Retinal Vascular Perfusion Density Mapping Using Optical Coherence Tomography Angiography in Normals and Diabetic Retinopathy Patients. *Retina*. 2015;35:2353-2363.

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Updates

- Wide-field OCTA for neovascularization identification *(Pichi et al. 2020)*
- Baseline OCTA may predict DR progression and visual decline *(Yang et al. 2026)*

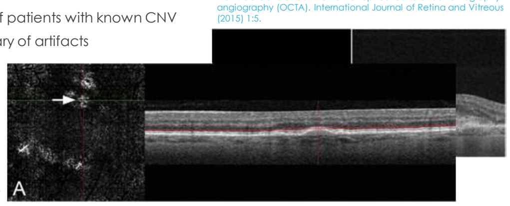
30

OCTA and Age-Related Macular Degeneration

- ***Detection*** of CNV including ***localization***
- ***Differentiation*** of drusenoid PED vs. CNV
- ***Monitoring*** of patients with known CNV
- Must be weary of artifacts

From: de Carlo et al. A review of optical coherence tomography angiography (OCTA). International Journal of Retina and Vitreous (2015) 1:5.

From:: Spaide RF, Fujimoto JG, Waheed NK. Image Artifacts in Optical Coherence Angiography. *Retina (Philadelphia, Pa)*. 2015;35(11):2163-2180.



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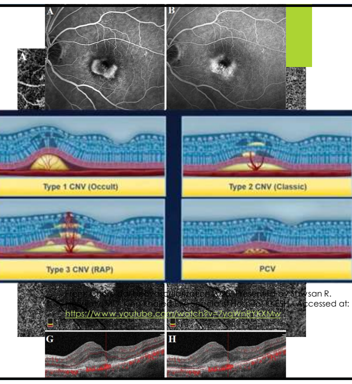
CNV types

- Type I (occult): Between Bruch's membrane and RPE
- Type II (classic): Between RPE and retina (within the subretinal space)
- Type III (retinal angiomatous proliferation): extends into outer retina
- Type IV: Mix of both occult and classic



...san R. ...ccessed at: https://www.youtube.com/watch?v=7waWnFYkXMw

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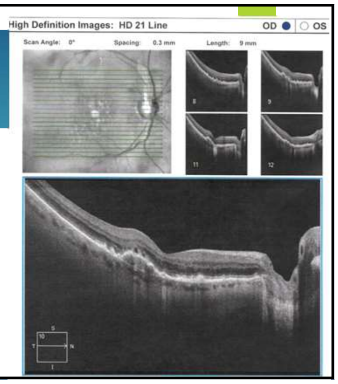
Vascular Flow Analysis

- Case example:
- 84-yr-old white male
- Dry AMD x 14 years
  - Soft, coalesced drusen
  - RPE pigment clumping, dropout
  - BCVA 20/60- OD, 20/40- OS
- OCT HD 21 Line raster
  - Confluent drusen, cystic changes
    - Dry retinal disruption or MNV?



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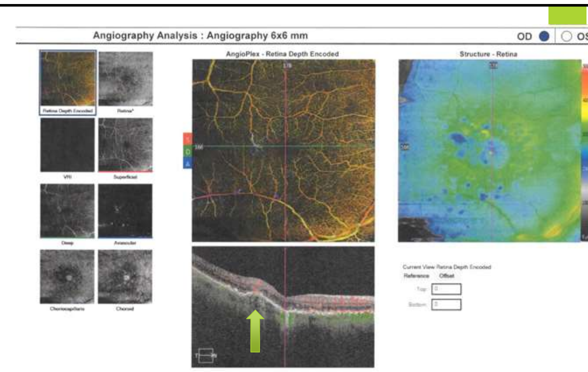

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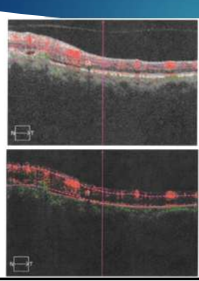
Vascular Flow Analysis



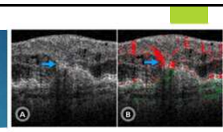


Figure 53: Structural OCT B-scan (A) and B-scan with flow overlay (B) in a patient with AMD presenting Type 3 MNV, with the communication point between retinal and choroidal vasculature identified (blue arrow).

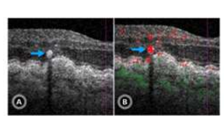


Figure 54: Structural OCT B-scan (A) and B-scan with flow overlay (B) of the contralateral eye from the previous patient, also presenting Type 3 MNV. The scan reveals flow within the hyperreflective lesion (blue arrow).

Zeiss "OCTA Simplified" 2025.

35

OCTA for AMD: Summary

- Detection and monitoring of subclinical MNV (nonexudative)
- Prediction of conversion to wet disease
- Differentiation between dry retinal disruption (PED) and neovascularization
- Helps enable accurate diagnosis (AMD vs "mimickers")

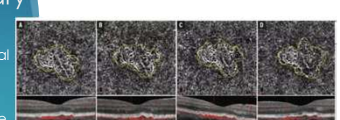


Figure 2. OCTA en face images (top row) and B-scans (bottom row) from an eye with nonexudative MNV: follow-up through 4 consecutive years (A-D). The MNV lesion area has increased in size from 1.445 mm² at baseline (A) to 1.620 mm² on the most recent visit (D).

https://retinatoday.com/articles/2021-july-aug/clinical-utility-of-oct-angiography-for-amd

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Billing & Coding for OCTA

- Recent update: new CPT code as of 2025!
- **CPT 92137**: *Computerized ophthalmic diagnostic imaging (e.g., optical coherence tomography [OCT]), posterior segment, with interpretation and report, unilateral and bilateral; retina,* ***including OCT angiography***
- Higher reimbursement than "traditional" OCT
  - But much less than FA
- Cannot report on same day as 92133/92134
- You CAN bill same day as FA/ICG

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Future applications of OCTA

- HARDWARE UPDATES
  - Swept Source OCTA
  - Widefield OCTA
  - Adaptive Optics
- SOFTWARE UPDATES
  - Normative database development, standardization across instruments, reduction in frequency of artifacts

Artificial intelligence (AI) in OCTA image analysis

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OCTA in summary

- OCTA, while not a replacement for FA, adds high-resolution, three-dimensional information to the clinical picture.
- OCTA allows for early detection of microvascular damage in diabetes, with increased FAZ observed in diabetics regardless of the presence of clinical retinopathy.
- Flow index, vessel density: Useful parameters
- Artifacts continue to pose a challenge in accurate interpretation.
- There is still a long way to go in terms of system congruity, normative database accumulation, and understanding of what it all means in the context of ocular disease.
  - But the outlook is promising!

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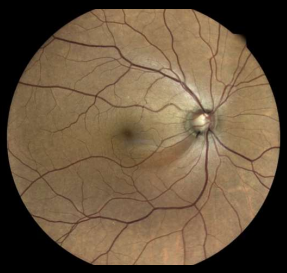
Questions and Answers



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Technology in early glaucoma detection

GLAUCOMA

Over 4 million Americans are estimated to have glaucoma

But…

ROUGHLY 50% ARE UNAWARE

Leading cause of irreversible blindness in the U.S.

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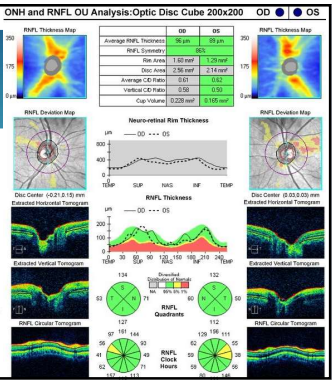
To review: ONH and RNFL Analysis

- Based on 6mmx6mm data cube captured by the "Optic disc cube 200x200" scan
  - 3.46mm diameter Calculation Circle
- Color coded based on normative database
- RNFL thickness map
  - Hourglass shape of yellow and red colors in normal eyes
- RNFL deviation map
  - Deviation from "normal"
  - Shows boundaries of cup and disc
- RNFL Quadrants/clock hours



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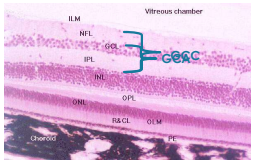
What is the "ganglion cell complex"?

- Ganglion Cell Complex (Optovue)
  - Inner plexiform layer
  - Ganglion cell layer
  - Nerve fiber layer
- Ganglion Cell Analysis (Zeiss Cirrus)
  - Inner plexiform layer
  - Ganglion cell layer



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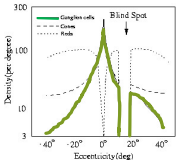
Macular ganglion cell thickness in early glaucoma detection

- Densest population of ganglion cells is within the central macula
- Less variability, more reproducibility than optic disc RNFL scan
- May be easier to obtain reliable, high-quality scan



http://uhw10503.utweb.utexas.edu/research/eyefix/index.php

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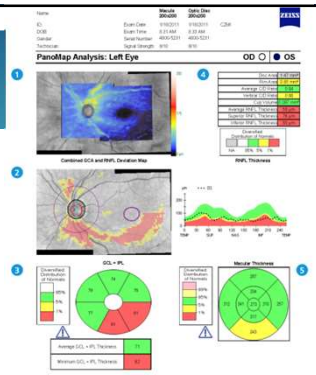
Ganglion Cell Analysis

- Derived from a macular cube scan
- Color-coded thickness based on normative database
- Thickness map
- Deviation map
- Sectors/cross-sections



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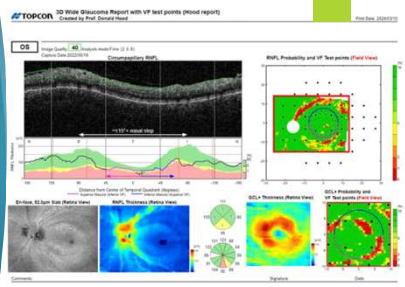
The Hood report (Topcon)

- Combines peripapillary RNFL and macular GCC data
  - Predicts visual field loss
  - Includes "NSTIN" plot



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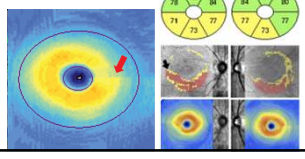
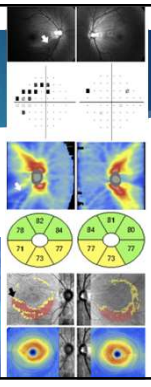
GCA in myopes

- Myope **with** glaucoma (left)
- Myope **without** glaucoma (right)
- Both eyes show "abnormal" GCA
  - Horizontal raphe
  - Nasal vs. temporal defects





From: Hwang YH et al. Macular ganglion cell analysis for early detection of glaucoma. *Ophthalmology*. 2014;121:1508-1515.

47

OCT GCA: Just for glaucoma?

- J.H., a 60-year-old AA female
  - Presented to UMSL Patient Care Center for a glaucoma work up (suspicious ONH appearance)
  - Pt had no complaints except for "blur at near"
- Medical Hx
  - Hypertension (controlled with amlodipine), hypercholesterolemia (controlled with atorvastatin, HCTZ), borderline diabetic (diet-controlled, last A1C 7%)
- Social Hx/Vitals
  - Social drinker, non-smoker
  - BP: 135/78

48

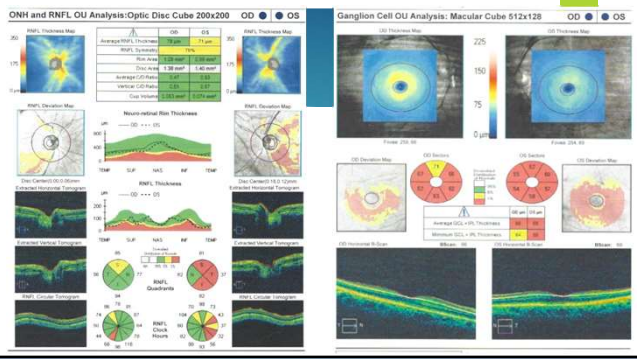
Entrance Testing/SLE

- VAsc: 20/20 OD, OS
- Pupils: PERRLA (-) APD OU
- EOM's FROM; Confrontations FTFC OU
- HRR Color testing: 4/6 OD, OS → mild R/G defect OU
- IOP: 18/16 mmHg
- Anterior segment evaluation: Unremarkable
  - PCIOL OU, clear, well-positioned

49

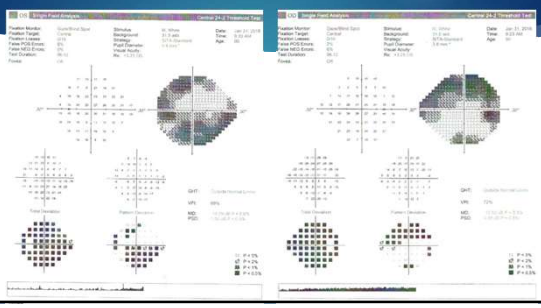
DFE:

50



51

24-2 SITA-Standard VF



52

Assessment and Plan

- Is this glaucoma?
- Referral to neuro-ophthalmology
  - Ordered MRI of brain and orbit with and without contrast
- Diagnosis
  - Large sphenoidal meningioma encasing both optic nerves with effects on chiasm
  - Patient underwent surgery for removal

53

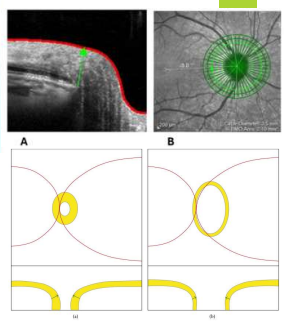
GCA in Summary

- Very important piece of the glaucoma puzzle!
- Incorporate into your RNFL evaluation
- Consider patient's refractive error in the presence of "abnormal" findings
- Keep in mind… nonspecific for glaucoma

54

Bruch membrane opening-minimum rim width (BMO-MRW)

- Measures the shortest distance from the inner opening of Bruch's membrane to the internal limiting membrane
- Allows for objective measurement of neuroretinal rim width to more accurately detect glaucomatous cupping vs "normal" nerve tissue
- Automatically calculated on some OCTs
- Consider ALL data (RNFL thickness)



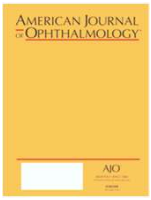
55

Visual field update: SITA Faster

- About 70% of the time of SITA Fast with same reproducibility
  - 2-minute test
  - Goal to increase frequency of VF testing, reduce patient fatigue
- **24-2C** includes 10 test points from the 10-2 test

*"Our overall results indicate that **SITA Faster can replace SITA Fast.** It is natural to consider whether also to abandon SITA Standard in favor of SITA Faster. This decision, in our opinion, **should depend on whether such a step will make it possible to increase the frequency of perimetric testing.** It is clear that more frequent tests are very important for earlier detection of progression and for assessing rate of progression. Considering comparisons of SITA Standard and SITA Fast in this regard, this new shorter test may be preferable, provided that the shorter test duration is used to increase test frequency. Future studies are needed to provide a definite answer as to how to best choose tests in different clinical settings."*

Heijl A, Patella VM, Chong LX et al. A new SITA perimetric threshold testing algorithm; construction and a multi-center clinical study. *American Journal of Ophthalmology* (2018).



56

10-2 perimetry in early glaucoma detection

- 24-2 testing: what are we missing?
  - Only 4 test points within the macula
  - Points spaced 6 degrees apart
  - Paracentral scotoma: common early field defect

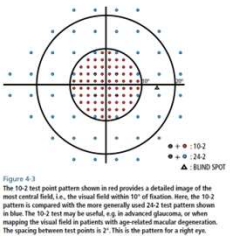


Figure 4-3
The 10-2 test point pattern shown in red provides a detailed image of the most central field, i.e., the visual field within 10° of fixation. Here, the 10-2 pattern is compared with the more generally used 24-2 test pattern shown in blue. The 10-2 test may be useful, e.g. in advanced glaucoma, or when mapping the visual field in patients with age-related macular degeneration. The spacing between test points is 2°. This is the pattern for a right eye.

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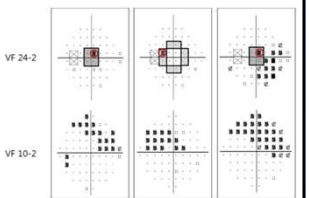
10-2 testing in the literature

- Traynis et al. (2014)
  - **22%** of open-angle glaucoma suspects showed clear 24-2 but abnormal 10-2 fields
- De Moraes et al. (2017)
  - **35%** of ocular hypertensives showed abnormal 10-2 fields
- Detecting *progression* of paracentral loss
  - **70%** of eyes with central progression were missed by 24-2 testing (Park et al. 2013)

58

Predicting a 10-2 defect

- Park et al. (2016)
  - 75% of glaucomatous eyes found to have a paracentral scotoma on 10-2 VF test
- **Predictive factors of 24-2 VF:**
- Any central points at **p<0.5%**
- Abnormal **PSD** greater than the MD
- Any central points correlating to **GCA OCT**

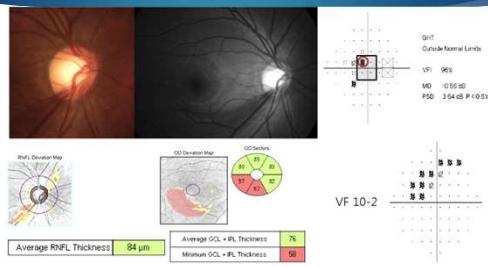


From: Park HL et al. Clinical clues to predict the presence of parafoveal scotoma on Humphrey 10-2 Visual Field using a Humphrey 24-2 Visual Field. Am J Ophthalmol. 2016;161:150-157.

59

Applying the interpretation: an example

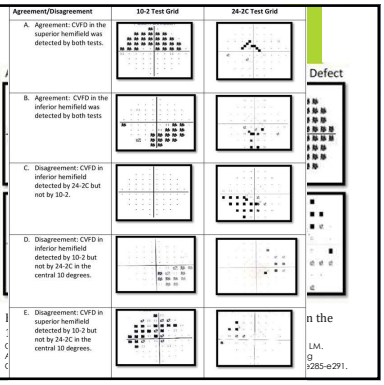
From: Park HL et al. Clinical clues to predict the presence of parafoveal scotoma on Humphrey 10-2 Visual Field using a Humphrey 24-2 Visual Field. Am J Ophthalmol. 2016;161:150-159.



60

24-2C Visual Field Testing

- Consider 24-2C testing
- Look for **correlation** with RNFL/GCA thinning on OCT
- Central defects found to be most accurately detected with 24-2C pattern in mild glaucoma (NISHIJIMA et al. 2024)



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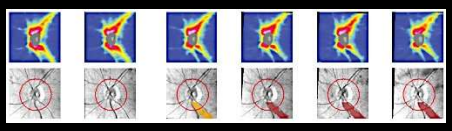
Questions and Answers



RNFL thickness and deviation maps showing I/T vulnerability.
OCT is non-invasive, based on low coherence interferometry.

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OCT Angiography (OCTA) in early glaucoma detection

THREE VASCULAR REGIONS OF INTEREST:

- SUPERFICIAL PERIPAPILLARY
- SUPERFICIAL MACULAR
- PERIPAPILLARY CHOROIDAL

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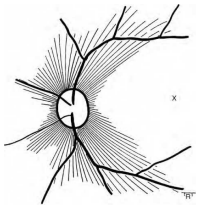
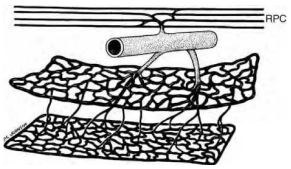
OCT Angiography (OCTA) in early glaucoma detection

- Radial Peripapillary Capillary Network



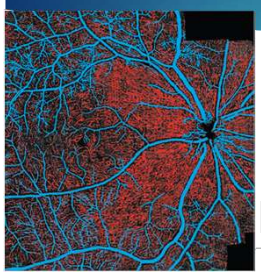


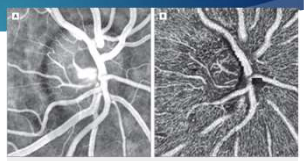
From: Henkind P. Radial Peripapillary capillaries of the retina. I. Anatomy: Human and comparative. Br J Ophthalmol. 1967;51(2):115–123.

64

Radial peripapillary capillary network

From: Retinal Vascular Layers Imaged by Fluorescein Angiography and Optical Coherence Tomography Angiography. JAMA Ophthalmol. 2015;133(1):45-50.





A. FA B. OCTA of same region

Larger retinal vessels: Blue
Radial peripapillary capillary network: Red

The JAMA Network

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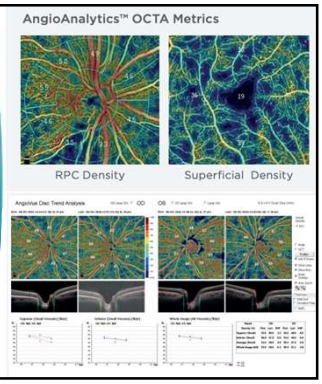
Available metrics for glaucoma

- **Vessel density (VD)**
- **Perfusion density (PD)**
- Flux/flow index
- Focal Loss Volume (FLV%) and Global Loss Volume (GLV%)
- Macular Analysis
  - FAZ
  - Parafoveal VD



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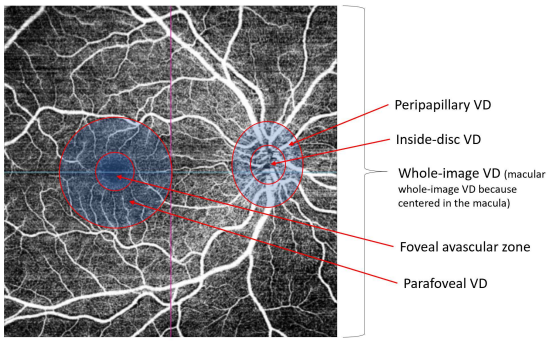

https://eyewiki.org/File:Fig_2_onamiguel_octa_terminology.png

67

OCTA in early glaucoma (pre-perimetric)

- Superficial peripapillary network shows **reduced density** compared to normals
  - May show changes earlier than GCC OCT (Kumar et al. 2016)
- Capillary changes may be more pronounced than RNFL loss in early disease (Kamalipour et al. 2022)
  - Choroidal capillary dropout → disc hemorrhage → RNFL thinning
- May be less prone to "red disease" than traditional OCT (ex. high myopes)
- 6x6mm scan better than 3x3mm for diagnosing early disease

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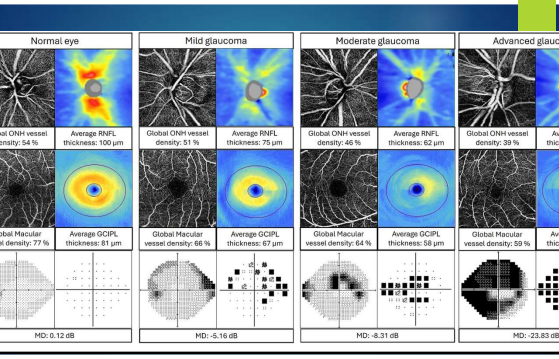

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OCTA challenges in glaucoma

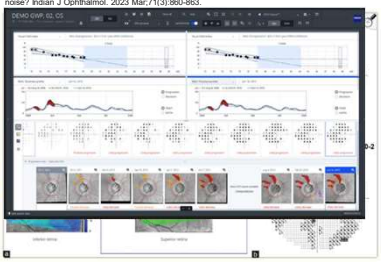
- Artifacts (motion, projection, segmentation)
- Lack of standardization among OCTA instruments
- Many tests already considered… how does this fit in?

70

Multimodal imaging and glaucoma

- Combines OCT/OCTA, visual fields, fundus photos, change analysis
  - Zeiss FORUM
  - The Hood report
- Enhances diagnostic ability
  - Including AI analysis

Ramesh PV, Devadas AK, Kumar NKS, Sainath D. Commentary: Rethinking 10-2 visual fields in early diagnosis of glaucoma for a glided glaucoma practice: The right choice to pick up a feeble noise? Indian J Ophthalmol. 2023 Mar;71(3):860-863.



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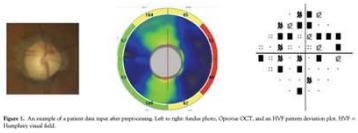
AI and glaucoma

- AI (Deep Learning) Segmentation of retinal layers in OCTA for glaucoma (Optovue Solix Essential)
- Zeiss Cirrus PathFinder AI



Hwang, Elizabeth E. et al. Utilization of Image-Based Deep Learning in Multimodal Glaucoma Detection Neural Network from a Primary Patient Cohort. Ophthalmology Science, 2025;5:3.

72

Fundus Autofluorescence (FAF)

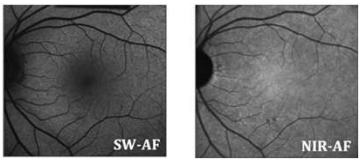
BASED ON THE FLUORESCENCE OF "FLUOROPHORES" NATIVE TO THE EYE

Primarily within choroid/RPE

73

General principles of FAF

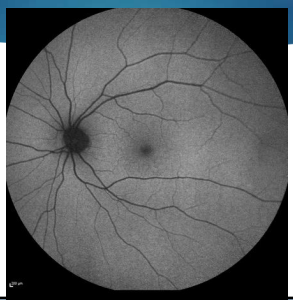
- Primary endogenous fluorophores of the eye
  - Melanin
  - Lipofuscin ***
- Two main types of FAF imaging
  - **Short-wavelength (SW-AF)**
  - Near-infrared (NIR-AF)



From: Greenstein VC, Schuman AD, Lee W, et al. Near-Infrared Autofluorescence: Its Relationship to Short-Wavelength Autofluorescence and Optical Coherence Tomography in Recessive Stargardt Disease. *Investigative Ophthalmology & Visual Science*. 2015;56(5):3226-3234.

74

FAF: healthy retina



75

FAF Interpretation

- Lipofuscin
  - Normal levels in all RPE
  - Increases with **age**
  - Increases in **retinal disease**
- General interpretation:
- Lipofuscin will *hyperfluoress* on FAF
- Non-functioning or missing RPE cells will *hypofluoress*
  - ***HYPER***-fluorescence: "sick/dying" RPE
  - ***HYPO***- fluorescence: "Dead" (atrophic) RPE

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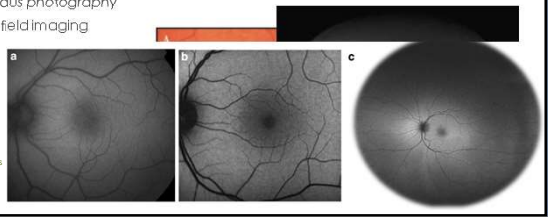
FAF in Clinical Practice

- Confocal scanning laser ophthalmoscopy (cSLO)
- Digital fundus *photography*
- Ultra-widefield imaging



Yung et al. Clinical applications of fundus autofluorescence in retinal disease. Int J Retin Vitr (2016) 2:12.

77

When is FAF useful in a clinical setting?

Tsui I, et al. A practical approach to retinal dystrophies. *Retinal Physician*. 2007. Available at: https://www.retinalphysician.com/issues/2007/april-2007/a-practical-approach-to-retinal-dystrophies

78

FAF: Case Example

- 39 yo AA female
- PMHx: H/o Gestational hypertension
  - BP 120/75 in office
- ROS:
  - Musculoskeletal: Joint and muscle pain constantly
  - Neurological: insomnia
  - Psychiatric: Anxiety
  - Endocrine: Body temp fluctuations
- Never smoker, no meds, social drinker
- Fam hx of glaucoma
- BCVA 20/15 OD, OS
- Normal color vision, entrance testing OU
- IOP 17/17

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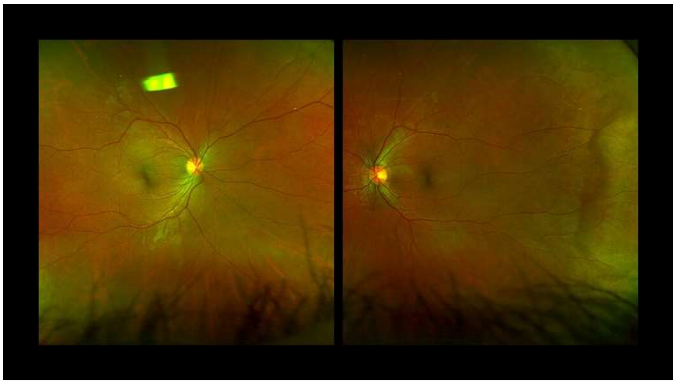

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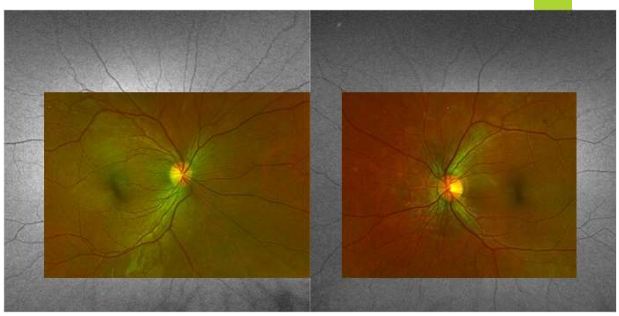

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FAF Case continued

- Diagnosis: Other disorders of optic nerve, NEC, left eye (H47.092)
  - FAF reveals **ring of hyperfluorescence in peripapillary watermark appearance**
  - Pt denies hx of ocular trauma; no current systemic conditions or medications
  - Good vision, color vision OU
- Plan:
  - Educated patient on findings and possible previous ONH edema
  - RTC 2 months medical exam (redcap, Amsler, Baseline ONH OCT and VF
  - Retina consult: **Suspect chronic CSR**; ask about steroids/stress; ONH OCT

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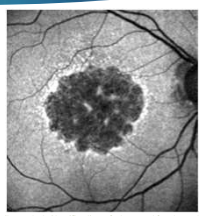
FAF & Age-related Macular Degeneration

- Appearance with FAF
  - Focal hyperfluorescence (drusen)
  - Areas of hypofluorescence (RPE atrophy)
- Geographic atrophy: 10% of all vision loss
- FAF allows for visualization of full extent of the disease
- What about wet AMD?



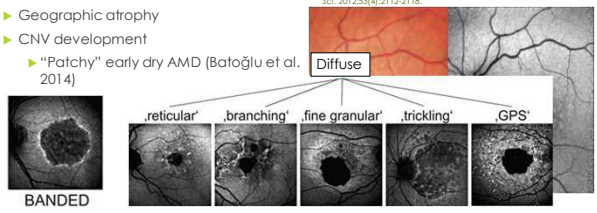
Bindewald A, Schmitz-Valckenberg S, Jorzik JJ, *et al*. Classification of abnormal fundus autofluorescence patterns in the junctional zone of geographic atrophy in patients with age related macular degeneration *British Journal of Ophthalmology* 2005;**89**:874-878.

83

FAF & AMD

- FAF: May allow for **prediction** of disease progression
  - Geographic atrophy
  - CNV development
    - "Patchy" early dry AMD (Batoğlu et al. 2014)

Fritsche LG, Fleckenstein M, Fiebig BS, *et al*. A Subgroup of Age-Related Macular Degeneration is Associated With Mono-Allelic Sequence Variants in the *ABCA4* Gene. *Invest. Ophthalmol. Vis. Sci.* 2012;53(4):2112-2118.



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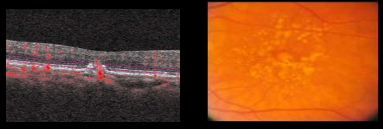
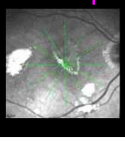
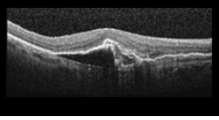
Questions and Answers



pizzimen@uiwtx.edu

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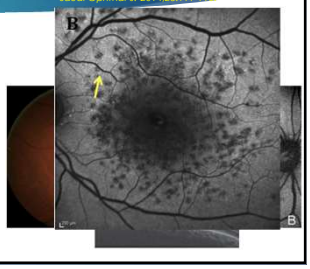
FAF & Diabetic Retinopathy

- Hyperglycemia in diabetes → free radicals → oxidative stress
- Reactive oxygen species (ROS) buildup leads to excess lipofuscin formation
- Calvo-Maroto et al. (2016)
  - Diabetic fundus changes more easily visualized with **FAF** than with **color fundus photography** (MA's, hemes)
- Vujosevic et al. (2011)
  - FAF showed 81% sensitivity in detecting cystoid macular edema (**hyperfluorescence**)

From: Sepah YJ et al. Fundus autofluorescence imaging: Fundamentals and clinical relevance. *Saudi Ophthal J.* 2014;28:111-116



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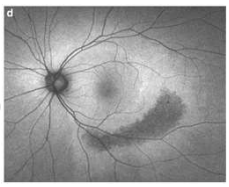
FAF & Hydroxychloroquine Toxicity

- Plaquenil
  - Metabolic damage to outer retina → RPE disruption → "Bull's eye" maculopathy
- FAF
  - Hyperfluorescence (brightness)
    - Inferiortemporal quadrant
  - Parafoveal, pericentral, mixed patterns
  - Hypofluorescence over time (RPE atrophy)
- Early changes are often subtle
  - Correlate with OCT



Elsevier: Ophthalmolog, "Pericentral retinopathy and racial differences in hydroxychloroq uine toxicity," 2015, pp. 110–116, Melles and Marmor, Fig. 1

87

FAF & Hydroxychloroquine Toxicity

- Updated Screening guidelines (2025)
  - Macular OCT
  - Wide-pattern FAF
- Baseline screening exam (DFE, testing) then annually
- Screening must consider both parafoveal and pericentral patterns
- Secondary tests
  - Visual fields (24-2C)
  - Multifocal ERG

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As an aside… 24-2C VF for hydroxychloroquine screening

- "Confirmatory test" rather than primary screening
- White light SITA testing pattern deviation plot
- 24-2C
  - Allows for detection of both parafoveal and pericentral loss
  - **Superonasal** loss most frequent
  - Frequent retesting for reliability

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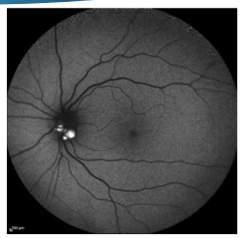
Consider FAF Imaging…

- In the case of unexplained vision loss
- For patients with macular degeneration or other retinal disease
- When patients are taking Plaquenil or other medications with known retinal toxicity
- As a screening tool for all patients!



http://imagebank.asrs.org/file/7389/optic-disc-drusen

90

Conditions in which FAF is useful

- AMD
- CSC (central serous chorioretinopathy)
- Plaquenil toxicity
- Nevi / melanomas, choroidal lesions
- White Dot syndromes
- ONH Drusen
- Inherited macular / retinal dystrophies

91

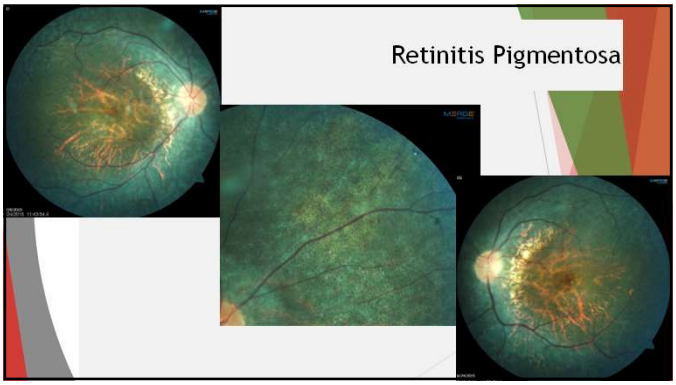
Fundus Flavimaculatus ou + nevus od

92

Fundus Flavimaculatus - FAF

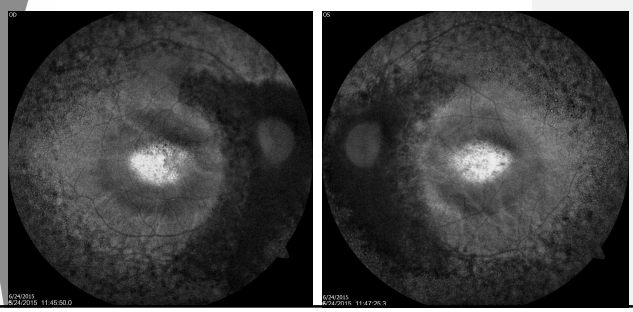
93

Retinitis Pigmentosa



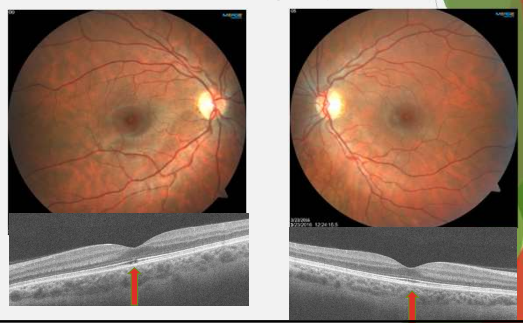
94

RP - FAF



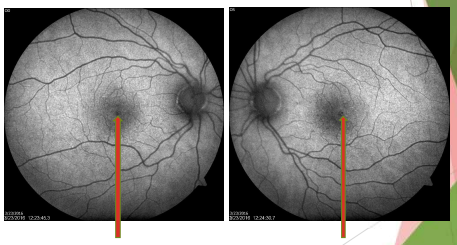
95

Solar Retinopathy



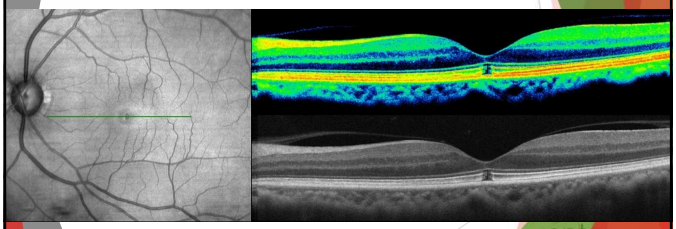
96

Solar Maculopathy



97

Another case of Solar maculopathy



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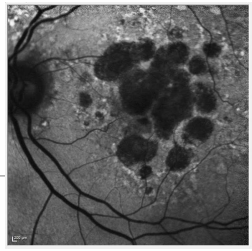
Questions and Answers?

AUDIENCE



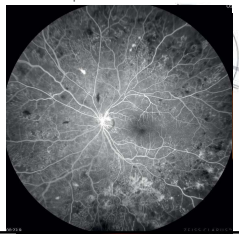
99

Ultra-Widefield (UWF) Imaging

100

Ultra-Widefield Imaging

- Uses confocal scanning laser technology combined with ellipsoid mirror for fundus imaging up to **200°** peripherally
  - **82.5%** of the retina
    - Unless… Gaze steering
  - Dilation not required
  - "True color" now available
- Often has multimodal capabilities
  - FAF
  - OCT
  - Red-free imaging
  - Fluorescein angiography

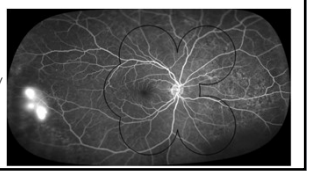


101

Ultra-Widefield Imaging

- "Pros"
  - Great way to document and aid in evaluation of peripheral retinal pathology
  - Look at the "big picture" all at once
  - Filters: FAF, red-free, choroidal visualization
- "Cons"
  - Lid/lash artifact
  - Pseudocoloration, peripheral distortion, low contrast
    - Improved with newer software devices
  - Still not imaging the *entire* retina!

Wessel MM et al. Ultra-Wide-field Angiography improves the detection and classification of diabetic retinopathy. *Retina*. 2012;32(4):785-791.



102

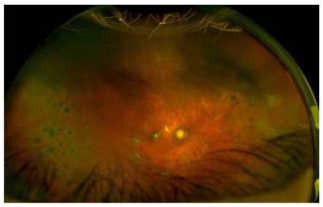
UWF Imaging: Diabetic Retinopathy

- DRCR Retina Network Protocol AA
  - Four-year prospective study
  - *Does evaluating the peripheral retina with UWF imaging improve assessment and prediction of diabetic retinopathy progression?*
    - *UWF photos*
    - *UWF Angiography (UWF-FA)*
  - 41% of eyes had predominantly peripheral lesions
  - 12.5% had increase in DR severity grading

https://retinatoday.com/articles/2019-sept/how-protocol-aa-fits-into-evolution-of-the-diabetic-retinopathy-severity-scale#:~:text=The%20DRCR%20Retina%20Network%20Protocol,on%20UWF%20images%20at%20baseline.

103

Patient with diabetes… deferred dilation



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UWF Imaging: A dilation substitute?

- Not quite…
- Dilation: essential for stereoscopic evaluation of the entire fundus
  - Required for all new patients
  - Malpractice considerations
- UWF imaging
  - Great supplement to dilation or "in between" dilated visits
- It's all in the presentation
  - Give the patient the "full story"

Consensus-Based Action Statement (AOA):

Pharmacologic dilation of the pupil is generally required for thorough stereoscopic evaluation of the ocular media, retinal vasculature, macula, optic nerve, and the peripheral retina.

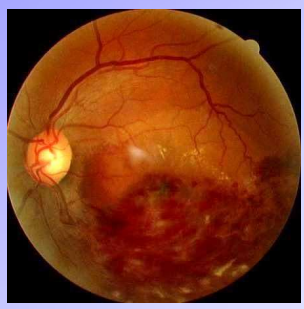
105

Other Wide Field and Enhanced Depth Imaging OCT

Confocal Scanning Devices
- Optic nerve
- Posterior Pole
- Wide field
- Microperimetry
- Multispectral Imaging
- Multicolor Imaging
- Near IR Imaging
- Wide field OCT
- Enhanced Depth Imaging OCT
- En face OCT

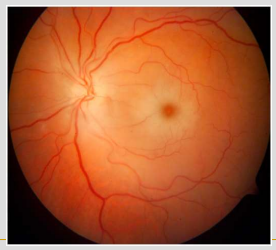
106

Questions and Answers



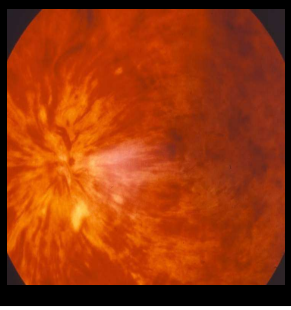
107

Case Studies:
Retinal Vascular Occlusion



108

CRVO, non-perfused (ischemic)



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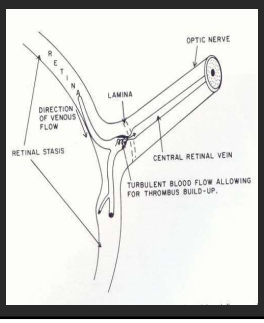
CRVO Anatomy



110

69 year old Caucasian Female

CC: Reduced central vision OD x 3 weeks @ distance and near

Ocular History: Unremarkable

Systemic History: Unremarkable ; Last PCP exam 15 years ago

Social History: Smokes ½ pack of cigarettes a day
Alcohol 5-6 drinks a day

Meds: Multivitamin

Allergies: +Penicillin

VA: s Rx 20/80 OD 20/20 OS

EOM: Smooth / Full

Pupils: PERRLA - APD

CF: Central blur OD Full Periphery OU

SLE: Unremarkable OU

TA: 20 mm Hg OU

Vitreous: PVD OU

BP: 168 / 98 RAS

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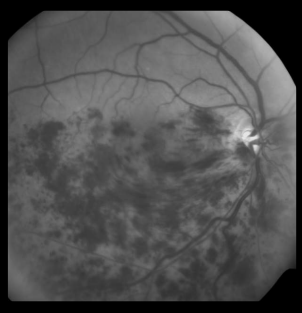
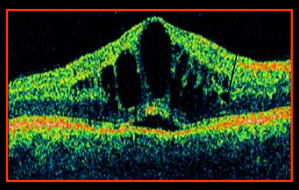


113

OCT Shows Cystoid Macular Edema, Sub-retinal fluid



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What is your assessment?

115

Hemi-central Retinal Vein Occlusion,
perfused (aka non-ischemic)
w/ME

What is your plan?

116

Follow w/o treatment or co-manage with retina?

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Hemi-central Retinal Vein Occlusion

- Uncommon type of hemispheric RVO
  - Occurs in "Dual Trunk" anomaly
- Same pathophysiology as CRVO.
- May affect either the superior or inferior CRV before they unite into common central retinal vein.
- Usually occurs at or near the optic disc.

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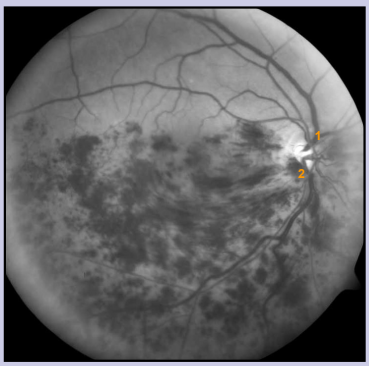
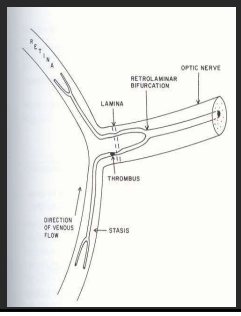
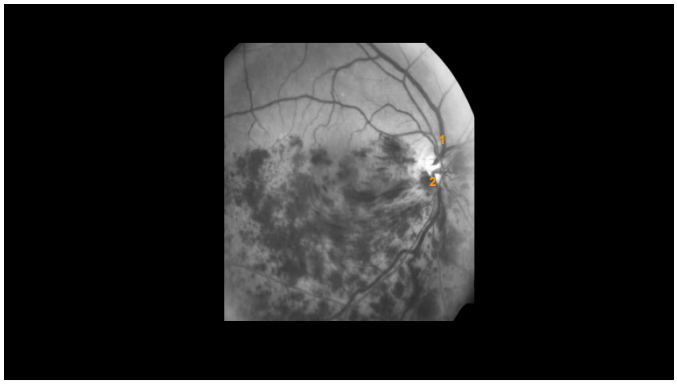


119

Anatomy of HCRVO



120



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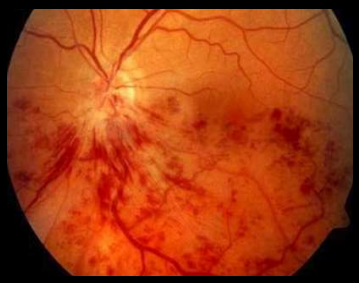
Hayreh's 6 Types of RVO

- Central retinal vein occlusion (CRVO)
  - Non-ischemic CRVO
  - Ischemic CRVO
- Hemi-central retinal vein occlusion (HCRVO)
  - Non-ischemic HCRVO
  - Ischemic
- Branch retinal vein occlusion (BRVO)
  - Major BRVO
  - Macular BRVO

122

Hemi-Central Retinal Vein Occlusion



123

Fluorescein Angiography HCRVO

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CRVO: Classification

Nonischemic	Ischemic
< 10DAs of NP via FA	~50% of all CRVOs
VA better than 20/200	≥10DAs of NP via FA
Usually no APD present	VA worse than 20/200
Limited hemes in all quadrants	Prominent APD
Limited VF defects	Severe hemorrhaging and CWSs in all quadrants ("blood and thunder")
<5% incidence of ant seg neo	Significant VF defects
	Abnormal ERG
	50-60% incidence of ant seg neo (most develop within 3-5 mo)!!!

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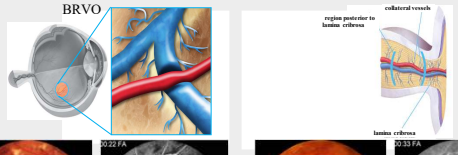
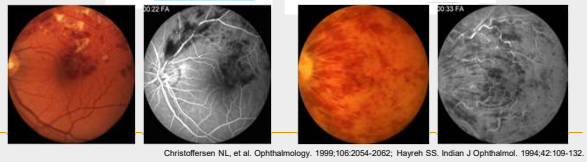
Pathophysiology of BRVO and CRVO

(Branch) BRVO

(Central) CRVO





Christoffersen NL, et al. Ophthalmology. 1999;106:2054-2062; Hayreh SS. Indian J Ophthalmol. 1994;42:109-132.

126

Pathogenesis of RVOs

- All types of RVO are *multifactorial in origin* and usually no single factor on its own causes the occlusion.
- Each patient with RVO may have a unique combination of systemic and local factors which finally produce an episode.
- CRVO and HCRVO pathogenically are very different from BRVO.
- Therefore, it is a mistake to try to explain all types of RVO by one common pathogenetic mechanism.

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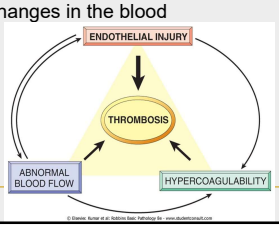
Thrombotic CRVO and HCRVO

- Virchow's triad for thrombus formation:
  - (i) slowing of blood stream
  - (ii) changes in vessel wall
  - (iii) changes in the blood



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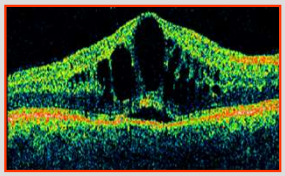
Treatment Options for ME in RVO



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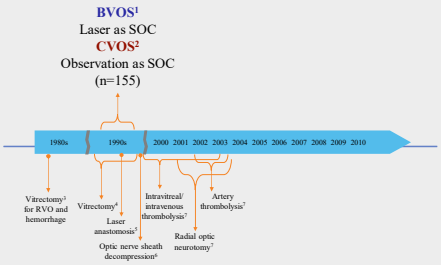
Interventions in Retinal Vein Occlusion,1980-2005



SOC = standard of care.

1. Branch Vein Occlusion Study Group. *Am J Ophthalmol*. 1984;98:271-282; 2. Central Vein Occlusion Study Group M. *Ophthalmology*. 1995;102:1425-1433; 3. Yeshaya A, et al. *Ann Ophthalmol*. 1983;15:615-617; 4. Amirikia A, et al. *Ophthalmology*. 2001;108:372-376; 5. McAllister IL, et al. *Arch Ophthalmol*. 1995;113:456-462; 6. Dev S, et al. *Ophthalmic Surg Lasers*. 1999;30:181-184; 7. Shahid H, et al. *Br J Opthalmol*. 2006;90:627-639.

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Fast Forward

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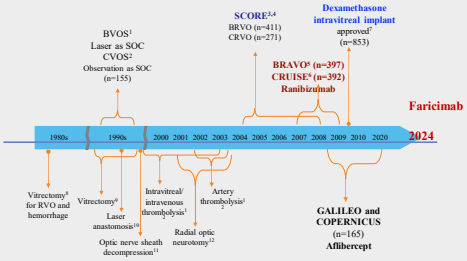
Interventions in Retinal Vein Occlusion, 2005-Present



1. Branch Vein Occlusion Study Group. *Am J Ophthalmol*. 1984;98:271-282; 2. Central Vein Occlusion Study Group M. *Ophthalmology*. 1995;102:1425-1433; 3. Ip MS, et al. *Arch Ophthalmol*. 2009;127:1101-1114; 4. Scott IU, et al. *Arch Ophthalmol*. 2009;127:1115-1128; 5. Campochiaro PA, et al. Ophthalmology. 2010;117:1102-1112.e1; 6. Brown DM, et al. *Ophthalmology*. 2010;117:1124-1133.e1; 7. Haller JA et al. *Ophthalmology*. 2010;117:1134-1146.e3; 8. Yeshaya A, et al. *Ann Ophthalmol*. 1983;15:615-617; 9. Amirikia A, et al. *Ophthalmology*. 2001;108:372-376; 10. McAllister IL, et al. *Arch Ophthalmol*. 1995;113:456-462; 11. Dev S, et al. *Ophthalmic Surg Lasers*. 1999;30:181-184; 12. Shahid H, et al. *Br J Opthalmol*. 2006;90:627-639.

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RVO Summary

	Non-ischemic CRVO	Ischemic CRVO
Visual acuity	>20/200	<20/200
RAPD (relative afferent papillary defect)	Mild or absent	present (>0.7 log units of neutral density filter)
Visual field defect	rare	common (use of Goldmann perimeter is suggested, as 30 degree field misses peripheral changes)
Fundus appearance	less disc/macular edema, hemorrhage, cotton-wool spot mild venous tortuosity and dilation	More disc/macular edema, hemorrhage, cotton-wool spot Severe venous tortuosity and dilation
Fundus fluorescein angiogram	less area of nonperfusion	retinal capillary nonperfusion more than 10 disc areas
ERG/electroretinogram	normal	Reduced b wave amplitude (≤60% of the normal mean value of both photopic and scotopic ERG), and reduced b/a
Prognosis	good, less chance of anterior segment neovascularization/neovascular glaucoma	Poor, high chance of anterior segment neovascularization/neovascular glaucoma The visual prognosis may be worse than central retinal arterial occlusion

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CRVO: Key Points

- A non-ischemic (perfused) CRVO can progress to an ischemic CRVO.
- When neovascularization develops in ischemic CRVO, it most often occurs in the anterior segment.
- 2/3 of patients with non-ischemic CRVO will recover to VA of 20/40 or better without any treatment.
- Up to 45% of eyes with ischemic CRVO develop neovascular glaucoma (NVG).**

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Co-manage RVO with:

Retina (non-perfused, or ME, or NV)

Internal Medicine/Cardiology

PCP

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Conclusions

- Multimodal imaging technologies have enhanced our ability to visualize tissue microstructure, as well as assess risk for and detect early signs of disease.
- In addition to their diagnostic value, MMI methods enable clinicians to more accurately monitor patients for disease progression vs stability.

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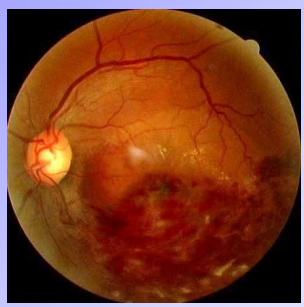
Questions and Answers



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Thank you!

"Doctor and physician are outdated terms. I'm your biological tech support specialist."

hammcm@umsl.edu
pizzimen@uiwtx.edu

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