

Optometric
Education
Consultants

OCT and OCT Angiography Something Old and Something New Retina Pearls

Greg Caldwell, OD, FAAO

Nashville – Music City Fall Classic 2022
Optometric Education Consultants

Saturday, October 22, 2022



Disclosures- Greg Caldwell, OD, FAAO

All relevant relationships have been mitigated

- The content of this activity was prepared independently by me - Dr. Caldwell
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Resource: OCT Community for OCT and OCT-A

The banner features a dark blue background with a subtle pattern of light blue lines and dots, resembling a circuit or network. Two stylized eyes, composed of concentric circles and lines, are positioned on the left and right sides. The text "OCT CONNECT" is centered in a large, white, sans-serif font. Below it, the text "Post your questions & cases so we can #OCTConnect!" is written in a smaller, white, sans-serif font. In the bottom left corner, there is a white Facebook logo icon followed by the text "Join this group to become part of our OCT Connect Family!" in a white, sans-serif font.

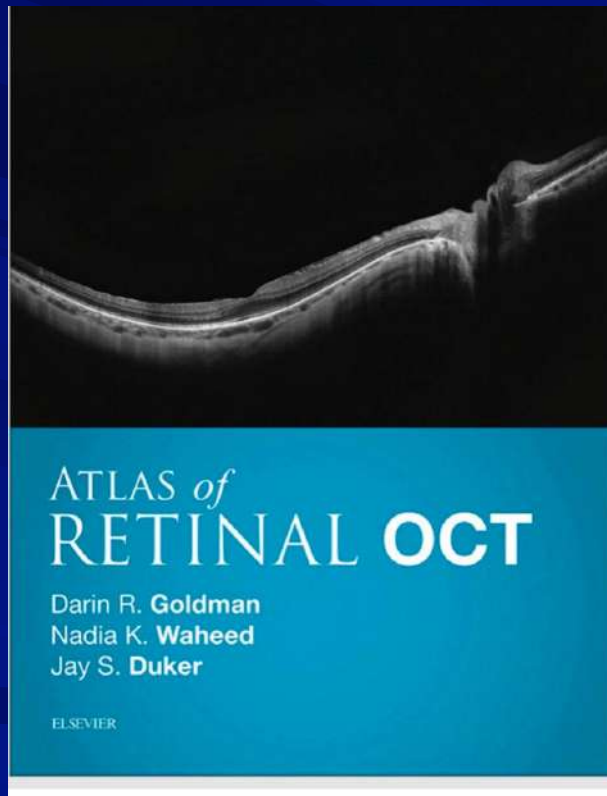
OCT CONNECT

Post your questions & cases so we can #OCTConnect!



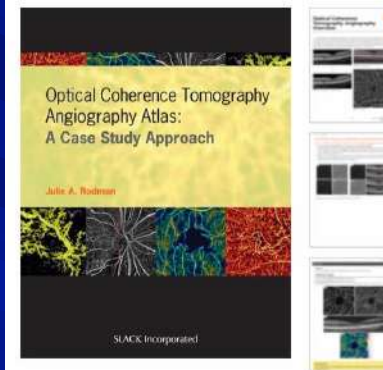
Join this group to become part of our
OCT Connect Family!

Book Resources



Optical Coherence Tomography Angiography Atlas: A Case Study Approach

Julie A Rodman, OD MSc FAAO



\$149.95

ISBN 10 1-63091-641-2

ISBN 13 978-1-63091-641-1

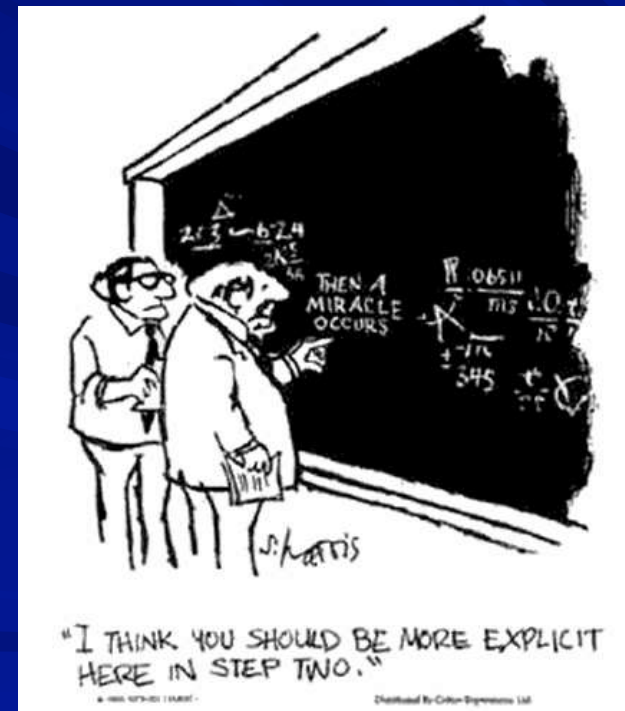
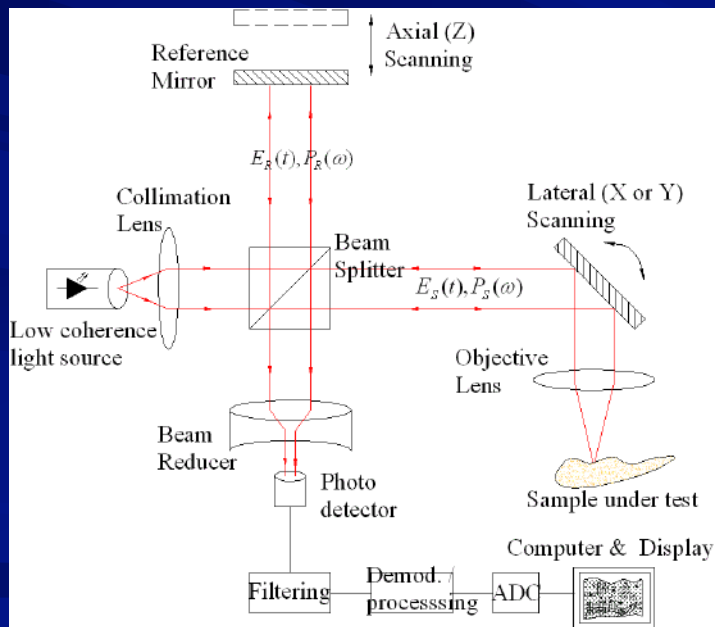
200 pp Hard Cover

Pub. Date: 2019

Order# 66411

Optical Coherence Tomography

Course Design



OCT and OCT Angiography

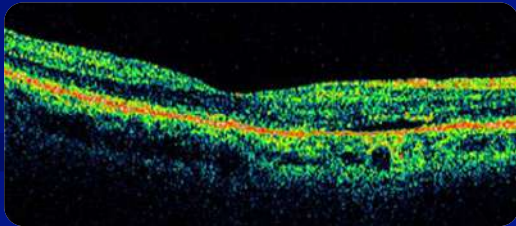
Both are Becoming Equally Important in
Diagnosis, Management, and Treatment

Optical Coherence Tomography

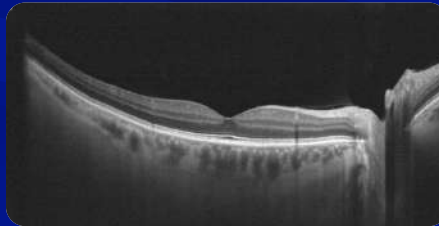
- ✧ OCT is an optical signal acquisition and processing method
- ✧ Time domain OCT
 - ★ 15-16 microns of resolution
 - ★ Stratus (Zeiss)
- ✧ Spectral domain (SD-OCT) or Fourier domain OCT
 - ★ Spatially encoded frequency domain OCT (SEFD-OCT)
 - ★ 5-6 microns of resolution
 - ☐ Able to see photoreceptor morphology (inner/outer segments)
 - ★ 50 times faster than time domain
- ✧ Swept source OCT
 - ★ Time encoded frequency domain OCT
 - ★ 1 micron of resolution
- ✧ Future of OCT- intraoperative imaging, blood flow and oxygenation measurements
- ✧ May have the possibility to assess retinal pathology like a pathologist

OCT Angiography: the Next Chapter in Posterior Imaging

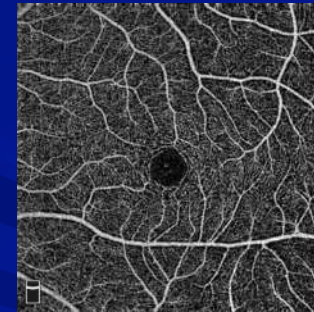
- Images retinal microvasculature without dye injection
- Displays structure and function from a single imaging system



2002: Time Domain OCT

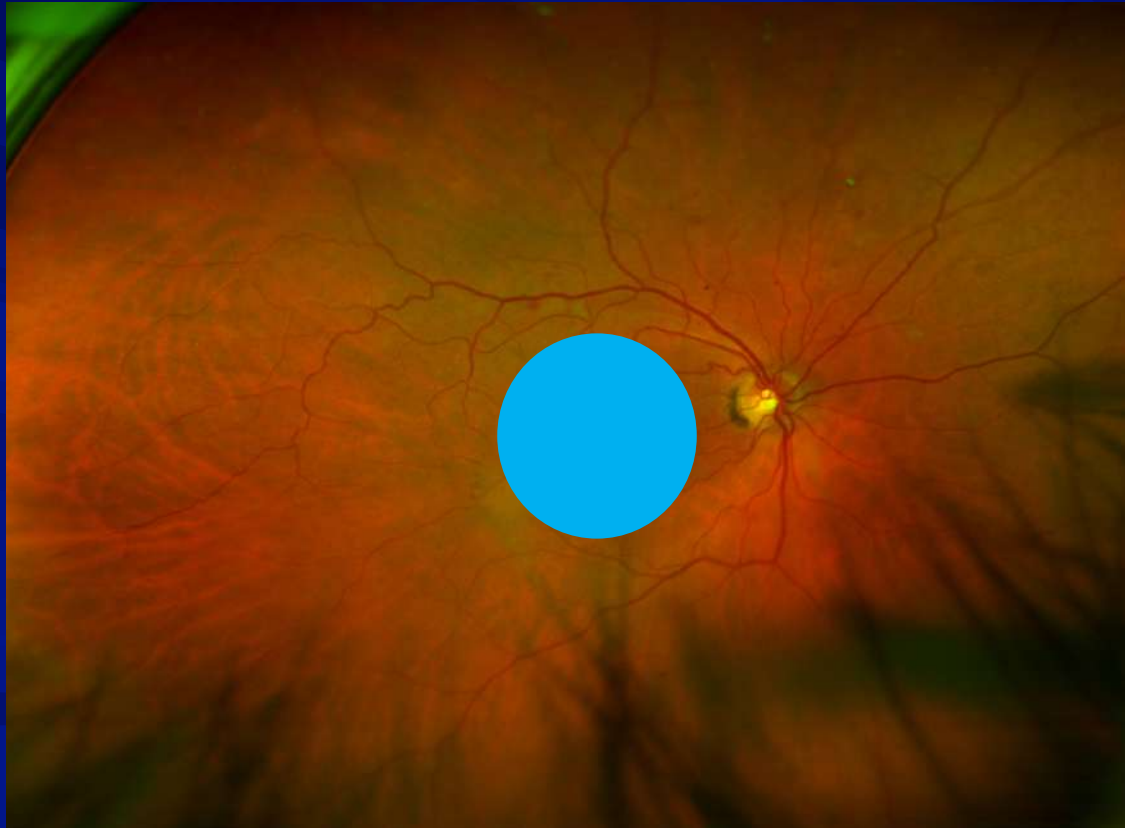


**2006: Spectral Domain
OCT**

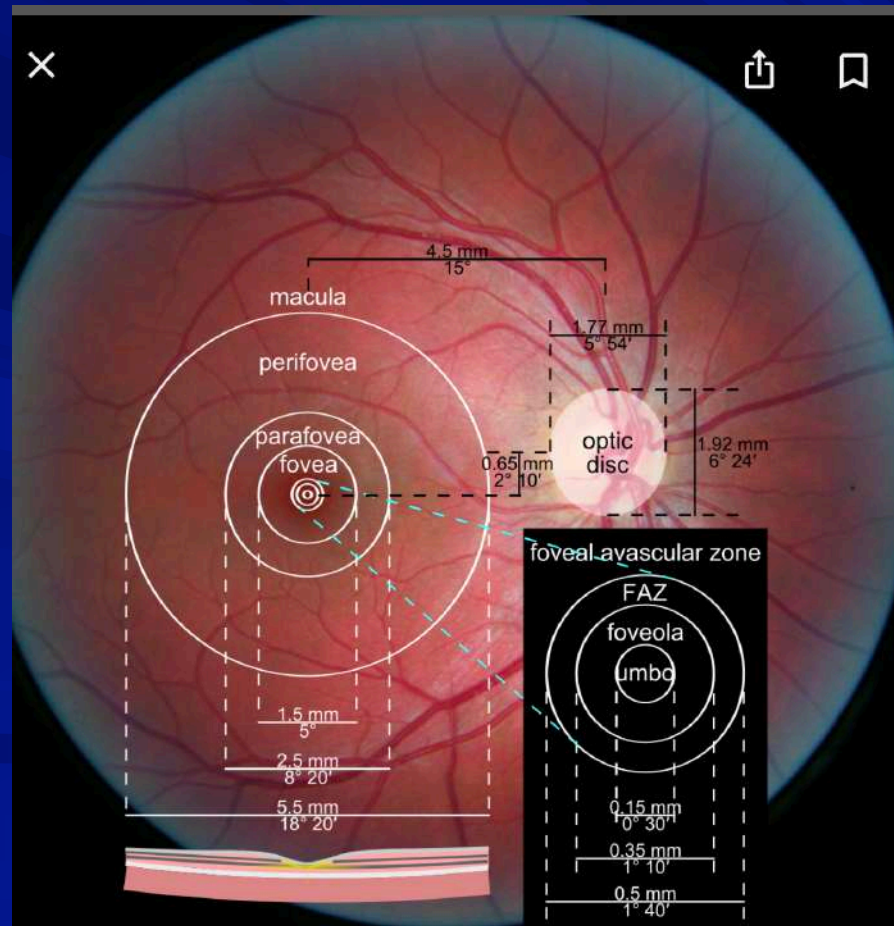


2014: OCTA

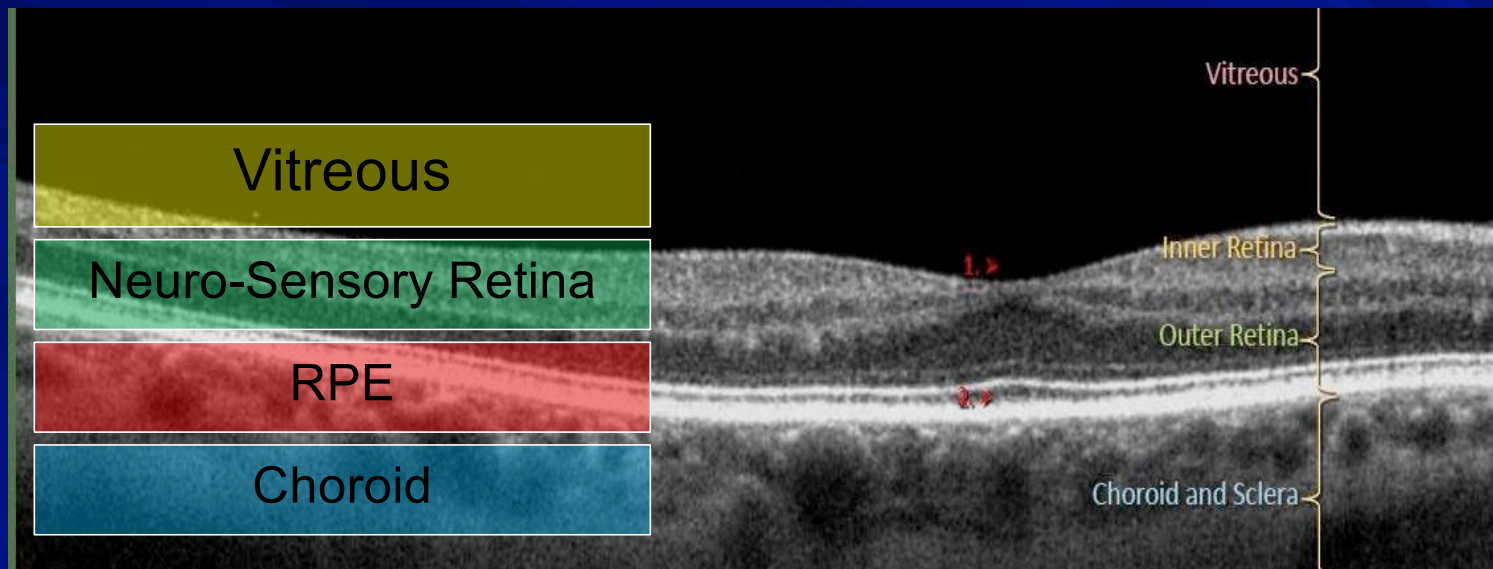
Where is the macula?

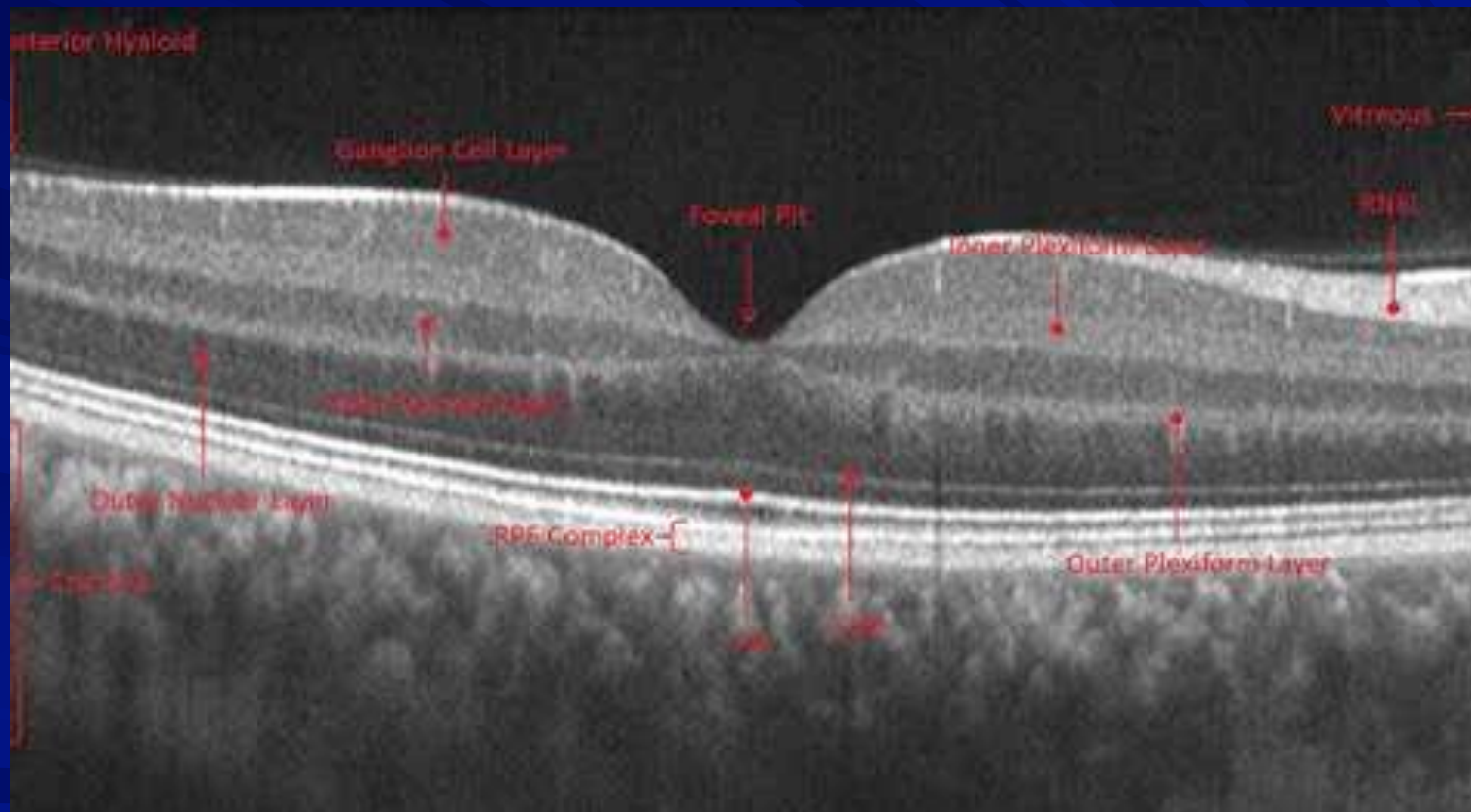


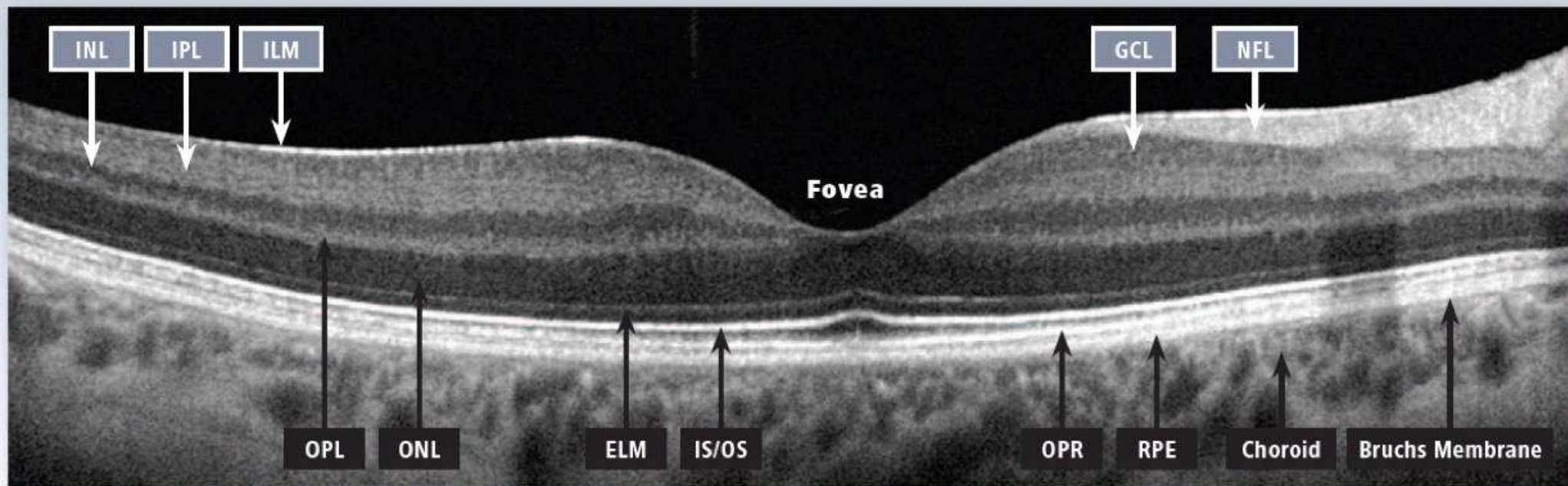
How large is the macula?



4 Basic Categories: Diseases of the....







ILM: Inner limiting membrane
 IPL: Inner plexiform layer
 INL: Inner nuclear layer
 OPL: Outer plexiform layer
 ONL: Outer nuclear layer

ELM: External limiting membrane
 IS/OS: Junction of inner and outer
 photoreceptor segments
 OPR: Outer segment PR/RPE complex

NFL: Nerve fiber layer
 GCL: Ganglion cell layer
 RPE: Retinal pigment epithelium
 + Bruch's Membrane

Thank You- Jian Zhou, MD



OCT Connect

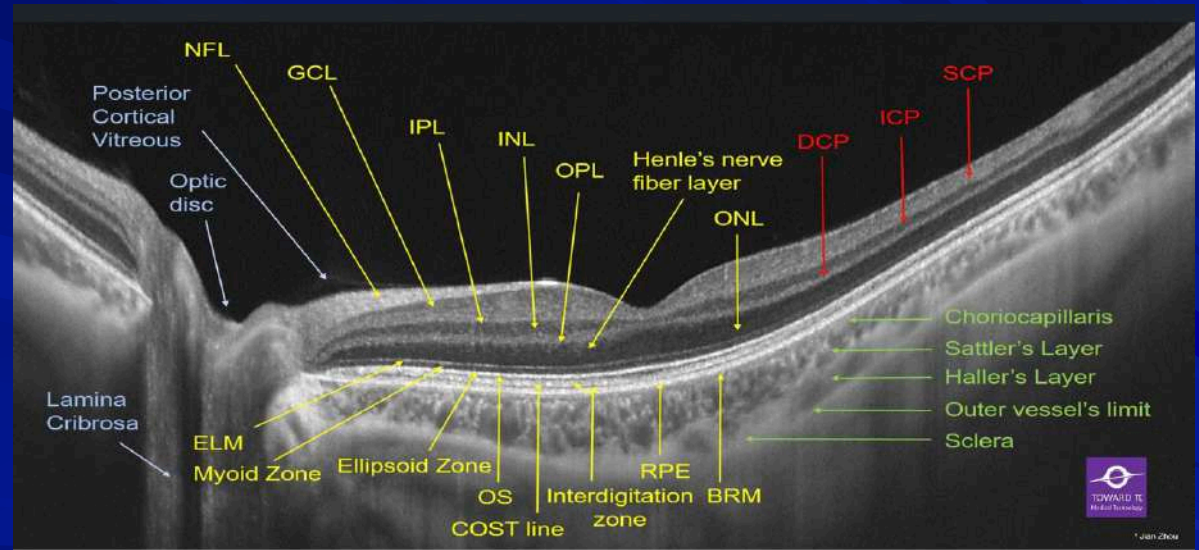
Jian Zhou · Jan 21 ·

OCT Diagram of retina (choroid), and enhanced vitreous, marked by myself. Ratio in 9:20 in case needed for phone wallpaper.

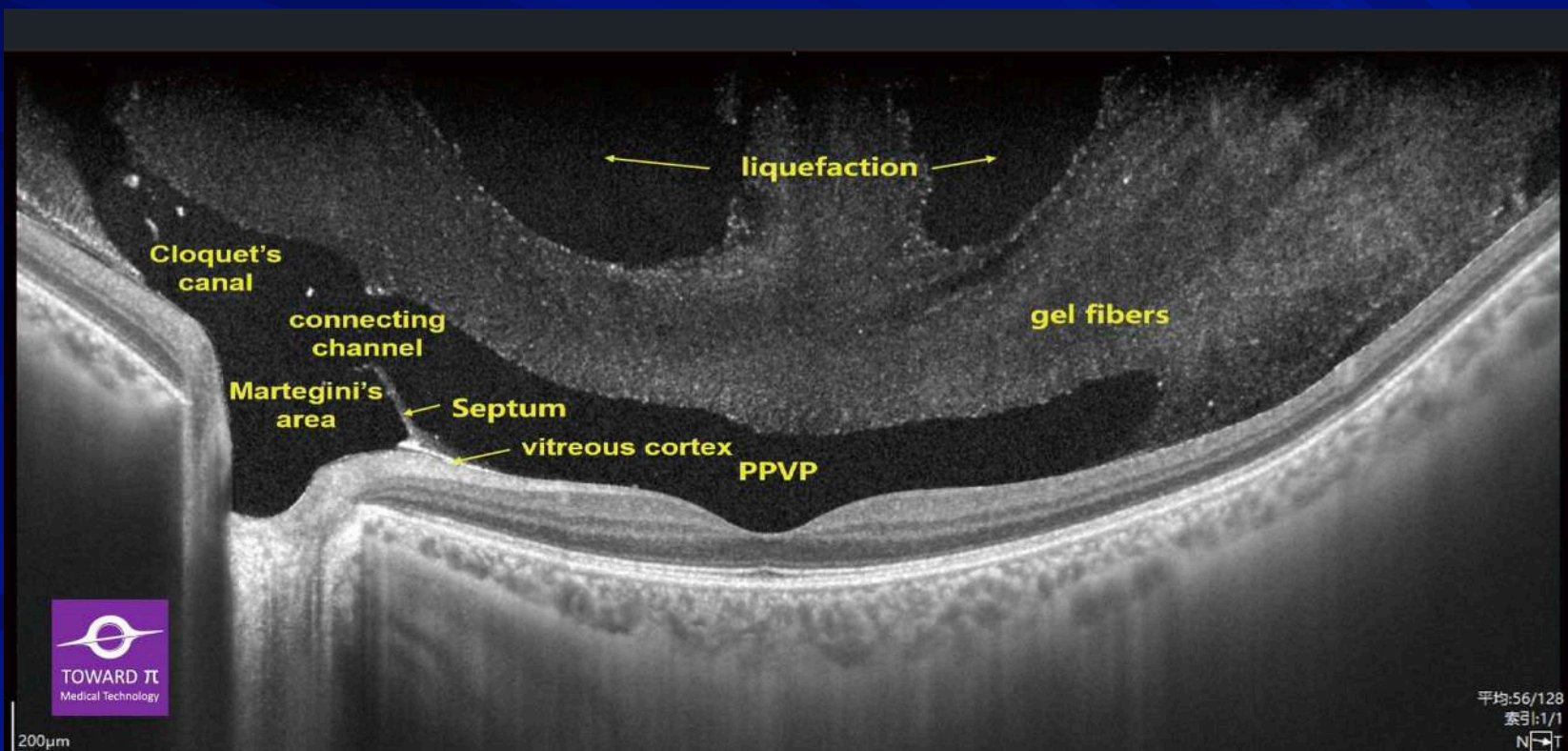
Abbreviation dictionary as below:

NFL= nerve fiber layer
GCL= ganglion cell layer
IPL= inner plexiform layer
INL= inner nuclear layer
OPL= outer plexiform layer
ONL= outer nuclear layer
ELM= external limiting membrane
OS= outer segment line
COST= cone outer segment tip
RPE= retinal pigment epithelium
BRM= Bruch's membrane
SCP= superficial capillary plexus
ICP= intermediate capillary plexus
DCP= deep capillary plexus

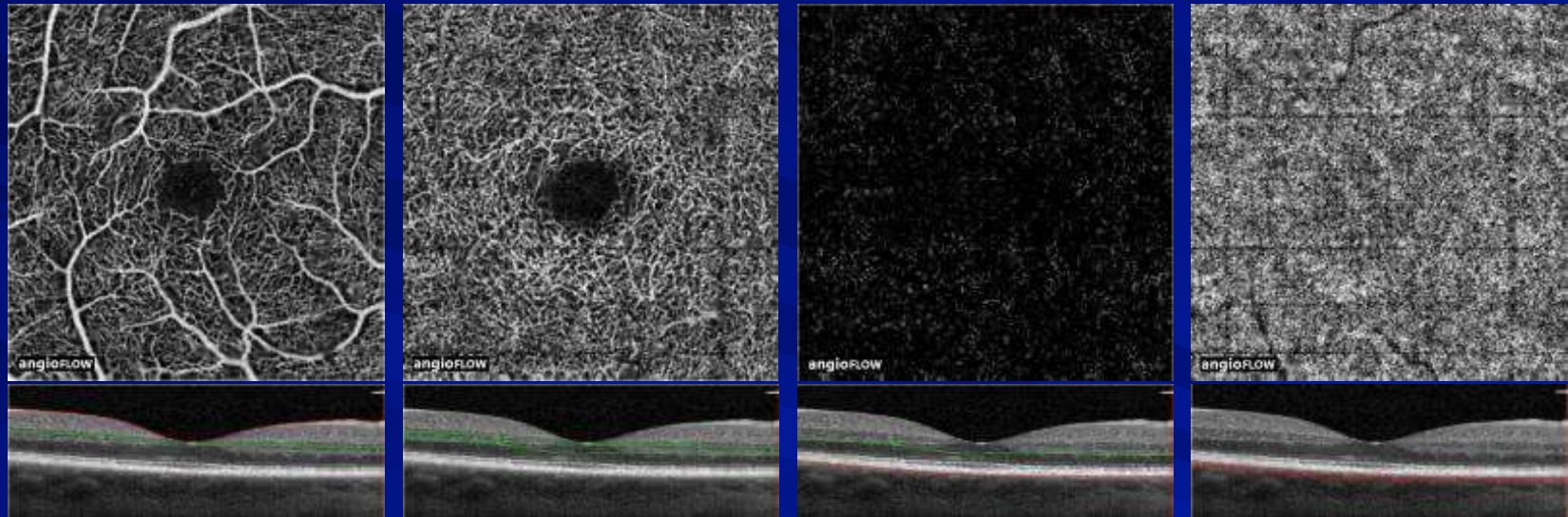
Author: Jian Zhou, MD. (Toward Pi)
[#OCT](#) [#SSOCT](#) [#Bscan](#)



Thank You- Jian Zhou, MD



Normal Retinal Vasculature



Superficial Capillary Plexus

3 μ m Below ILM \rightarrow 15 μ m
Below IPL

Deep Capillary Plexus

15 μ m Below ILM \rightarrow 70 μ m
Below IPL

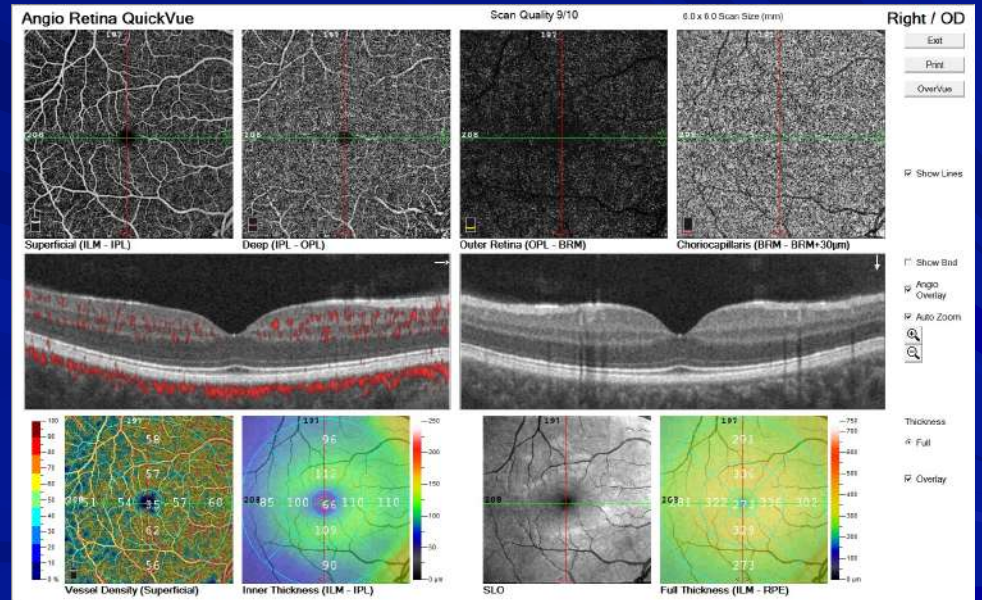
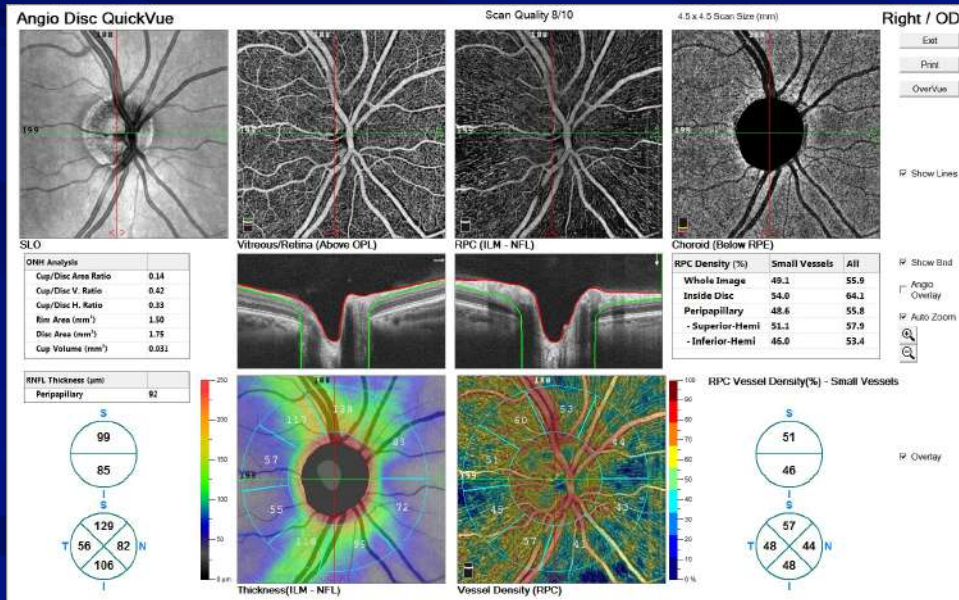
Outer Retina

70 μ m Below IPL \rightarrow 30 μ m
Below RPE Reference

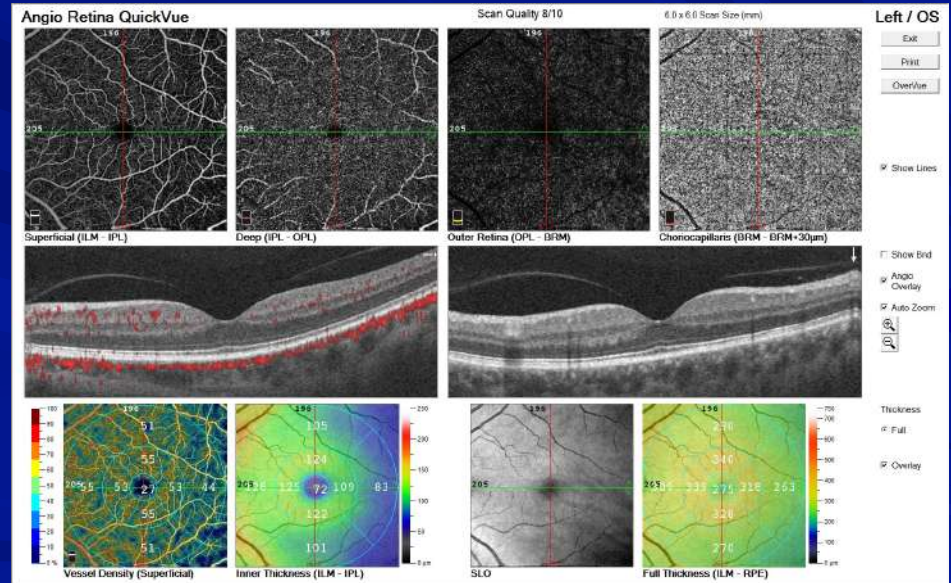
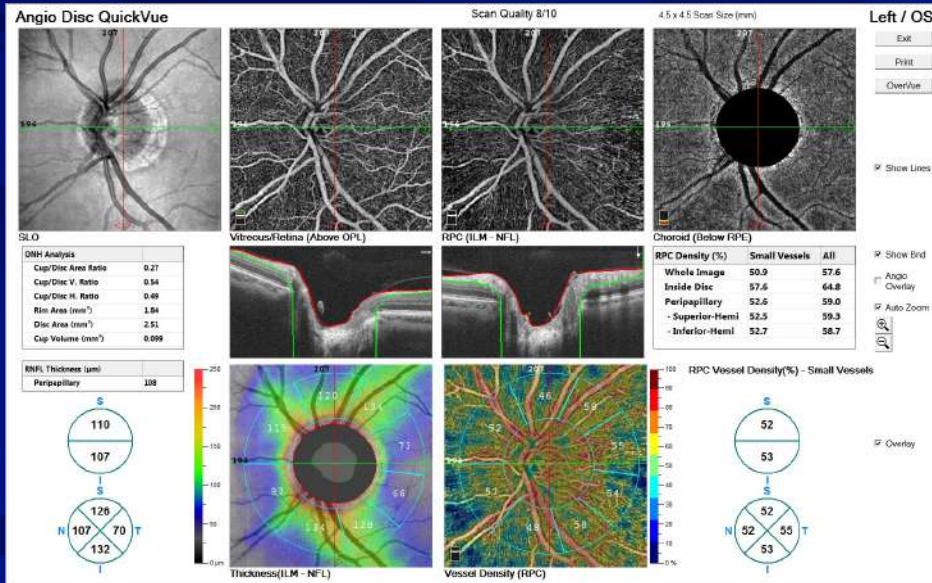
Choriocapillaris

30 μ m Below RPE Reference \rightarrow 60 μ m
Below RPE Reference

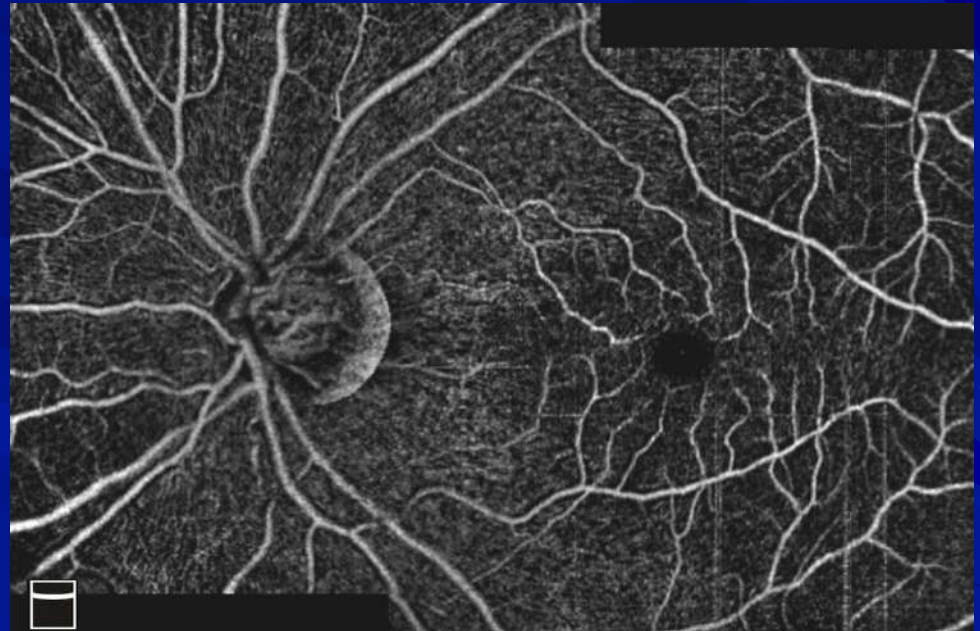
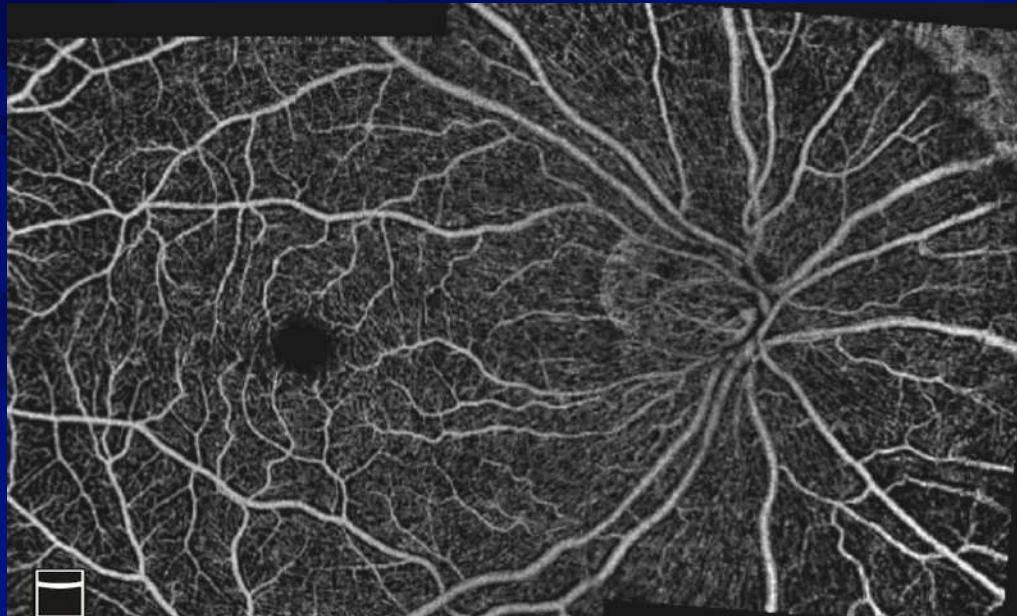
Review of Normal 25 year old man

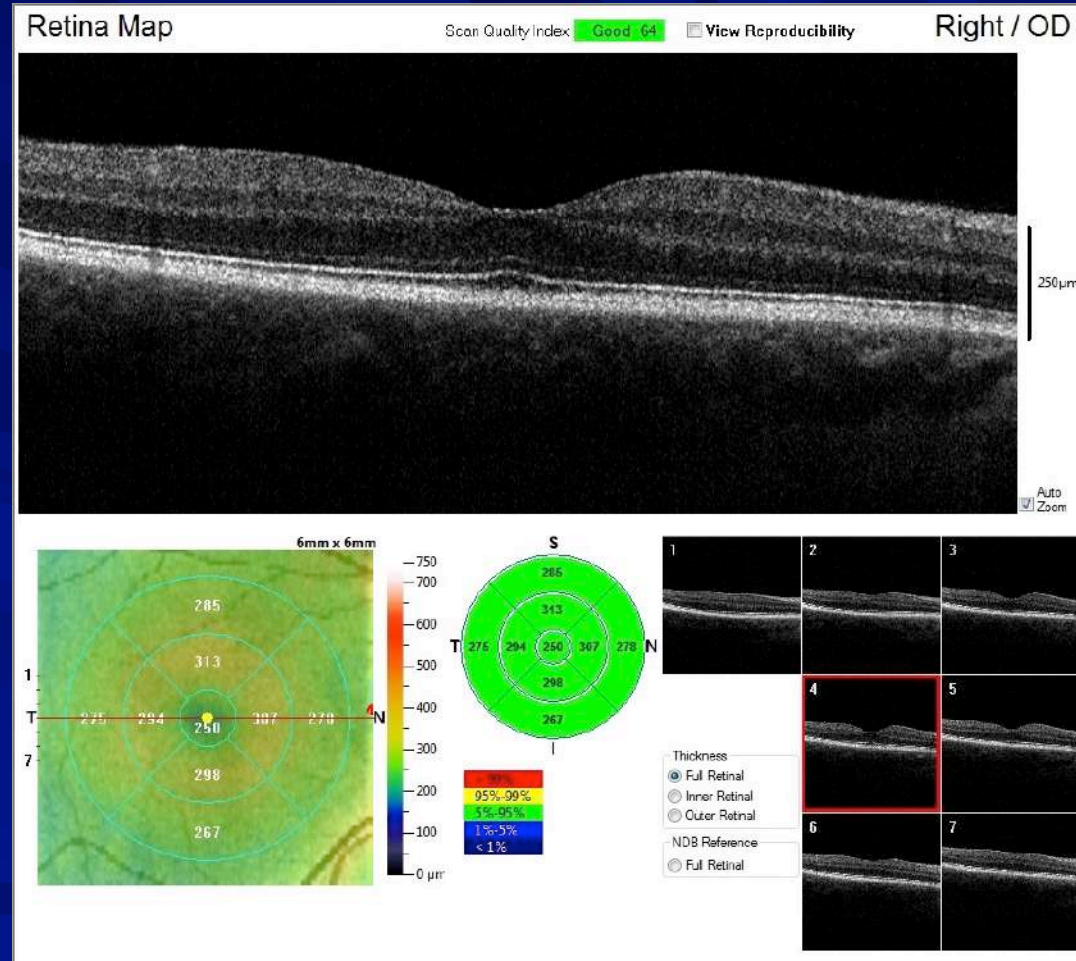


Review of Normal 60 year old man



60 Year Old Montage OU





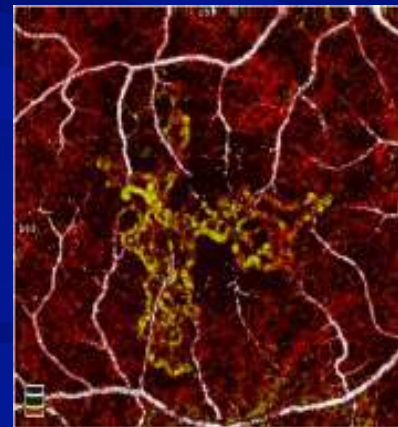
Learn to predict visual acuities

OCT Angiography A New Approach to Protecting Vision

- ▶ Non-invasive visualization of individual layers of retinal vasculature
- ▶ Pathology not obscured by fluorescein staining or pooling
- ▶ Image acquisition requires less time than a dye-based procedure
- ▶ Reduced patient burden allows more frequent imaging to better follow disease progression and treatment response

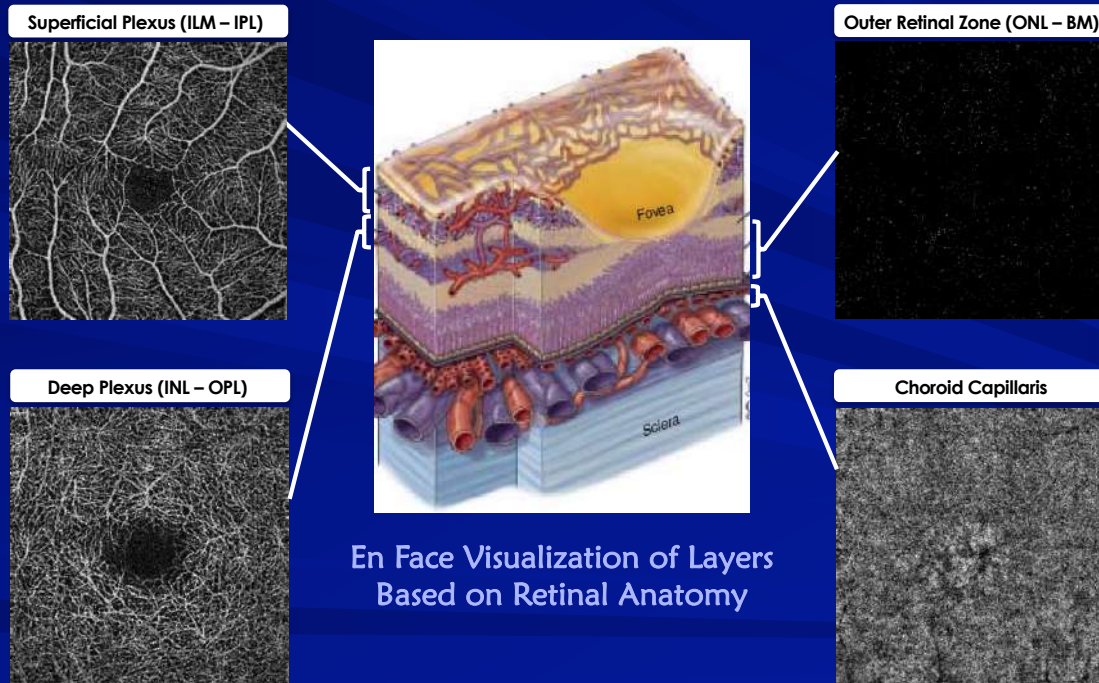


FA of CNV

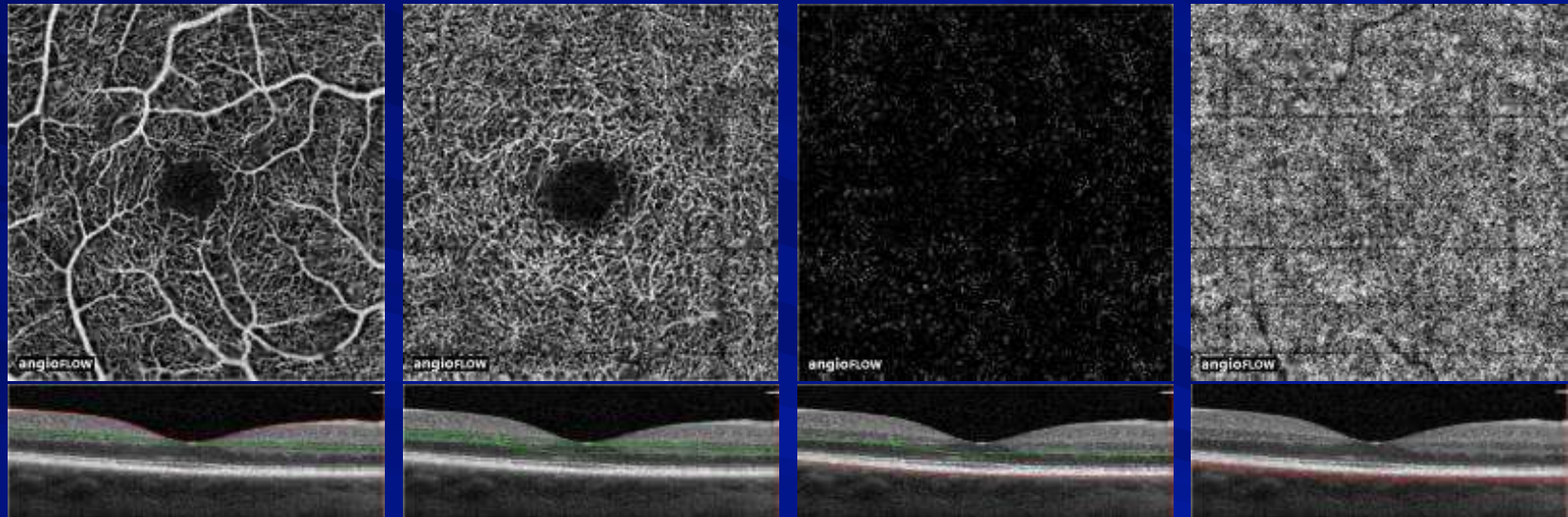


OCTA of CNV

Enface OCT-A Slabs Based on Retinal Anatomy



Normal Retinal Vasculature



Superficial Capillary Plexus

3 μ m Below ILM \rightarrow 15 μ m
Below IPL

Deep Capillary Plexus

15 μ m Below ILM \rightarrow 70 μ m
Below IPL

Outer Retina

70 μ m Below IPL \rightarrow 30 μ m
Below RPE Reference

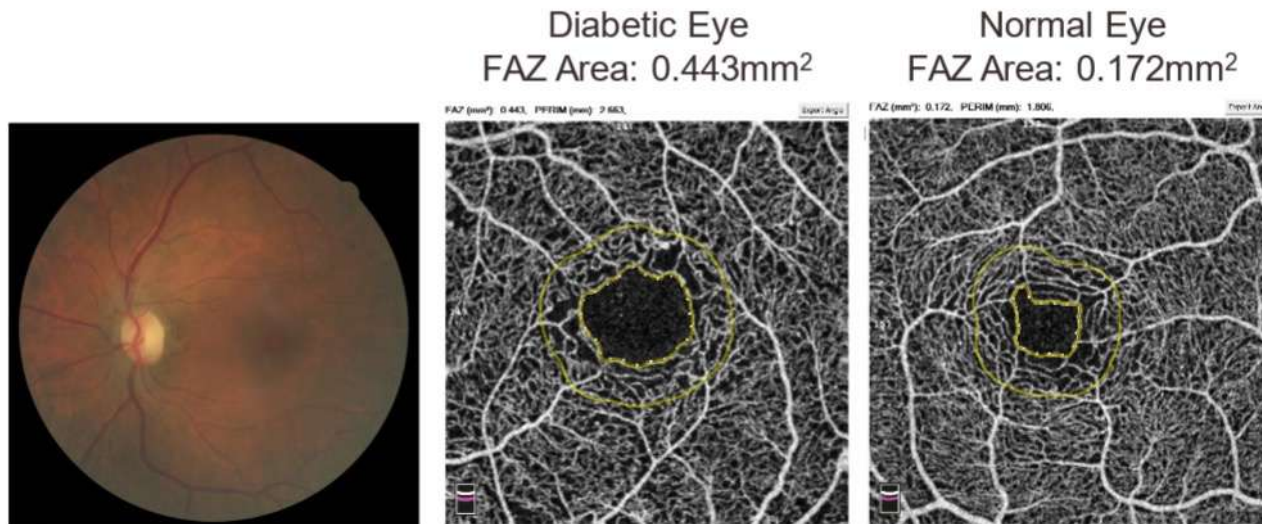
Choriocapillaris

30 μ m Below RPE Reference \rightarrow 60 μ m
Below RPE Reference

Diabetes

Identify Early Vascular Changes in Diabetic Eyes

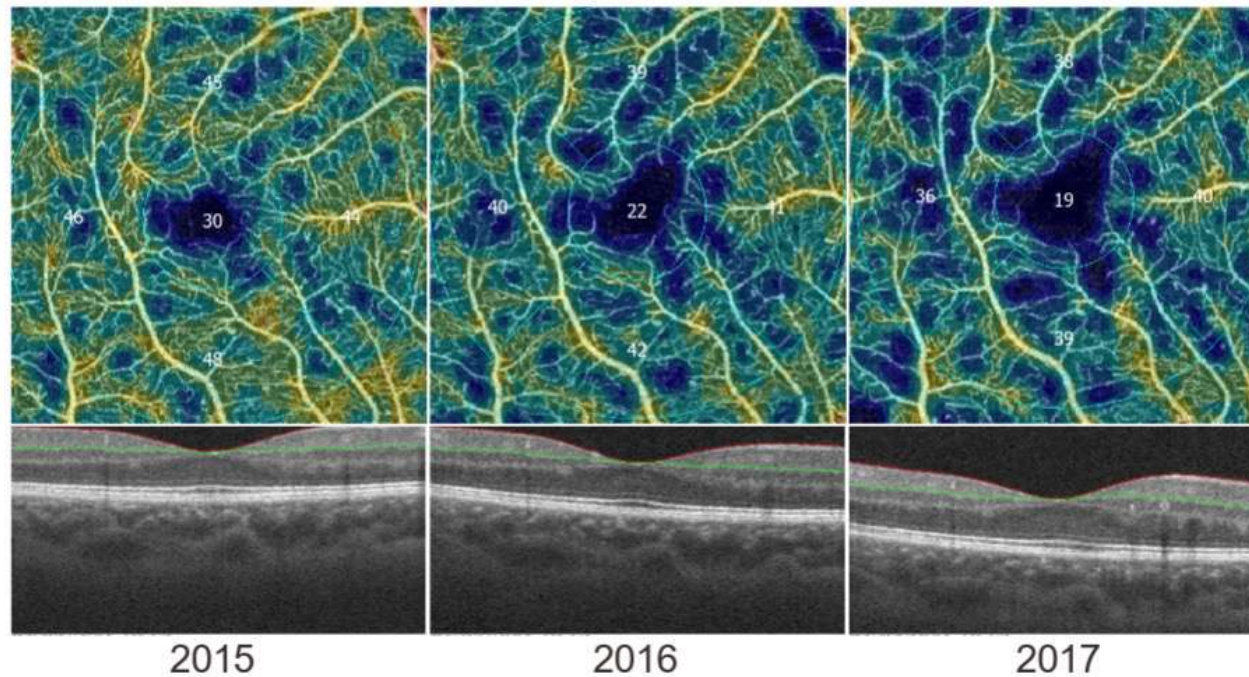
Patients with DM have a larger FAZ than healthy eyes.³



3. Di, G., Weihong, Y., Xiao, Z. et al. Graefes Arch Clin Exp Ophthalmology (2016) 254: 873. <https://doi.org/10.1007/s00417-015-3143-7>
Images courtesy of Julie Rodman, OD, FAAO

Assess Disease Progression with Multiscan View

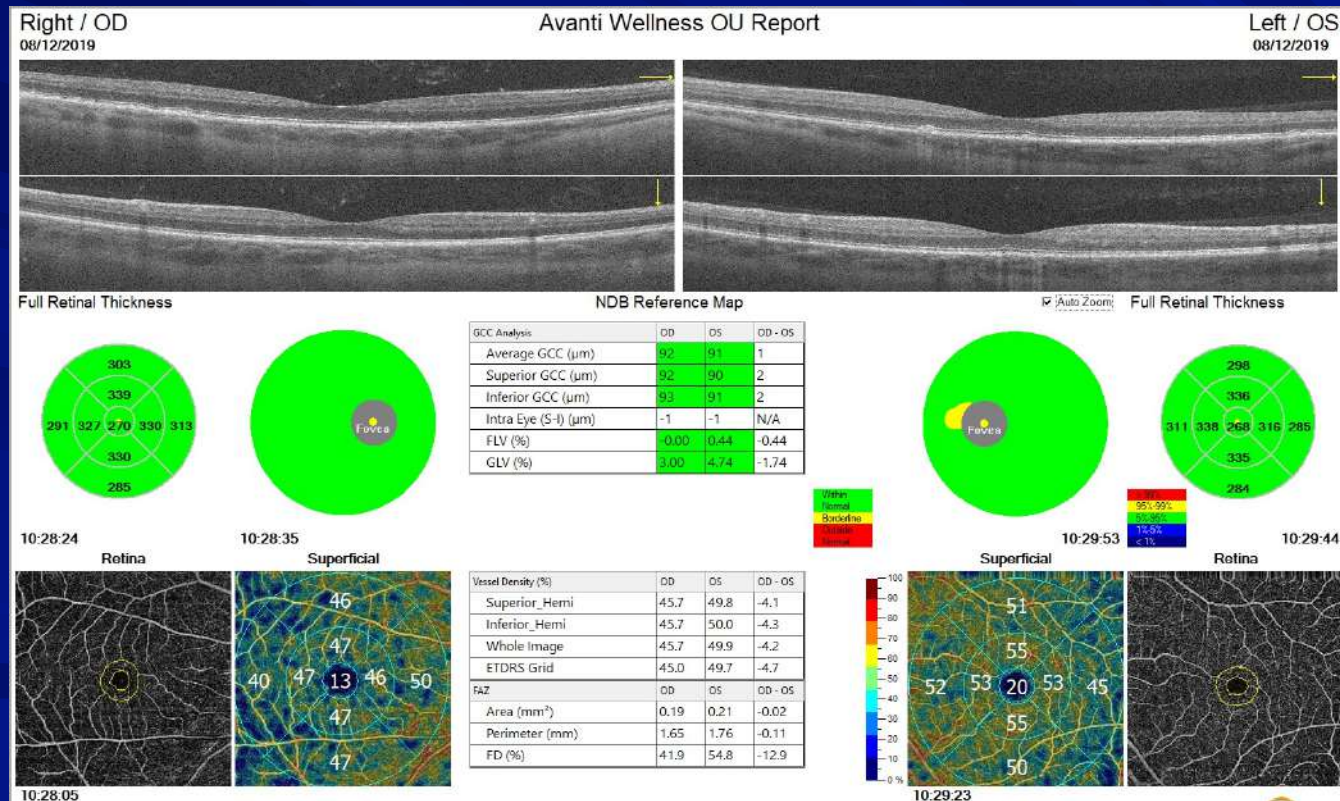
Vessel Density Decreases Significantly with Disease Severity⁴



4. Nesper PL, Roberts PK, Onishi AC, et al. Quantifying Microvascular Abnormalities With Increasing Severity of Diabetic Retinopathy Using Optical Coherence Tomography Angiography. *Investigative Ophthalmology & Visual Science*. 2017;58(6):BIO307-BIO315. doi:10.1167/iov.17-21787.

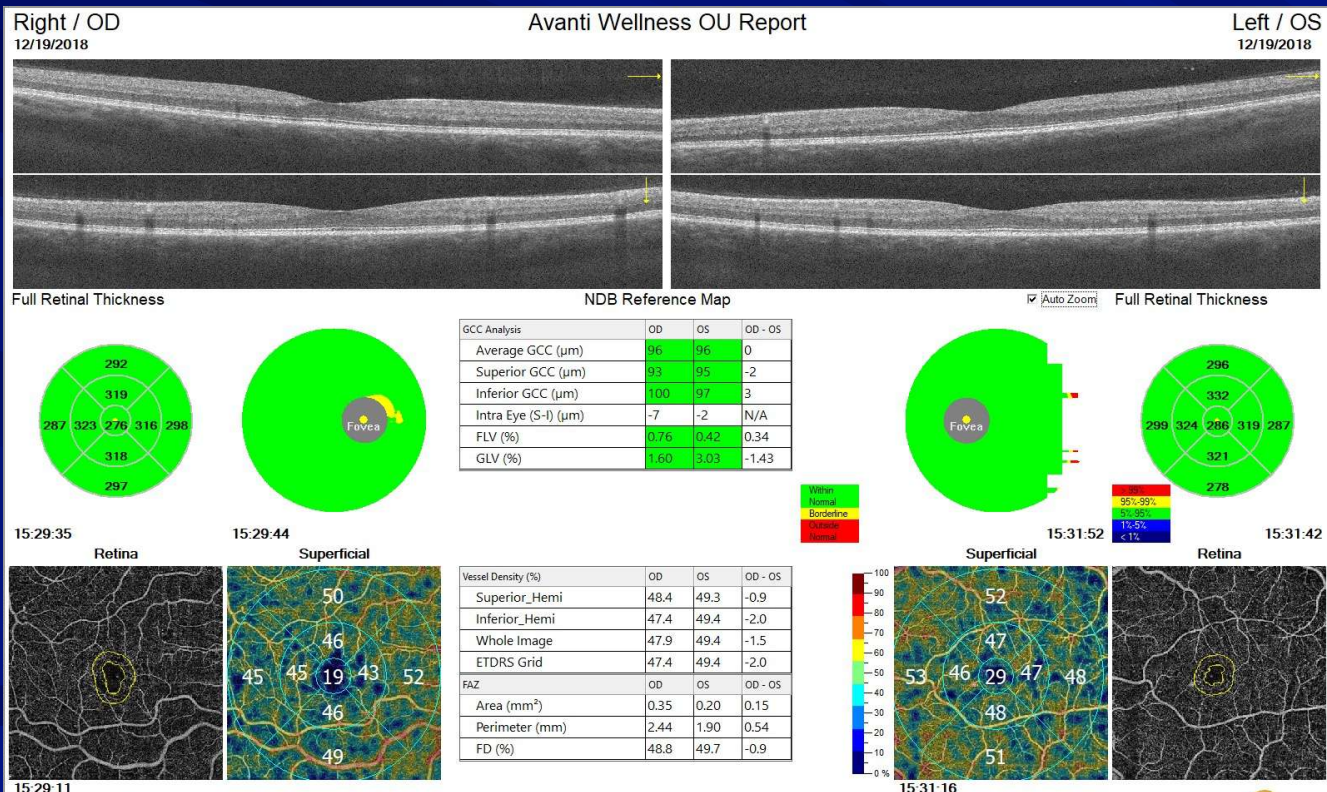
AngioWellness Report

Comprehensive Eye Exam - Healthy

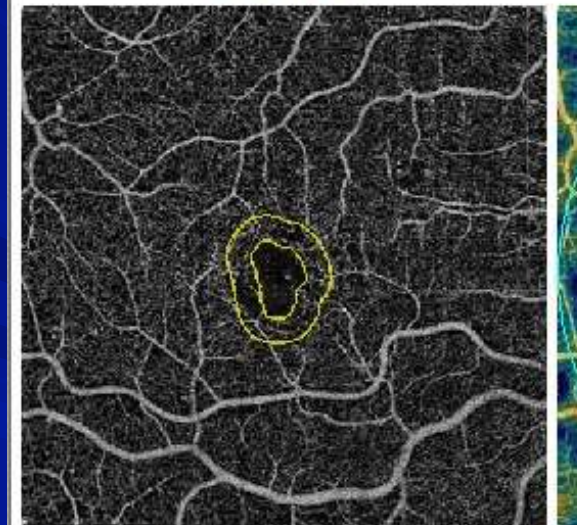


AngioWellness Report

Patient 1 with Diabetes



Retina

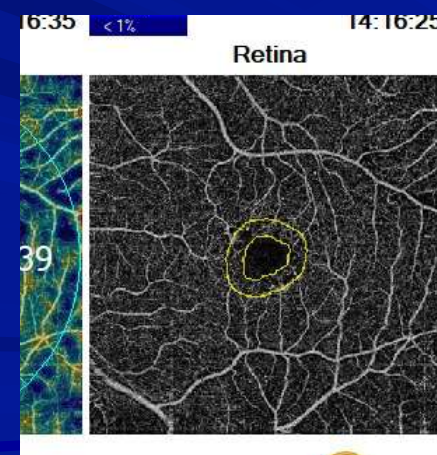
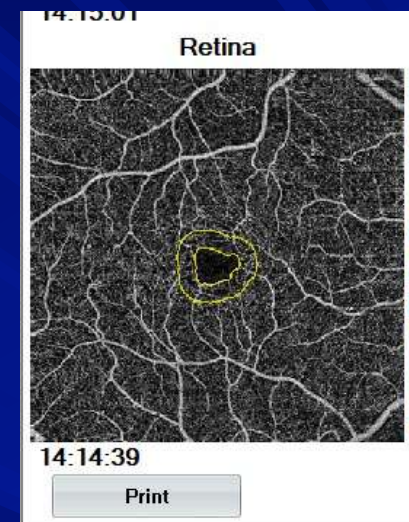
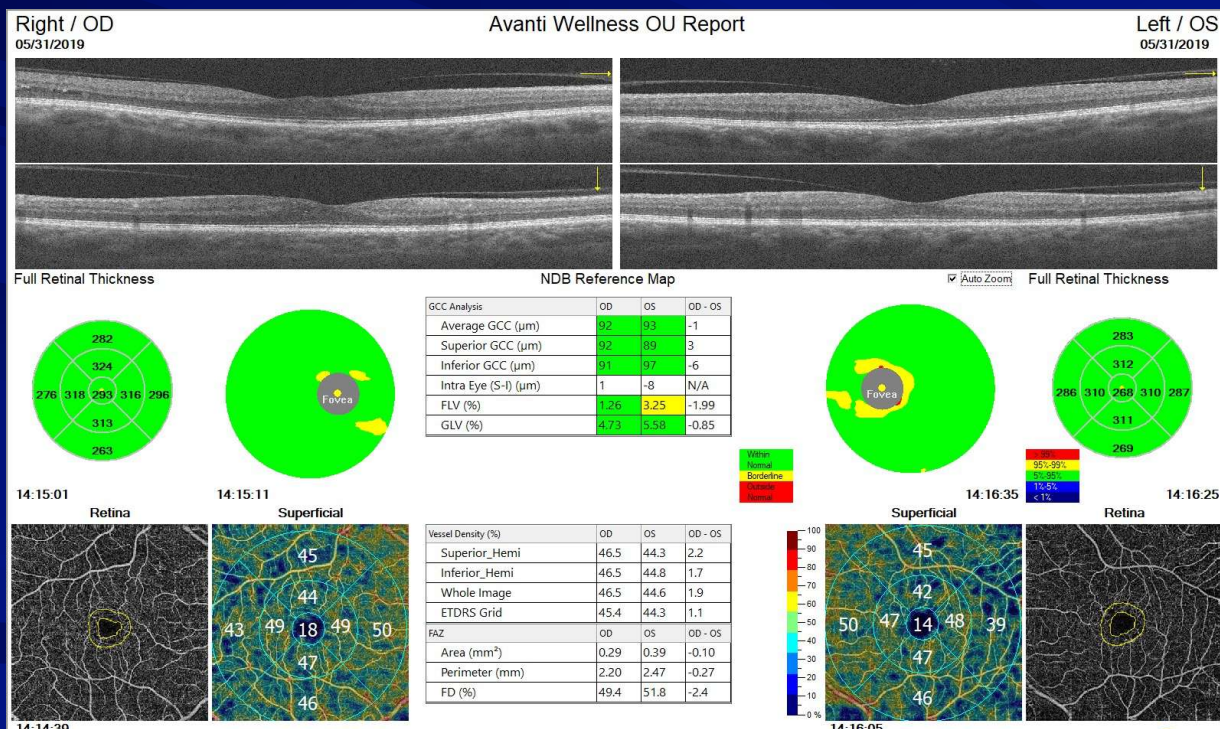


15:29:11

Print

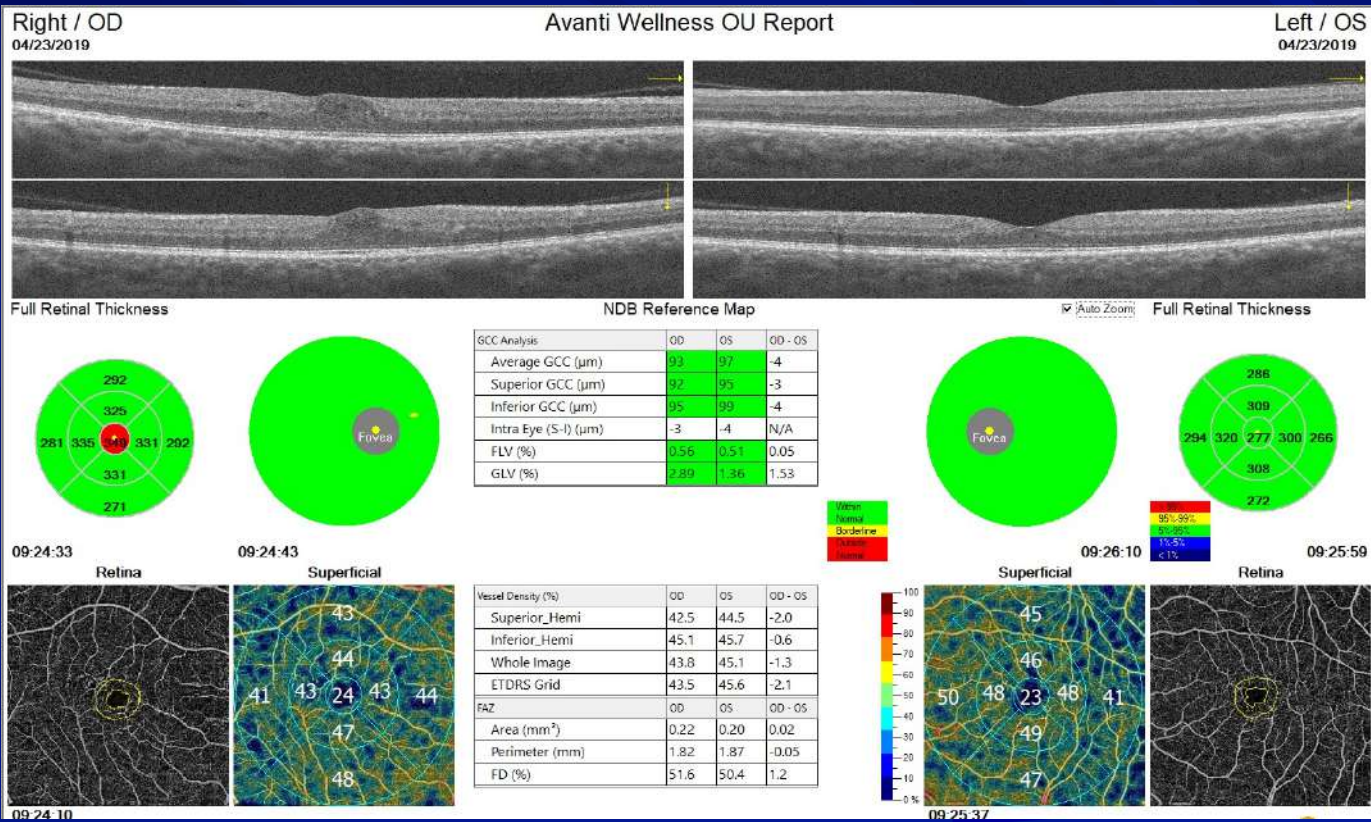
AngioWellness Report

Patient 2 with Diabetes



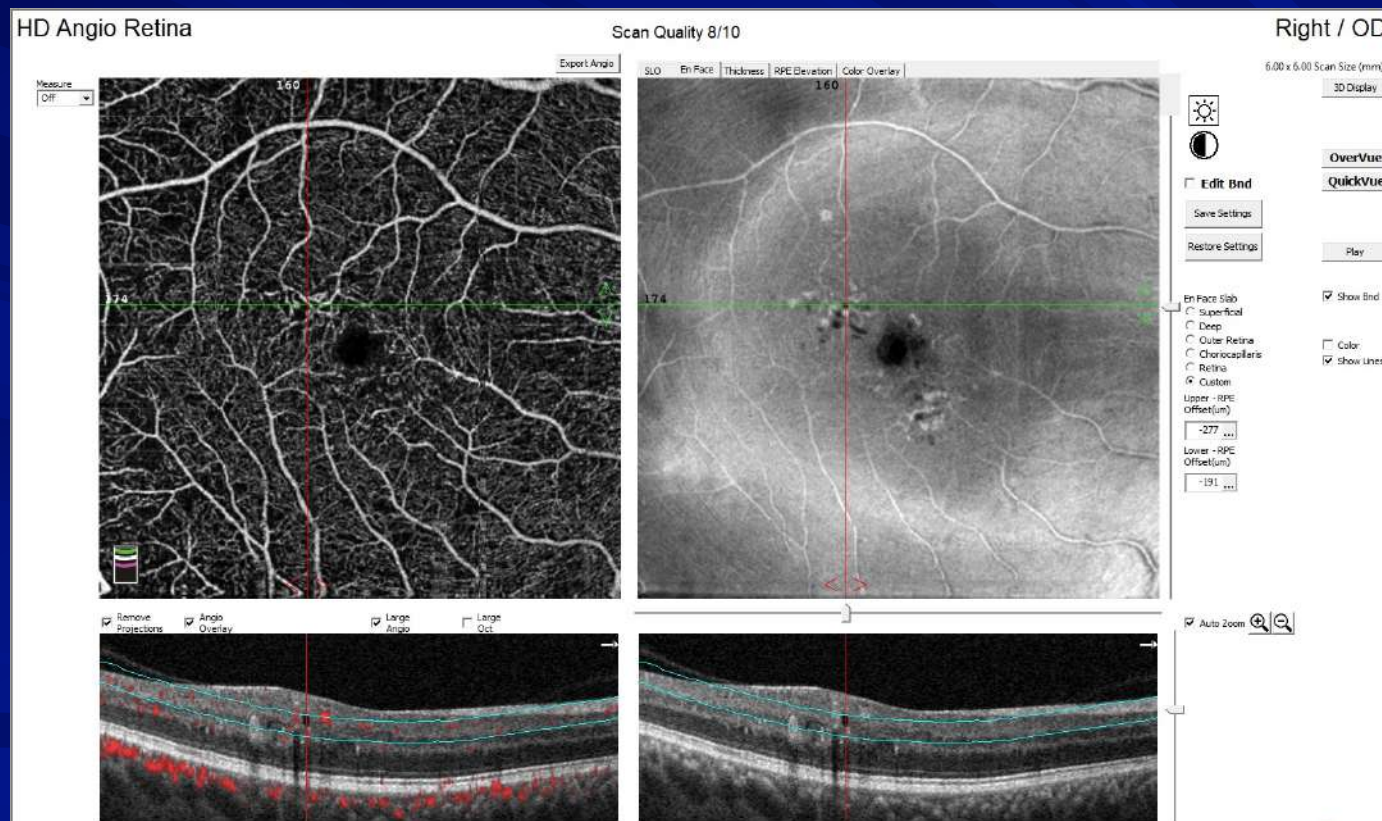
AngioWellness Report

Patient 3 with Diabetes



AngioWellness Report

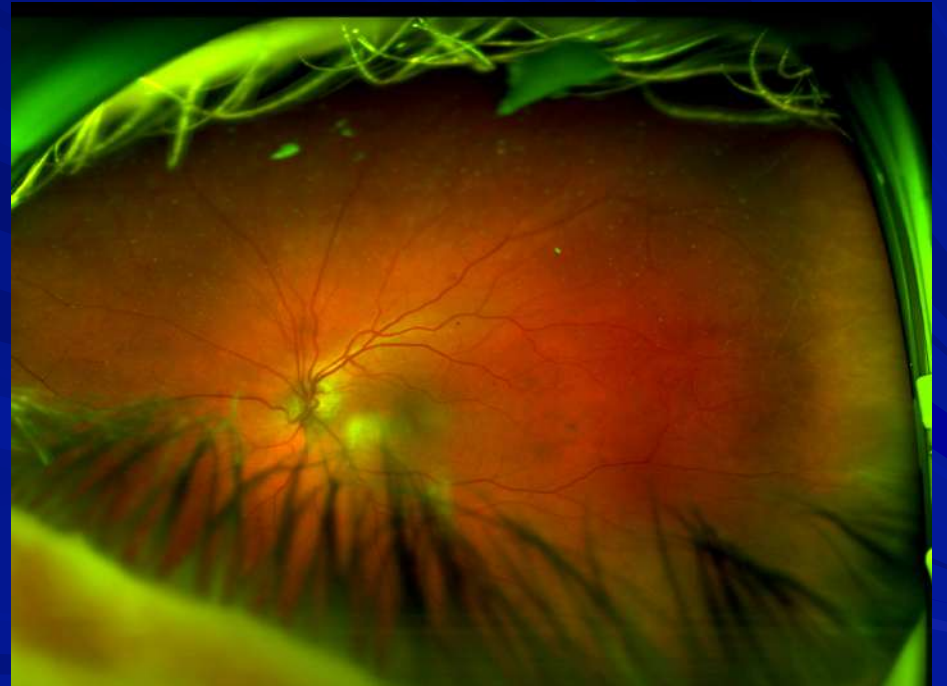
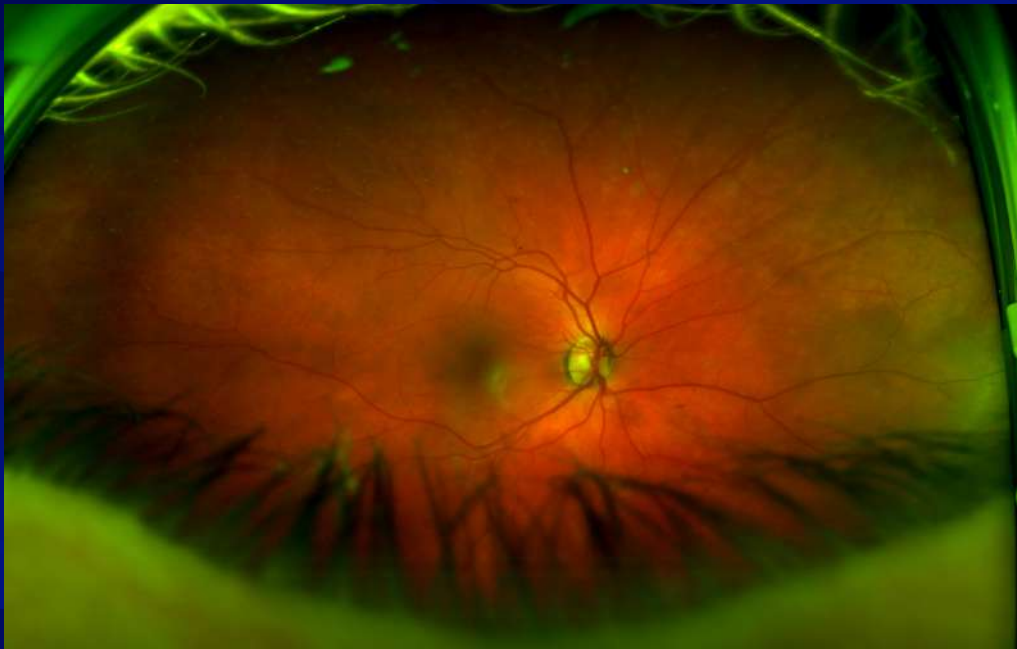
Patient 3 with Diabetes



58-year-old man with diabetes

- 👓 New patient to the practice
- 👓 BS: unsure, last HbA1c unsure
- 👓 DM meds: metformin, glyburide, Invokana
- 👓 Vision 20/20
- 👓 Anterior segment: normal

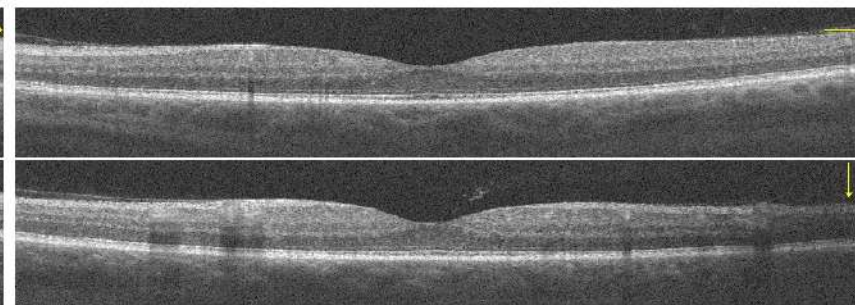
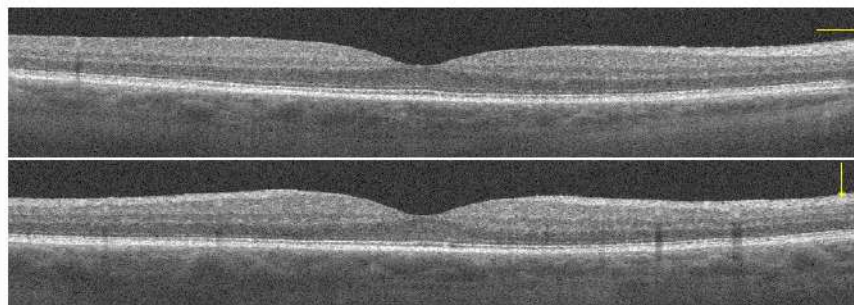
Widefield Imaging



Right / OD
08/18/2020

Avanti Wellness OU Report

Left / OS
08/18/2020

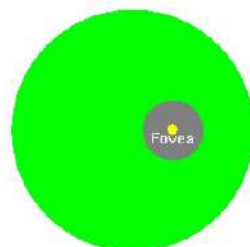


Full Retinal Thickness

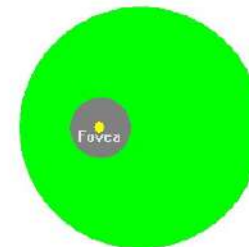
NDB Reference Map

☒ Auto Zoom

Full Retinal Thickness

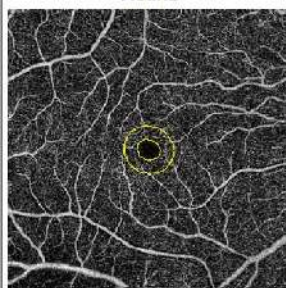


| GCC Analysis | OD | OS | OD - OS |
|----------------------|------|------|---------|
| Average GCC (μm) | 107 | 110 | -3 |
| Superior GCC (μm) | 105 | 107 | -2 |
| Inferior GCC (μm) | 110 | 113 | -3 |
| Intra Eye (S-I) (μm) | -5 | -6 | N/A |
| FLV (%) | 0.02 | 0.00 | 0.02 |
| GLV (%) | 0.02 | 0.00 | 0.02 |



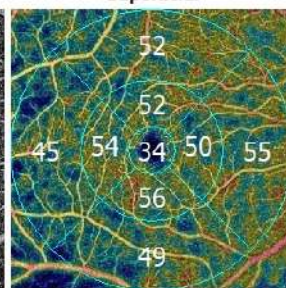
10:06:26

Retina



10:06:35

Superficial

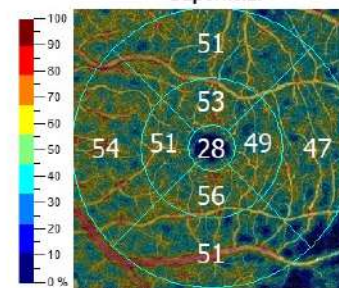


| Vessel Density (%) | OD | OS | OD - OS |
|--------------------|------|------|---------|
| Superior_Hemi | 50.7 | 50.0 | 0.7 |
| Inferior_Hemi | 49.5 | 49.1 | 0.4 |
| Whole Image | 50.1 | 49.5 | 0.6 |
| ETDRS Grid | 50.3 | 50.4 | -0.1 |
| FAZ | OD | OS | OD - OS |
| Area (mm²) | 0.15 | 0.24 | -0.09 |
| Perimeter (mm) | 1.49 | 1.92 | -0.43 |
| FD (%) | 55.5 | 55.0 | 0.5 |



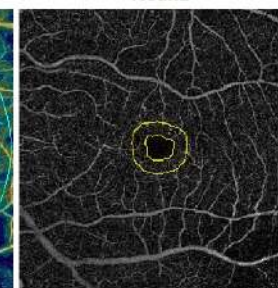
10:08:03

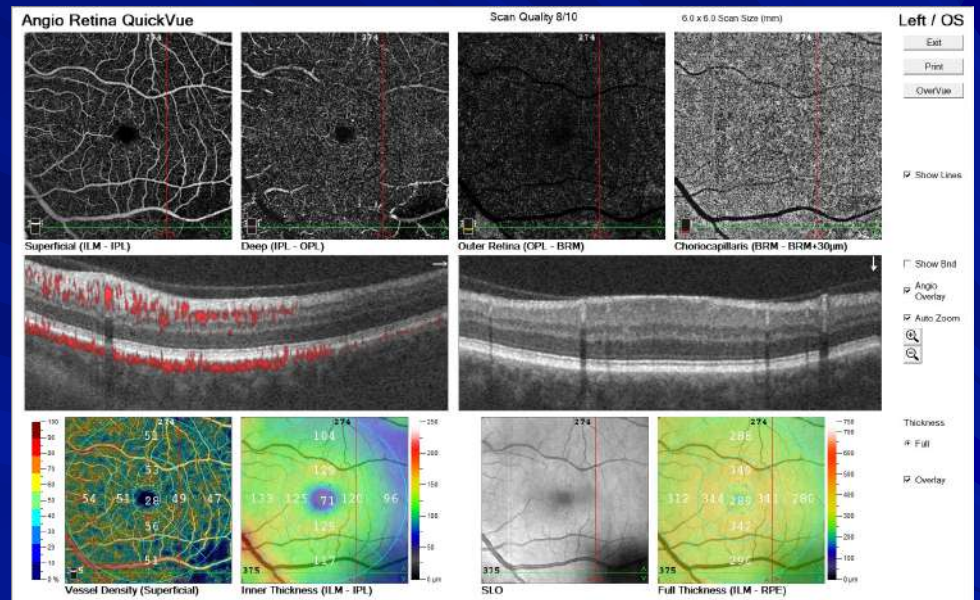
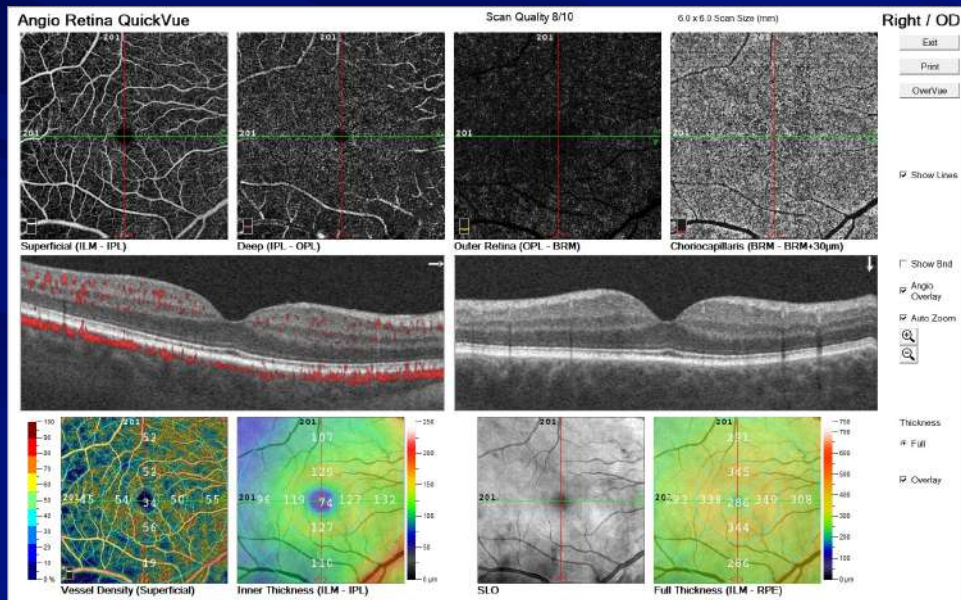
Superficial



10:07:54

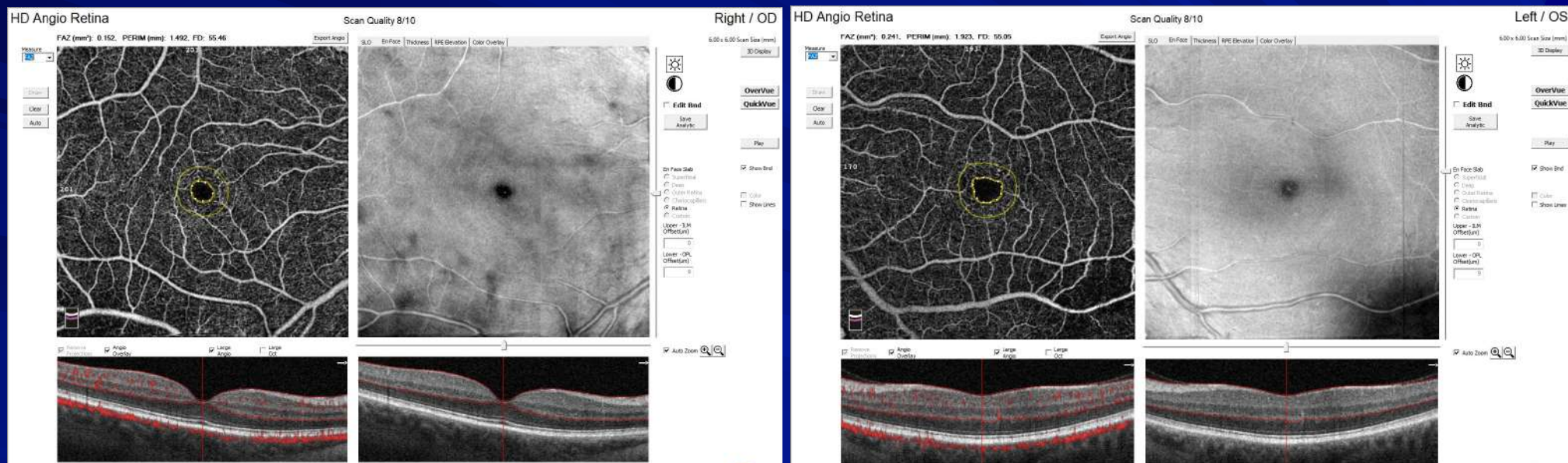
Retina





FAZ Damage – This is DR

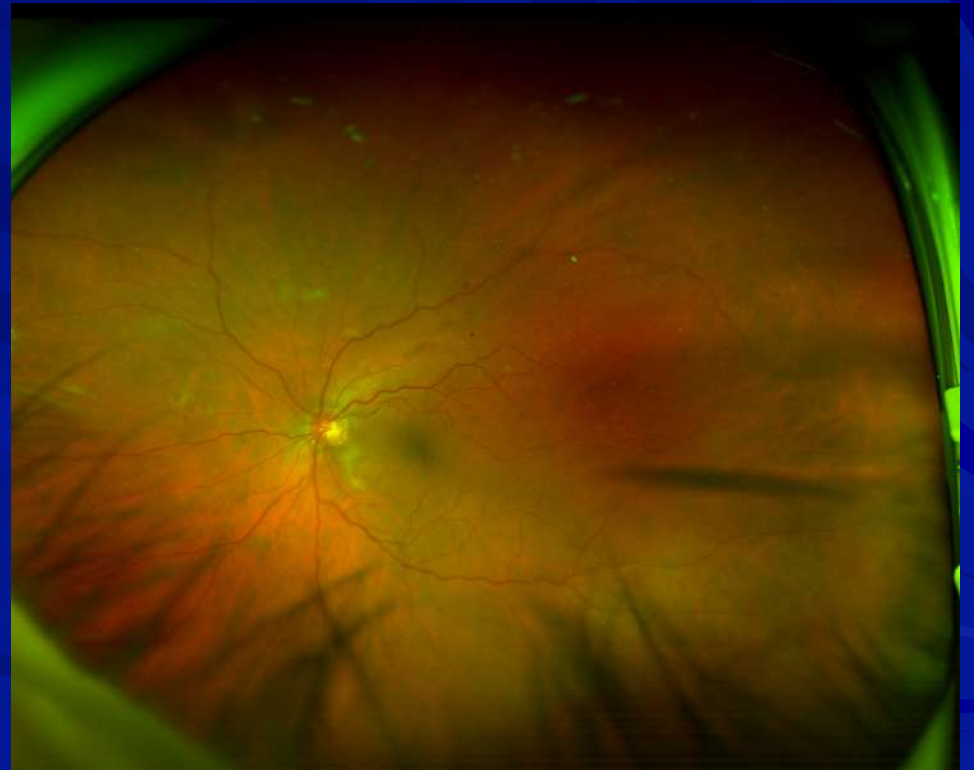
Time to get to know your BS and HBA1c



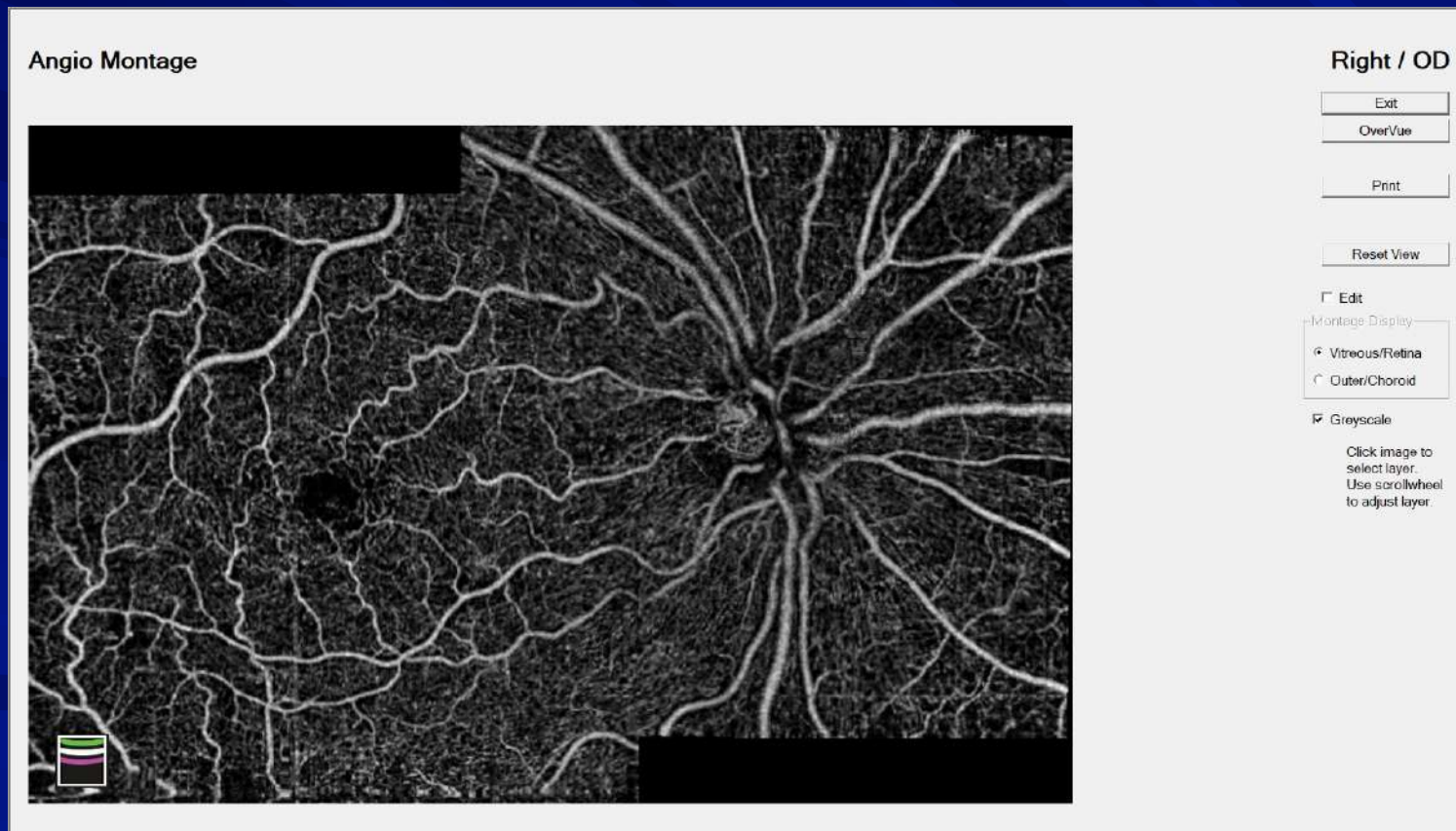
64-year-old man with diabetes

- BS: 134 this AM, last HbA1c 8.0
- DM meds: Novolog and Amaryl
- Vision 20/20
- Anterior segment: normal

Widefield Imaging

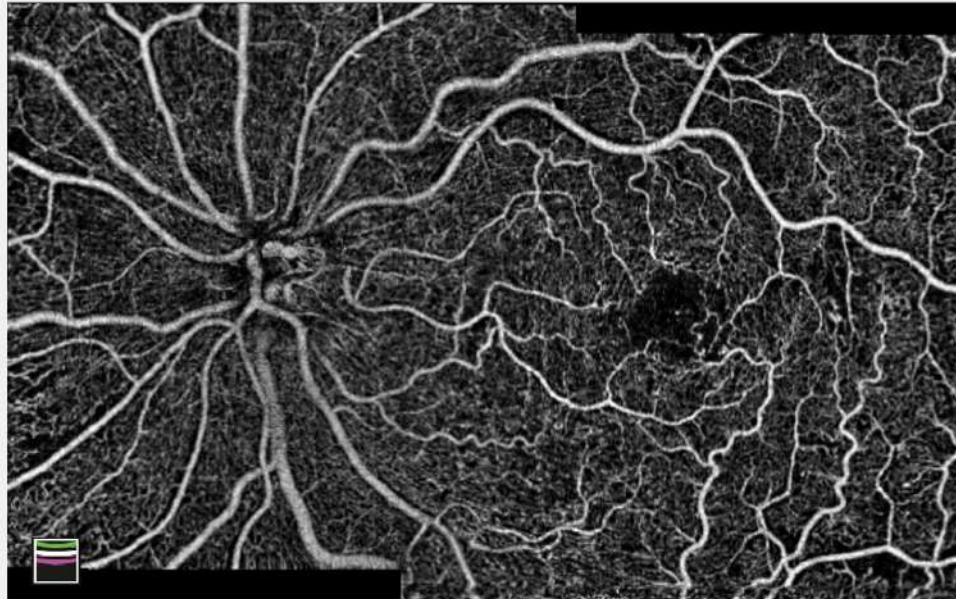


64-year-old man with diabetes



64-year-old man with diabetes

Angio Montage



Left / OS

Exit

OverVue

Print

Reset View

☐ Edit

Montage Display

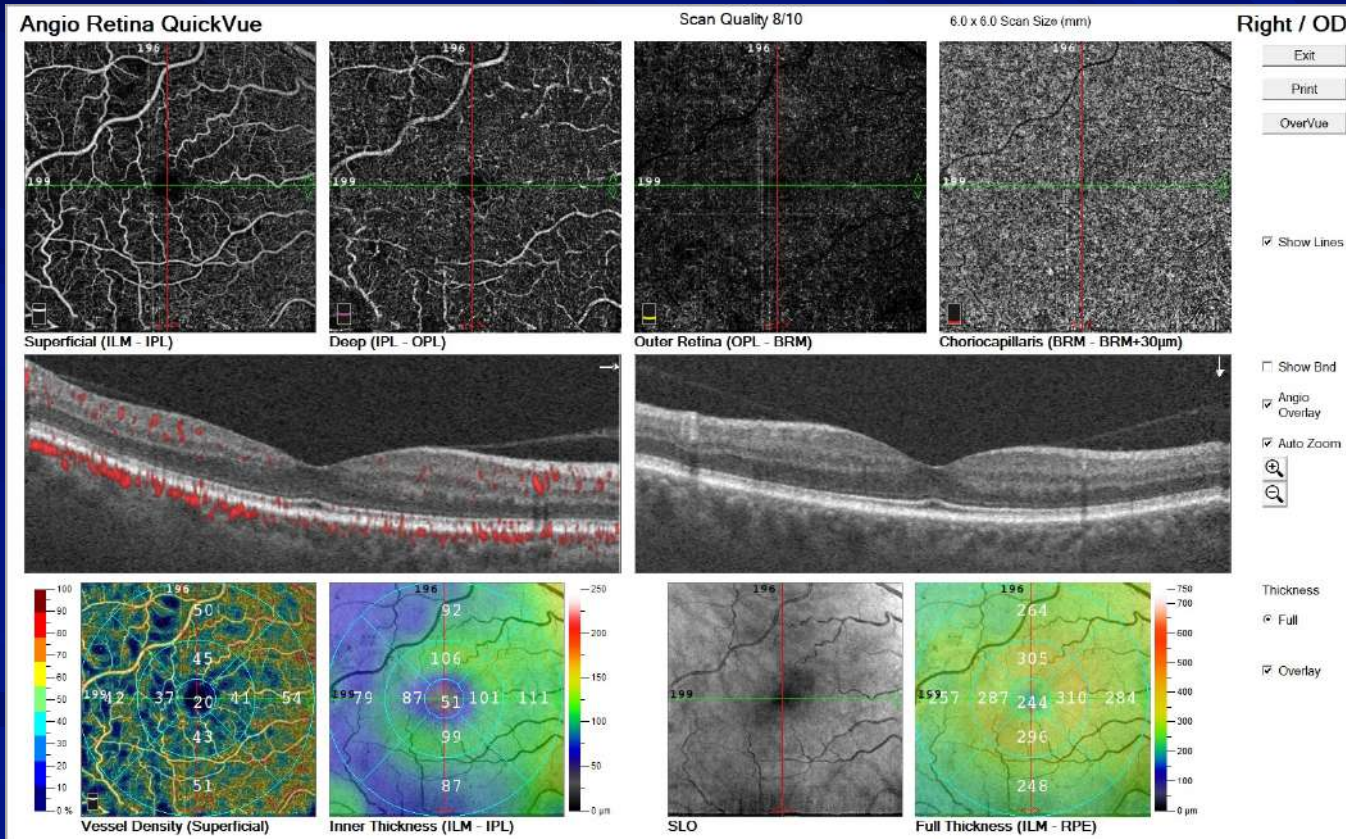
☒ Vitreous/Retina

☐ Outer/Choroid

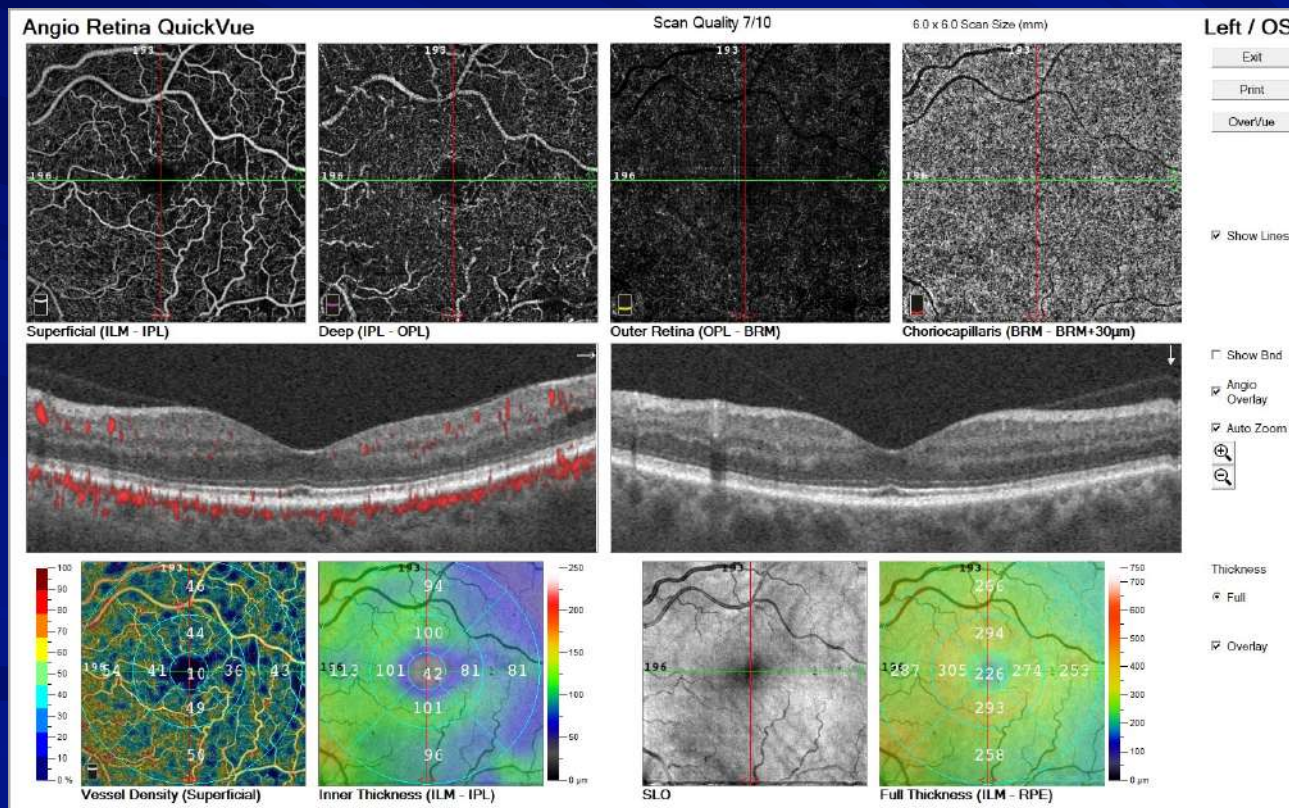
☒ Greyscale

Click image to
select layer.
Use scrollwheel
to adjust layer.

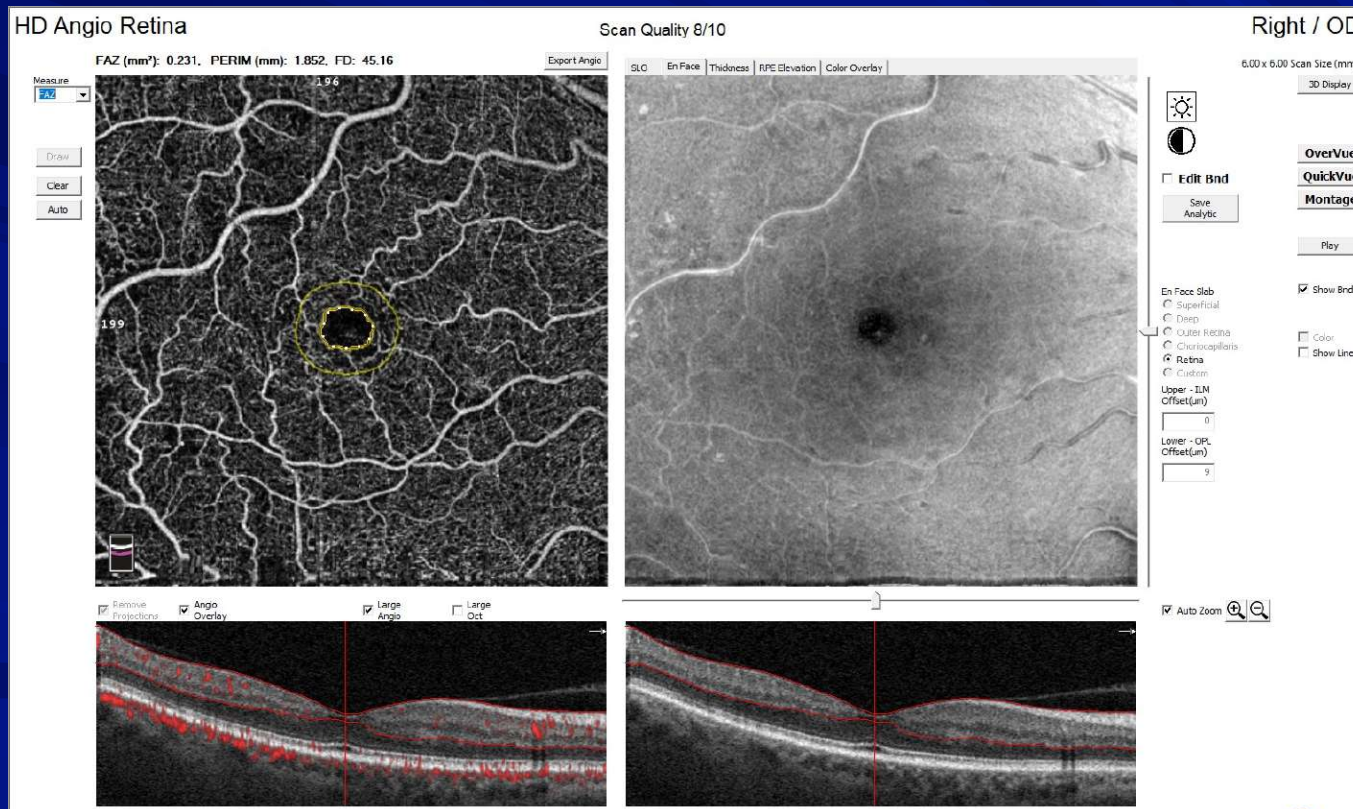
64-year-old man with diabetes



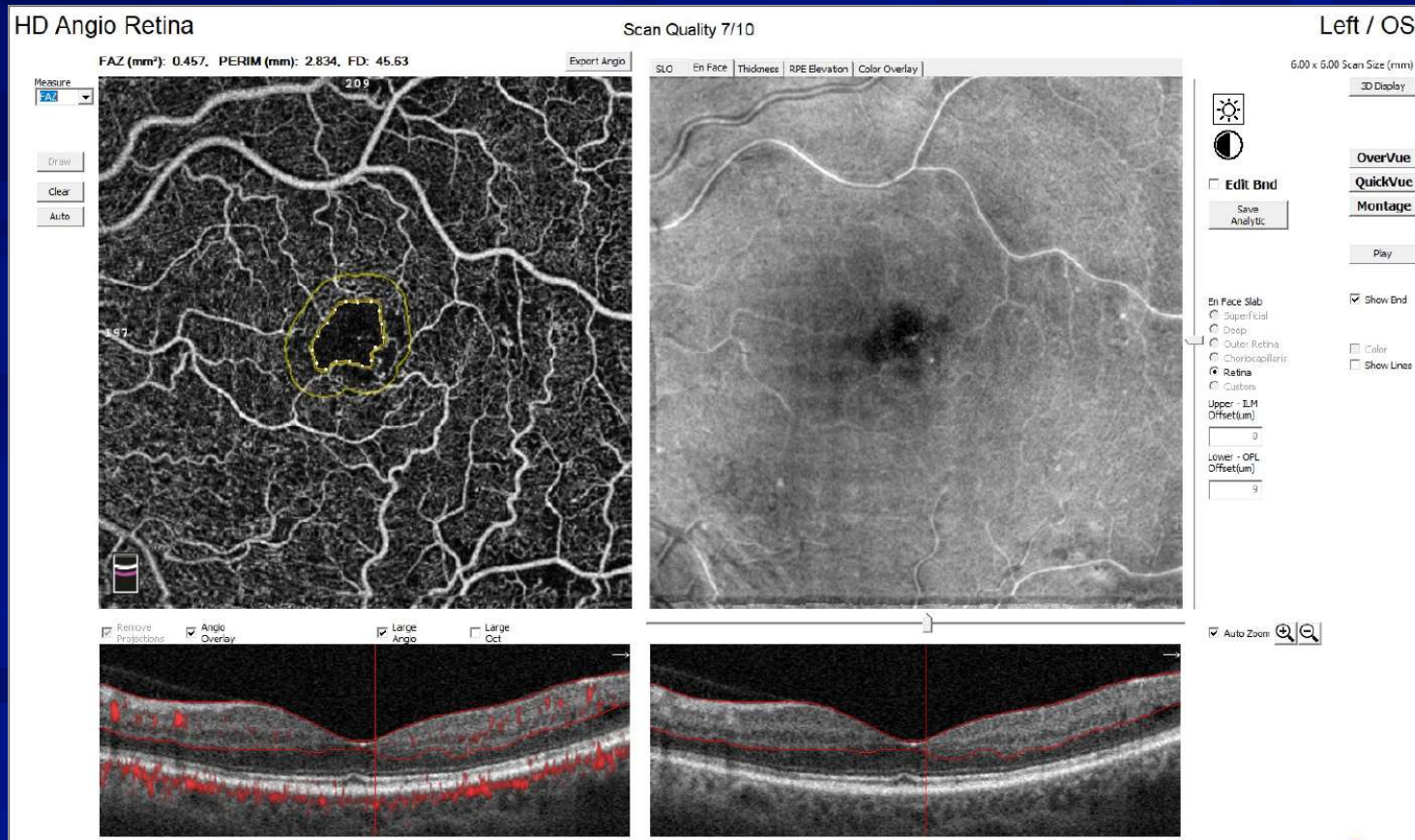
64-year-old man with diabetes



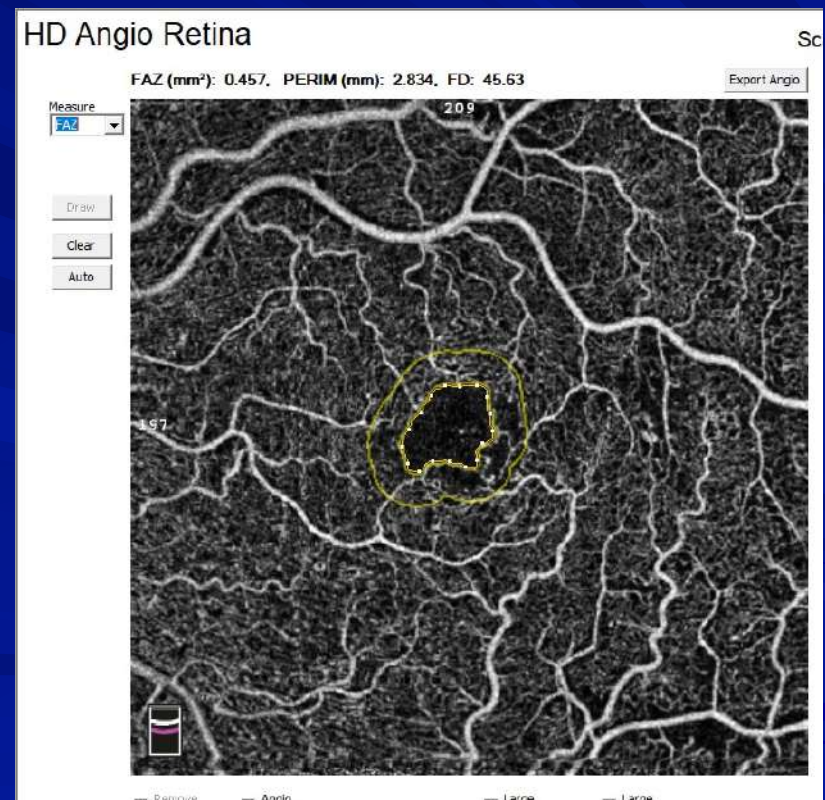
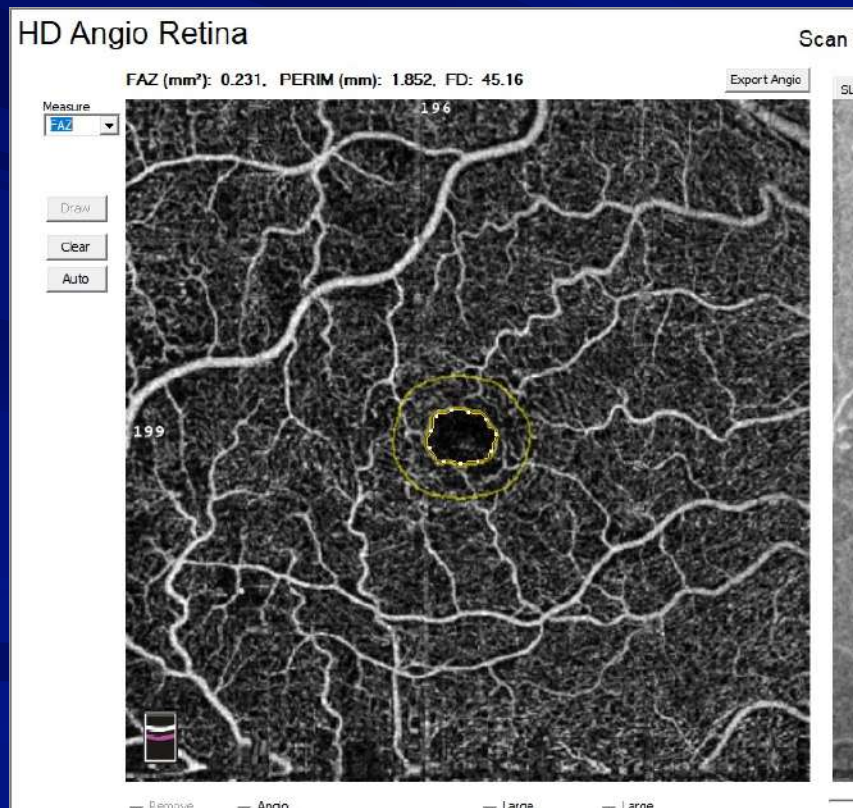
64-year-old man with diabetes



64-year-old man with diabetes



64-year-old man with diabetes



OCT and OCT-A

👁️ Treatment?

👁️ Certainly useful, beneficial, essential, and important in following the patient with diabetes

👁️ Improved HbA1c

The image features the AMD logo in a light blue, serif font, centered on a dark blue background. The background is decorated with numerous diagonal stripes of varying shades of blue, creating a sense of motion and depth. The stripes radiate from the right side of the frame towards the left.

AMD

Optometrists and All Eye Care Professionals Responsibility

- 👁️ Rethink our responsibility related AMD diagnosis and management
- 👁️ Commit to that we will do better in
 - ★ Early detection
 - ★ Treatment
- 👁️ Know, execute, and employ current clinically appropriate Practice Guidelines
 - ★ Those that preserve vision
 - ★ Don't wait until vision has been lost
- 👁️ Closely monitor and treat the early detected disease
 - ★ If progresses to advanced AMD, better opportunity to save vision

Instruments for AMD – fragmented care

- 👁️ Slit lamp/DFE
- 👁️ Camera
- 👁️ OCT
- 👁️ OCT Angiography
- 👁️ Dark adaption
- 👁️ PHP
- 👁️ Macula pigment eval – Scanner
- 👁️ Genetic testing

Beckmann Committee Classification of AMD

👁️ Based on presence of lesions within 2 DD of fovea in either eye

- ★ No AMD

- ☐ None or few small drusen, < 63 microns
- ☐ No AMD pigmentary abnormalities

- ★ Early AMD

- ☐ Medium drusen, > 63 – <125 microns
- ☐ No AMD pigmentary changes

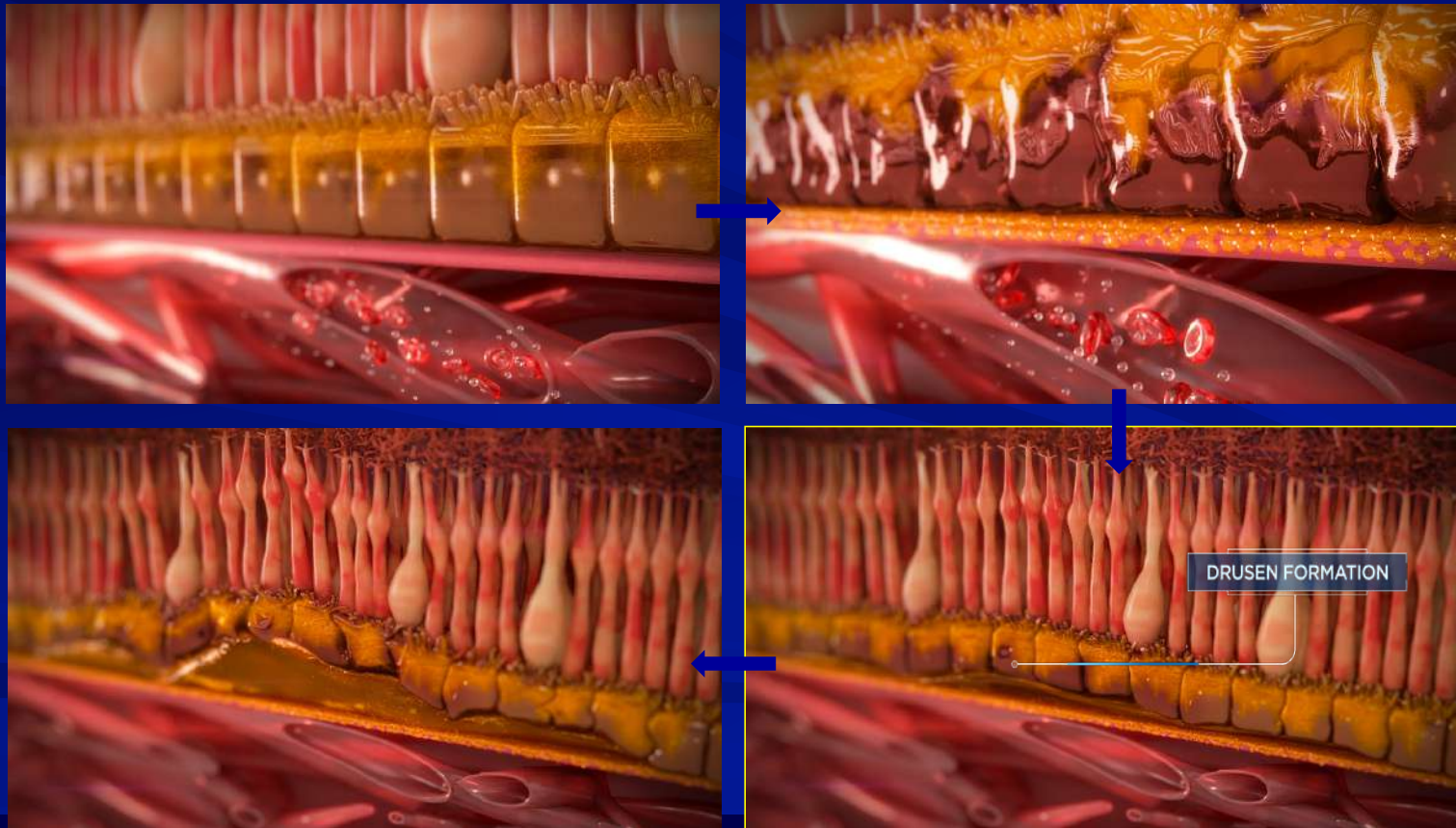
- ★ Intermediate AMD

- ☐ 1 large drusen, > 125 microns
- ☐ Any AMD pigmentary changes

- ★ Advanced AMD

- ☐ Any geographic atrophy
- ☐ Choroidal neovascularization (CNV)

AMD is a Disease Process that Starts Below the Surface



Raster Comparison Report

Scan 09/29/2020 13:20:09

Reference En Face IR

Signal Strength Index 55

12.00 x 4.00 Scan Size (mm)

Right / OD



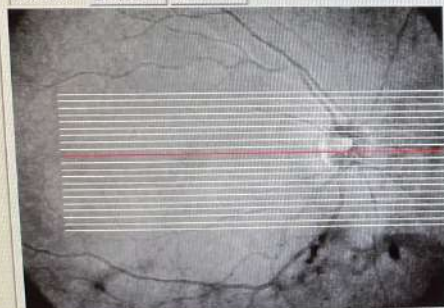
10

250µm



Auto Zoom

Reference En Face IR



10

250µm



Signal Strength Index 43

12.00 x 4.00 Scan Size (mm)

Right / OD

OPTOVUE

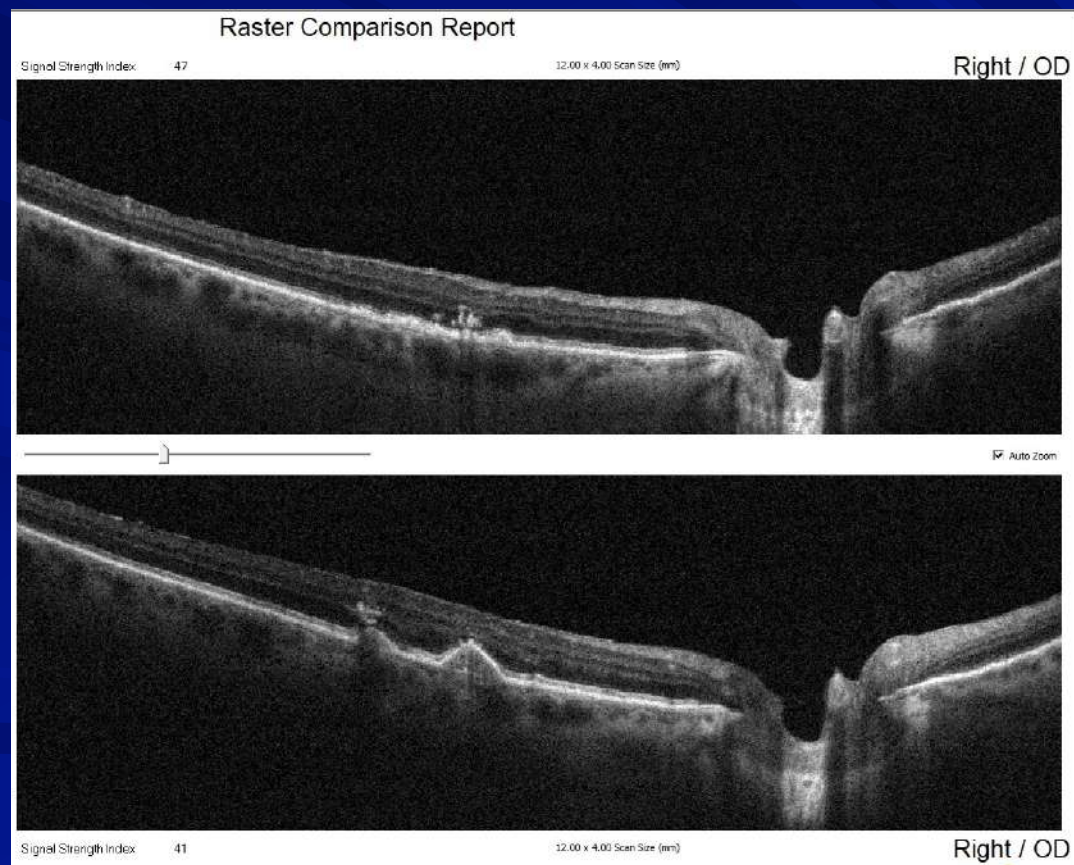
Scan 06/23/2021 10:22:11

Print

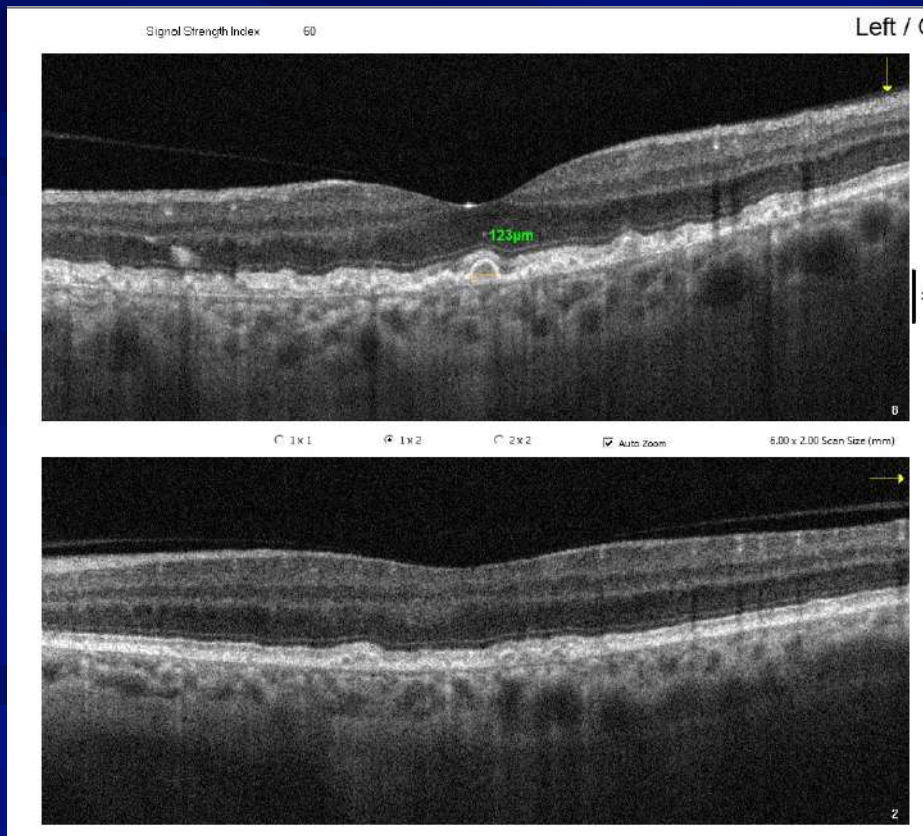
OU Report

49°F Sunny 10:46 AM 6/23/2021

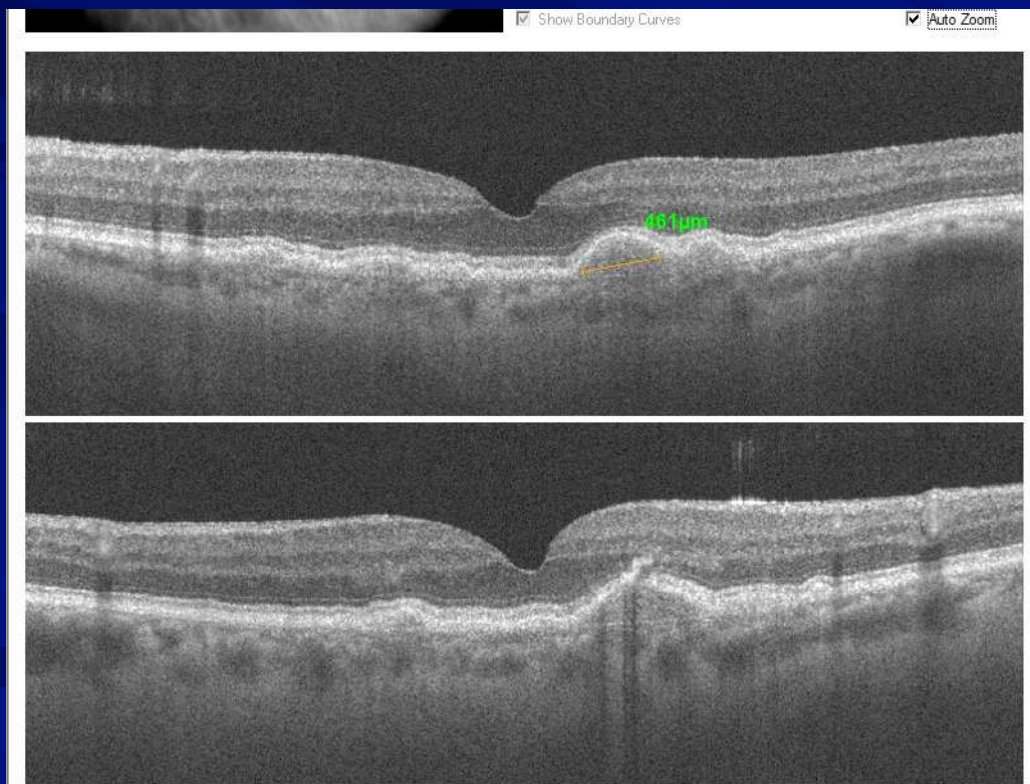
April 27, 2021 – January 26, 2022 (9 months)



Measure the Drusen with Your OCT



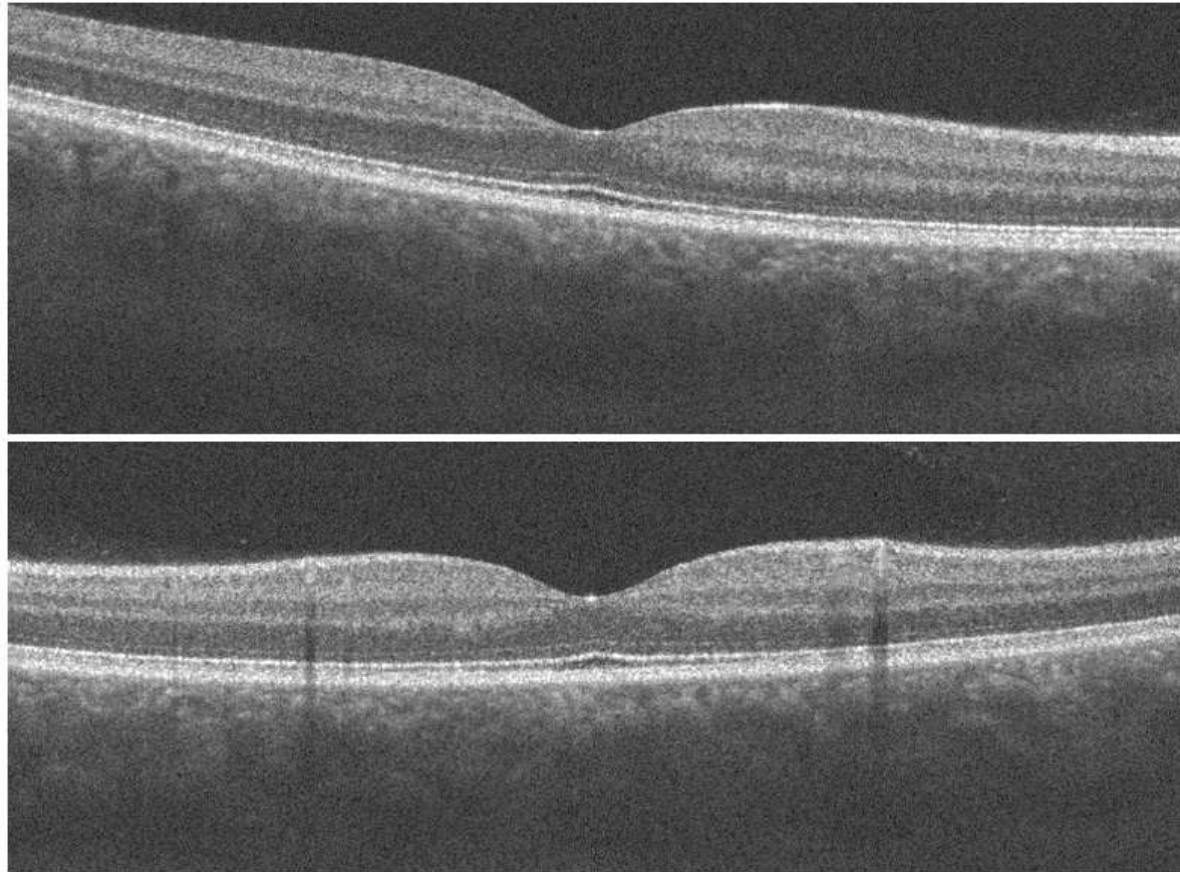
Measure the Drusen with Your OCT



OCT in AMD

- 👁️ Need spectral domain to follow intermediate or worse AMD
- 👁️ Able to identify OCT predictors of progression
- 👁️ Especially in identifying OCT predictors of progression
 - ★ Hyper-reflective foci
 - ★ Reticular pseudodrusen
 - ★ Nascent geographic atrophy
 - ★ Sub-RPE hyper-reflective columns
 - ★ Drusen substructures
 - ★ Drusen load and regression

Hypo versus Hyper Reflectance



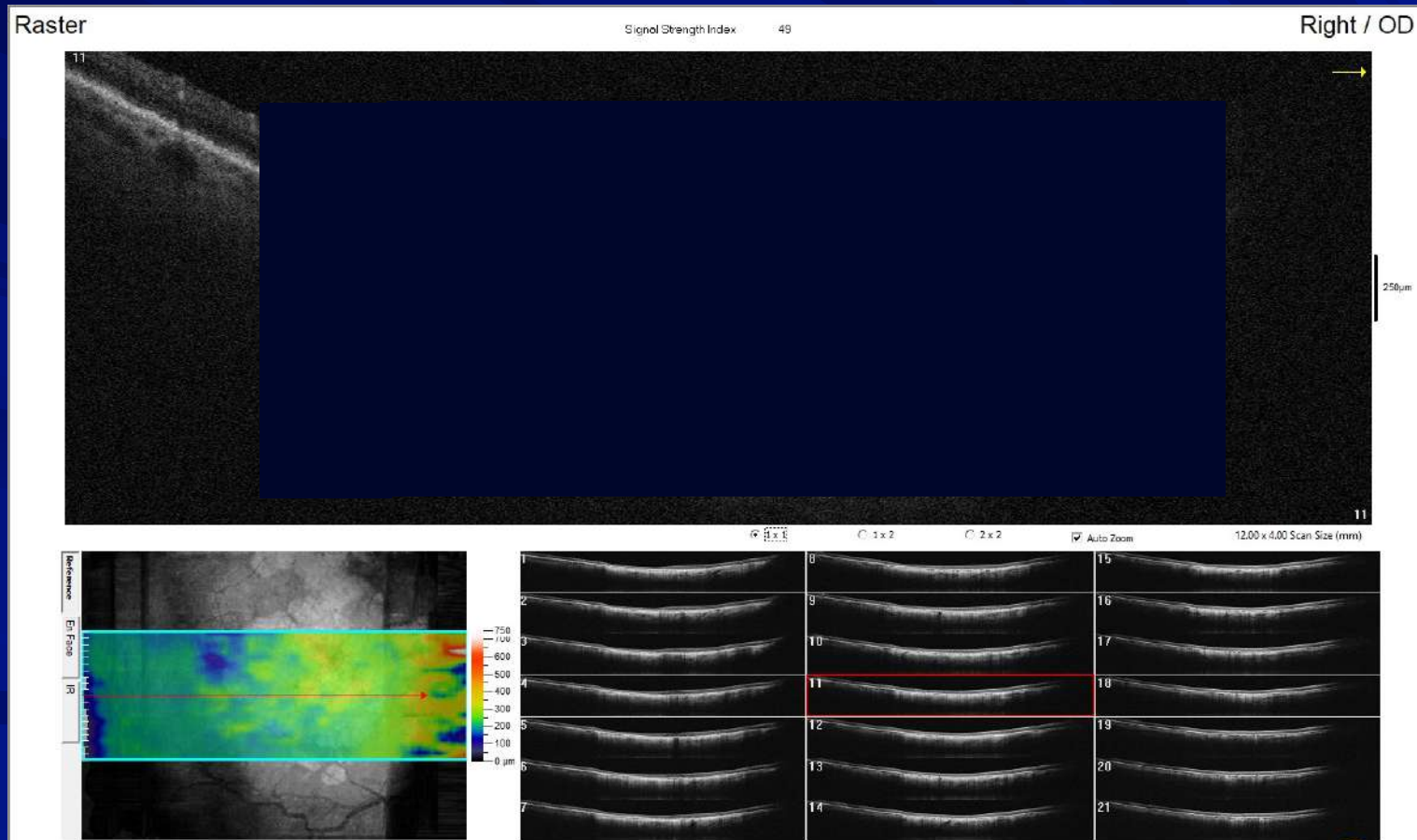
Can We Learn From These Pictures?



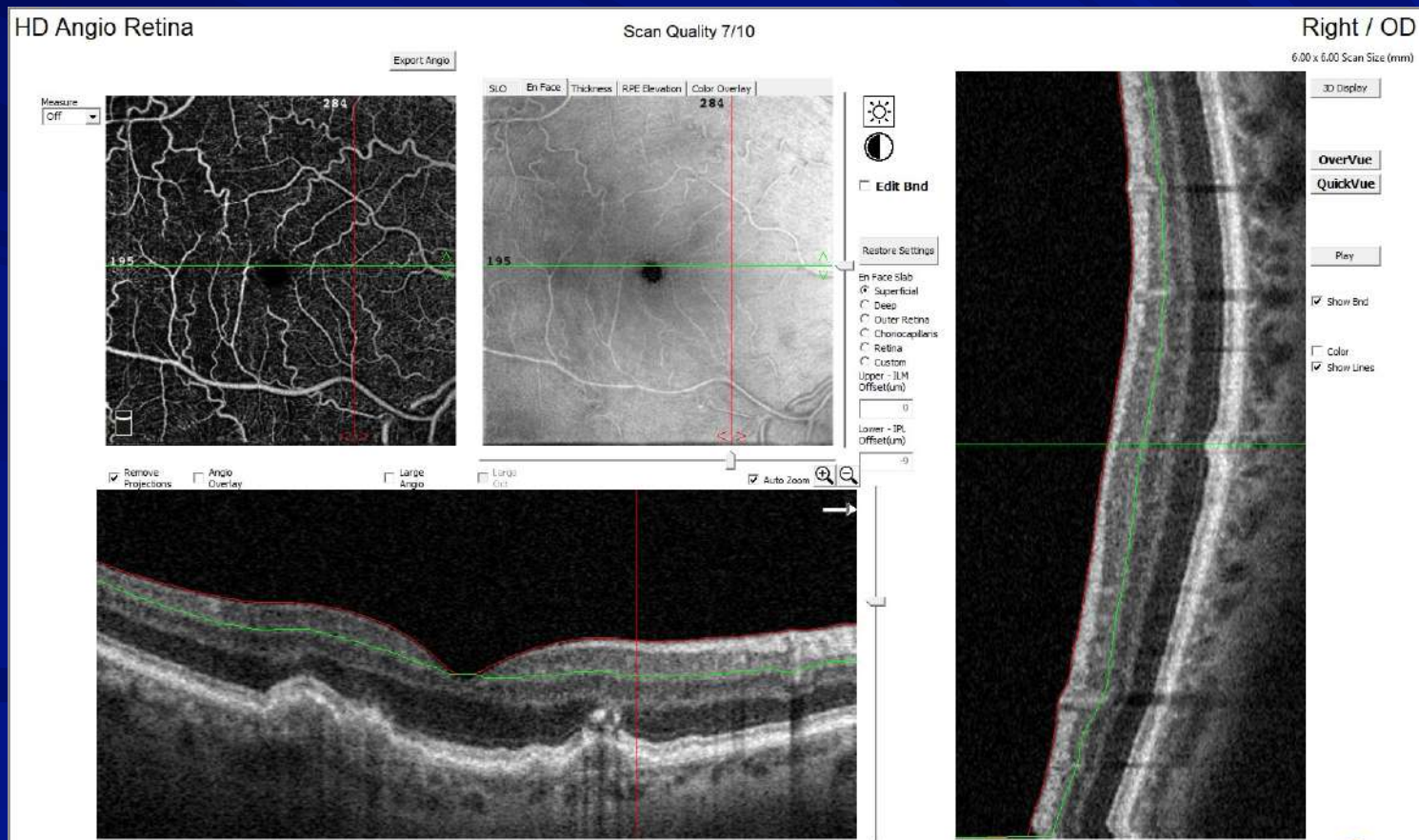
Can We Learn From These Pictures?



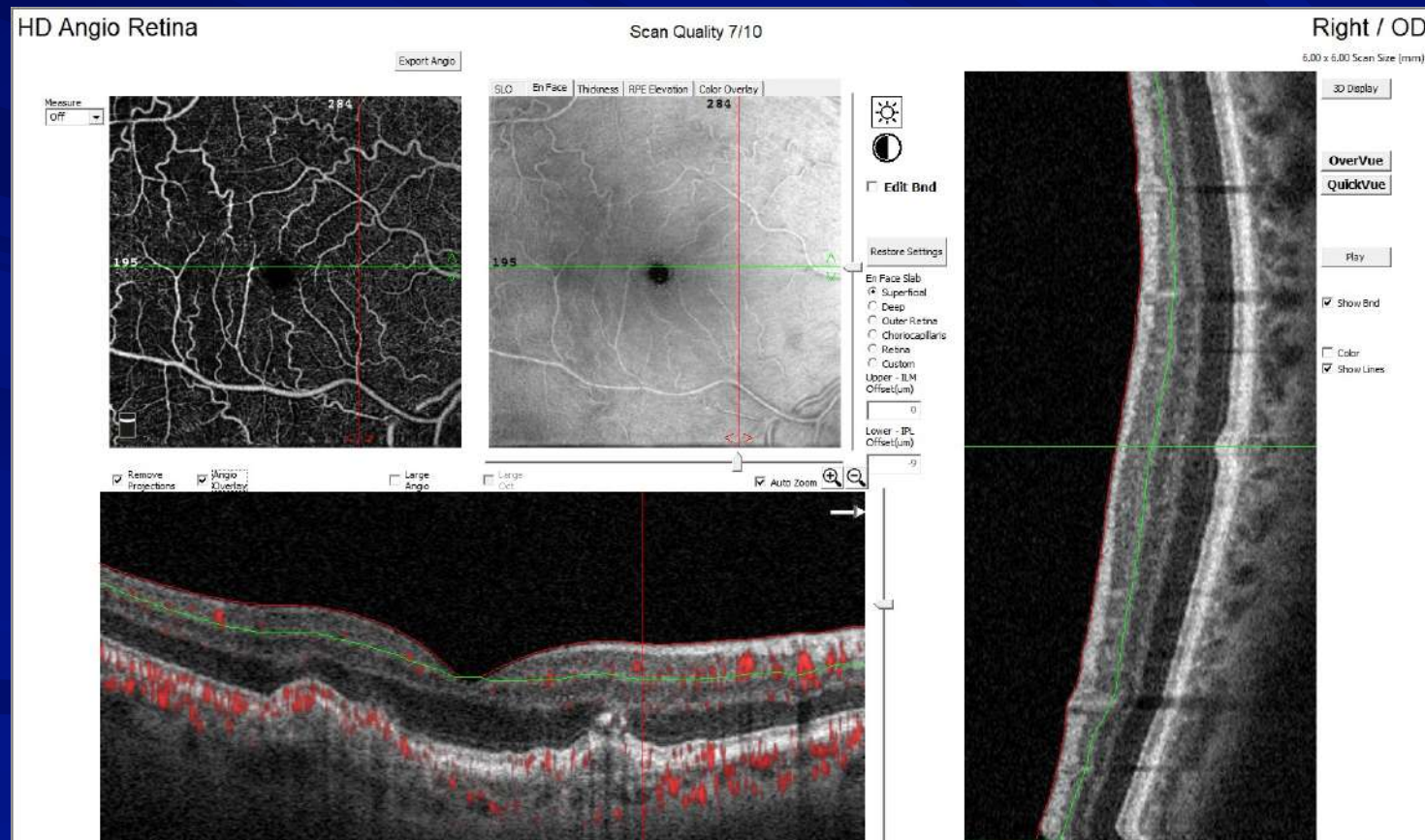
Hypo versus Hyper Reflectance



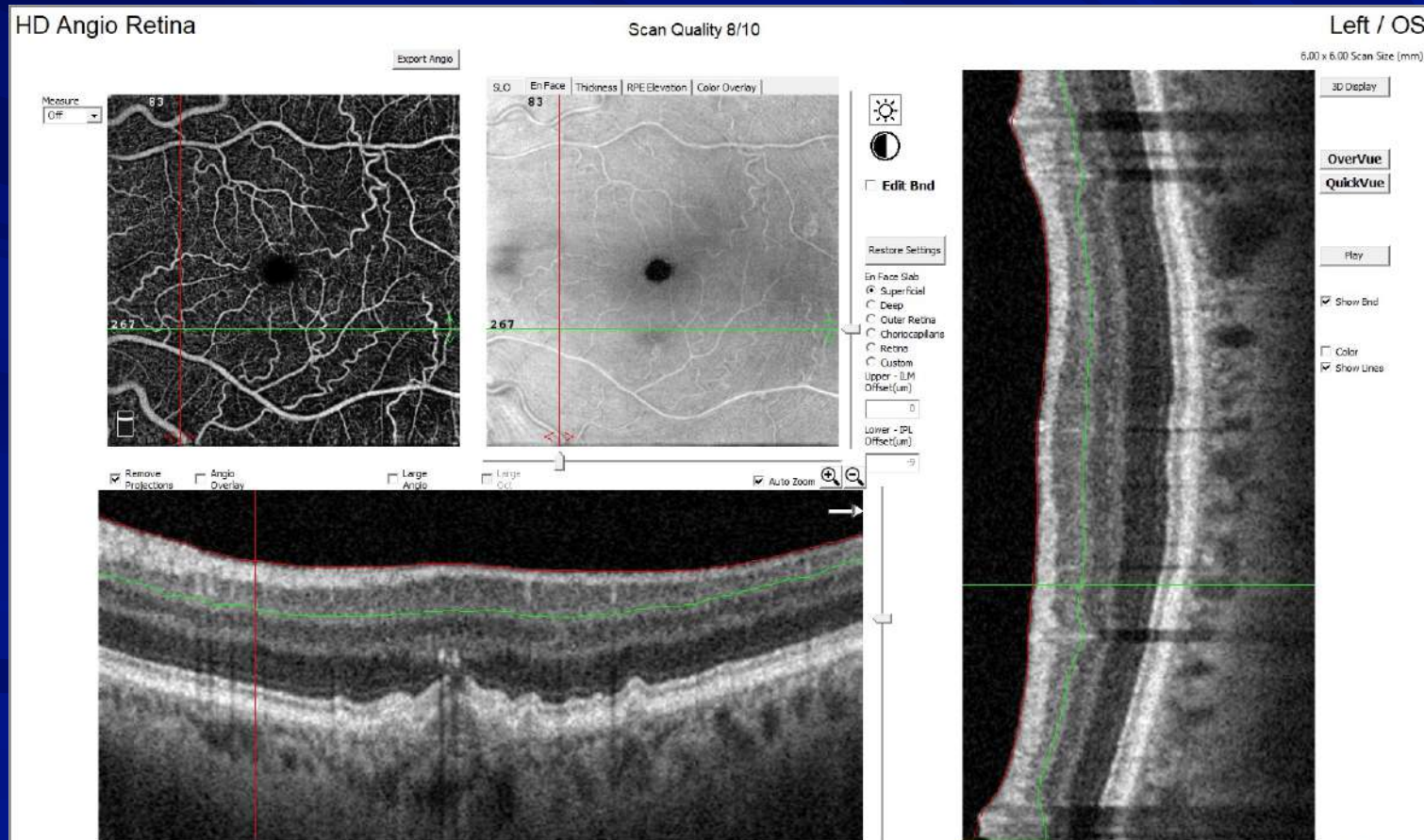
Case 1 - OCT Predictors of Progression



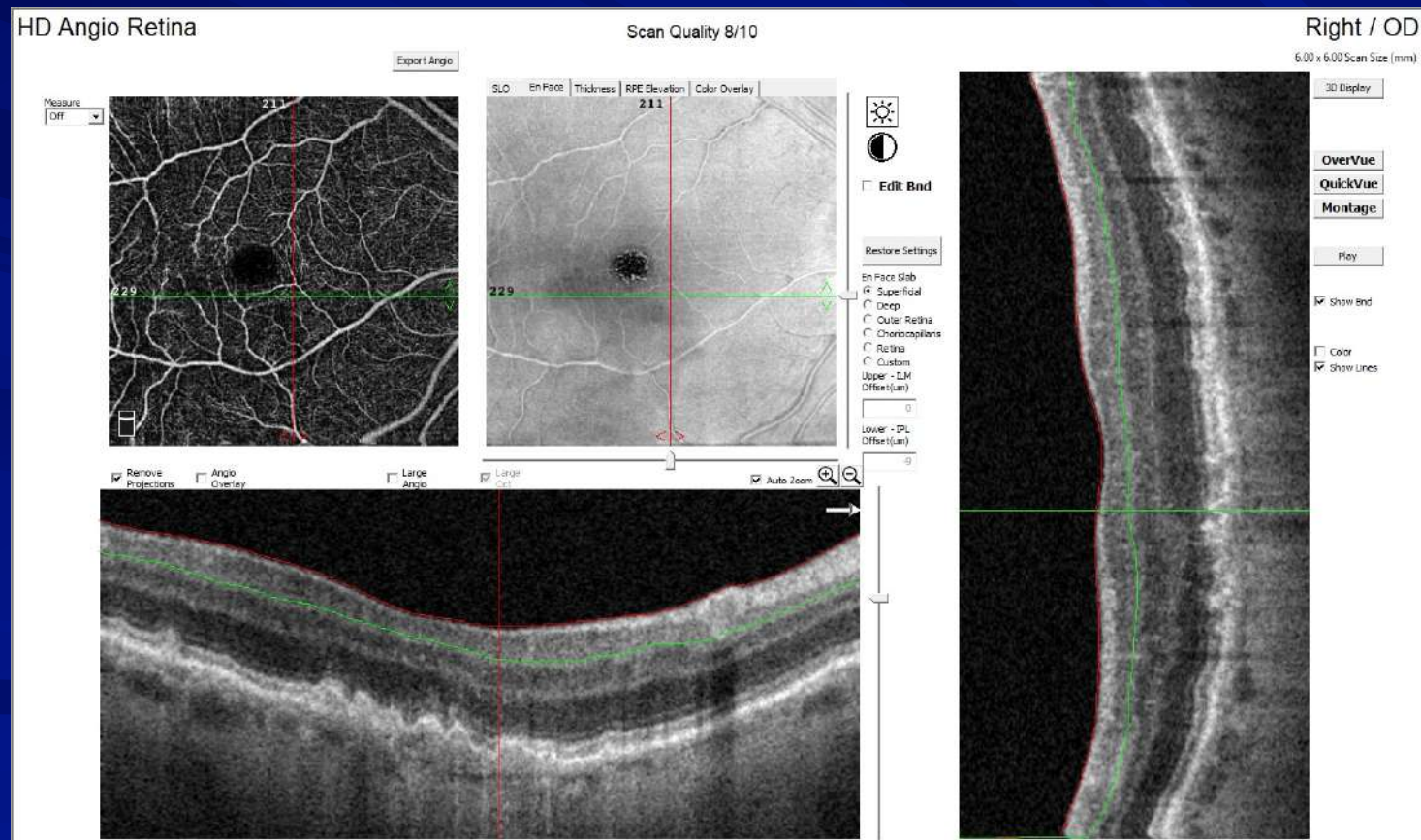
Case 1 - OCT Predictors of Progression



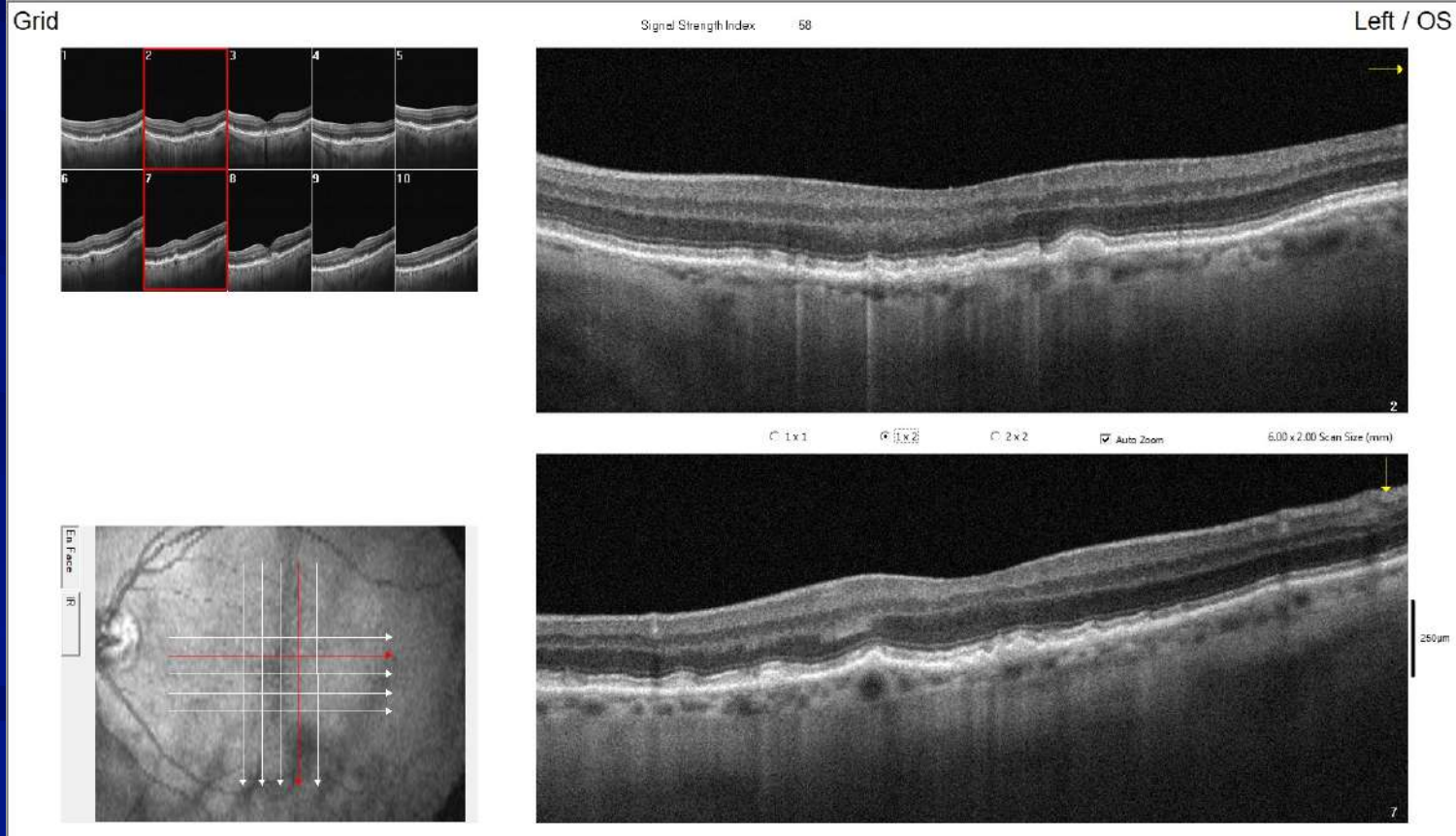
Case 1 - OCT Predictors of Progression



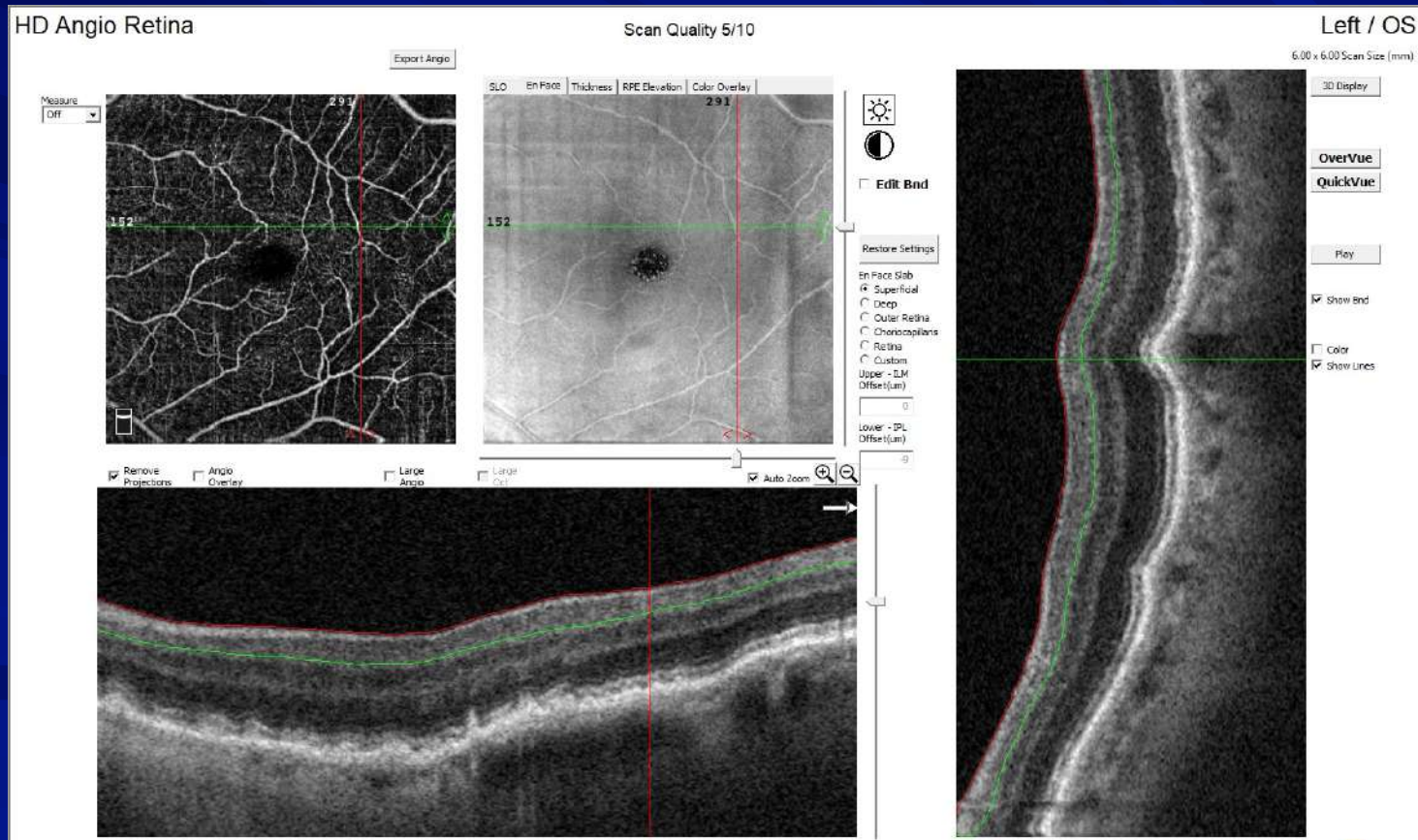
Case 2 - OCT Predictors of Progression



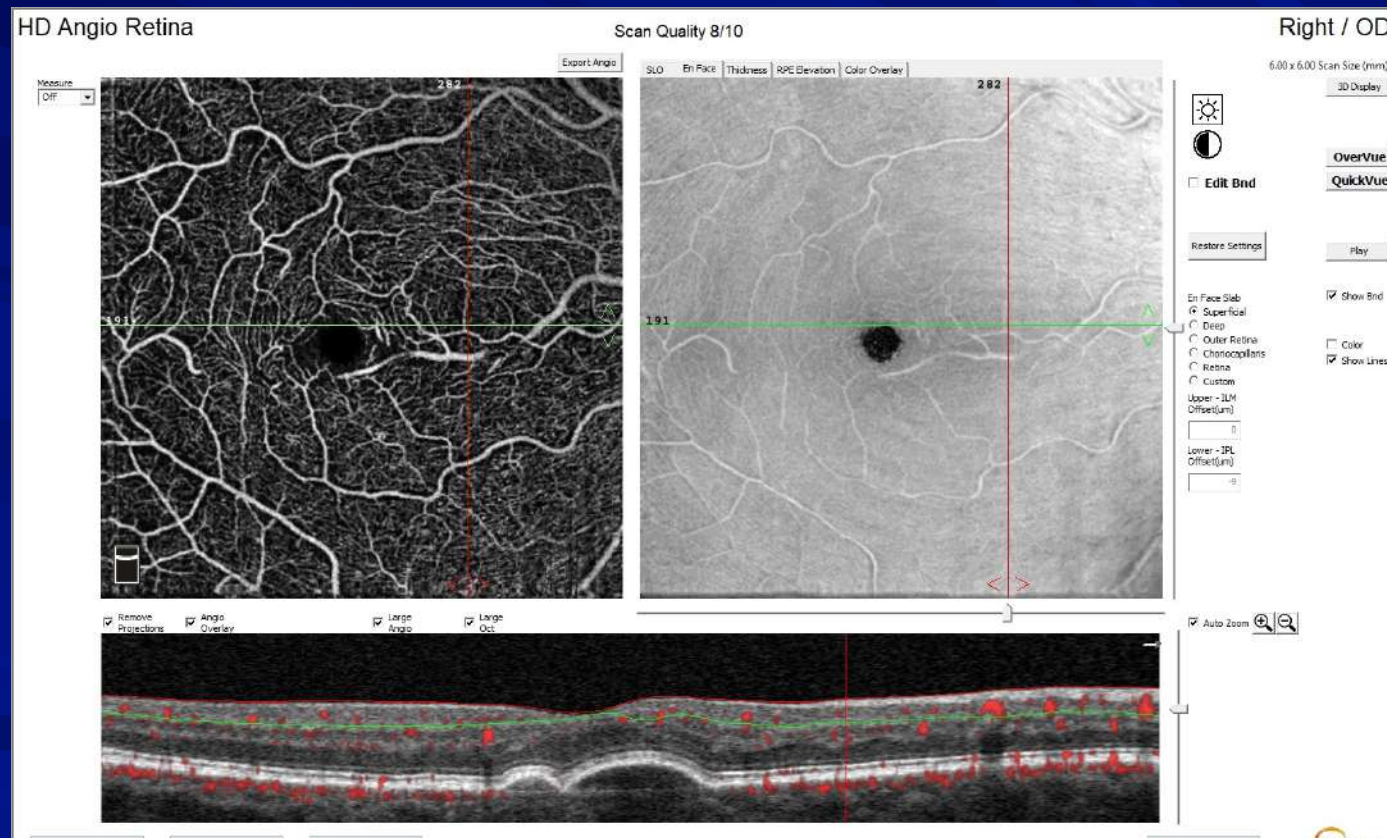
Case 2 - OCT Predictors of Progression



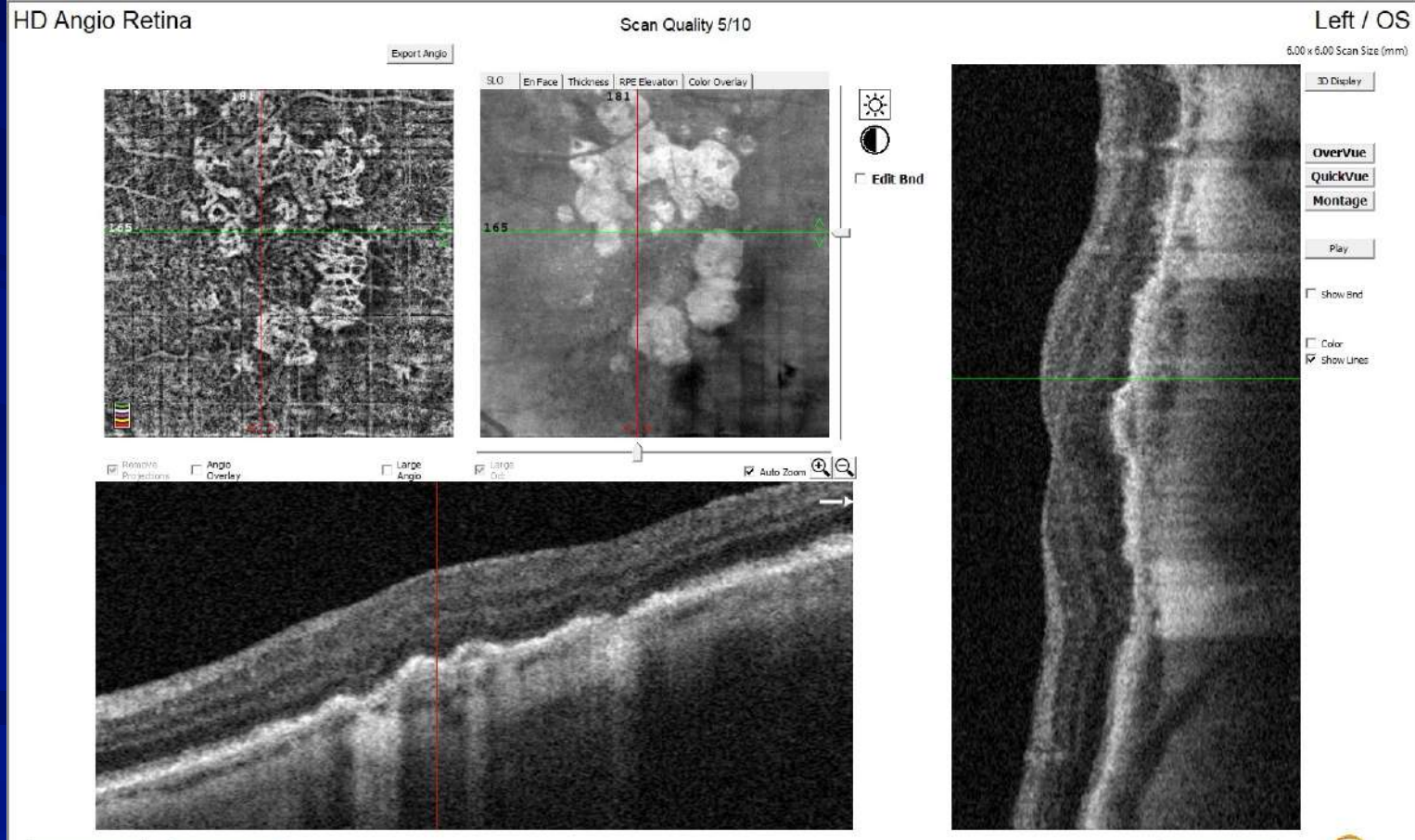
Case 2 - OCT Predictors of Progression



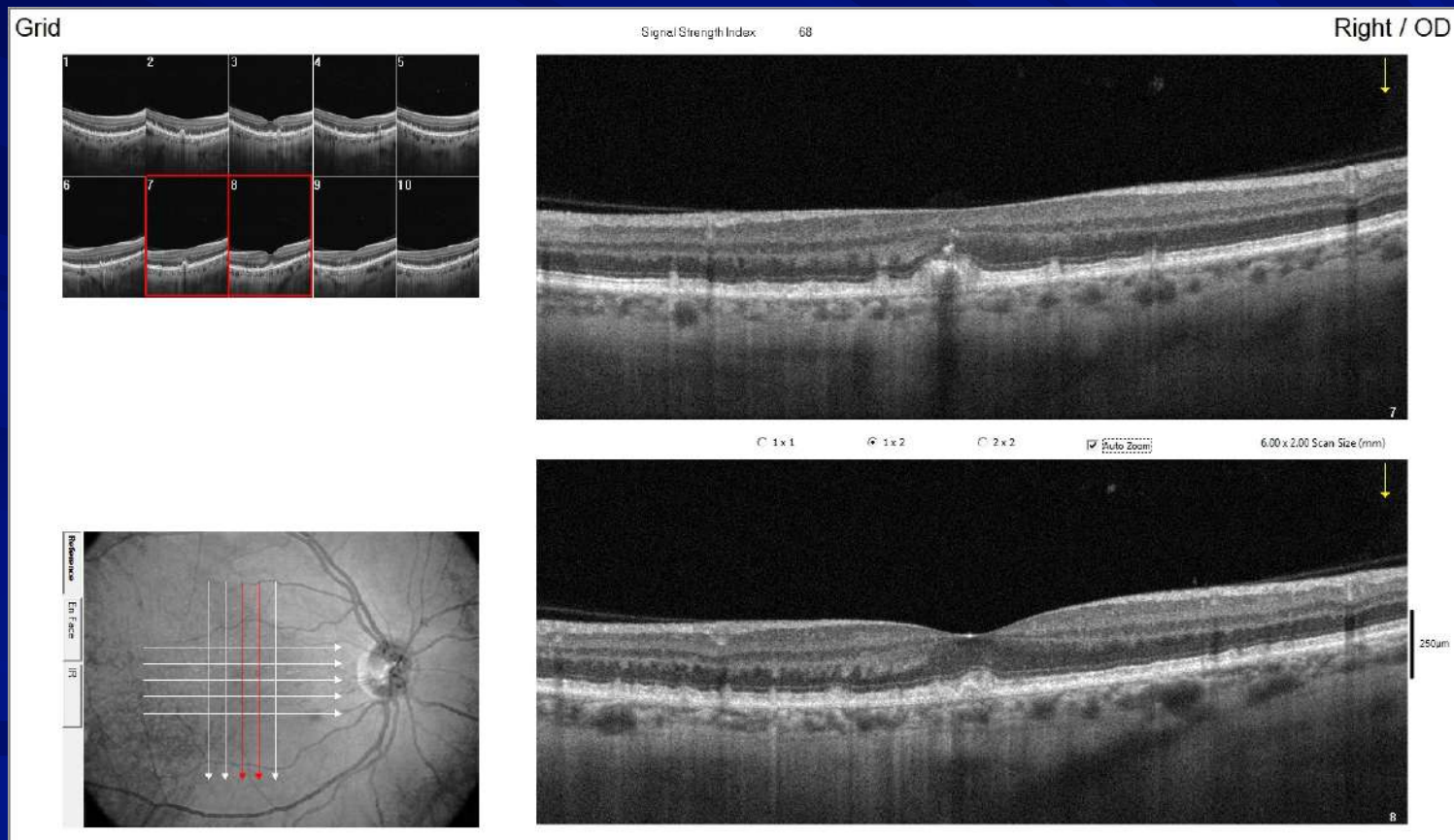
Case 3 - OCT Predictors of Progression



Case 4 - OCT Predictors of Progression



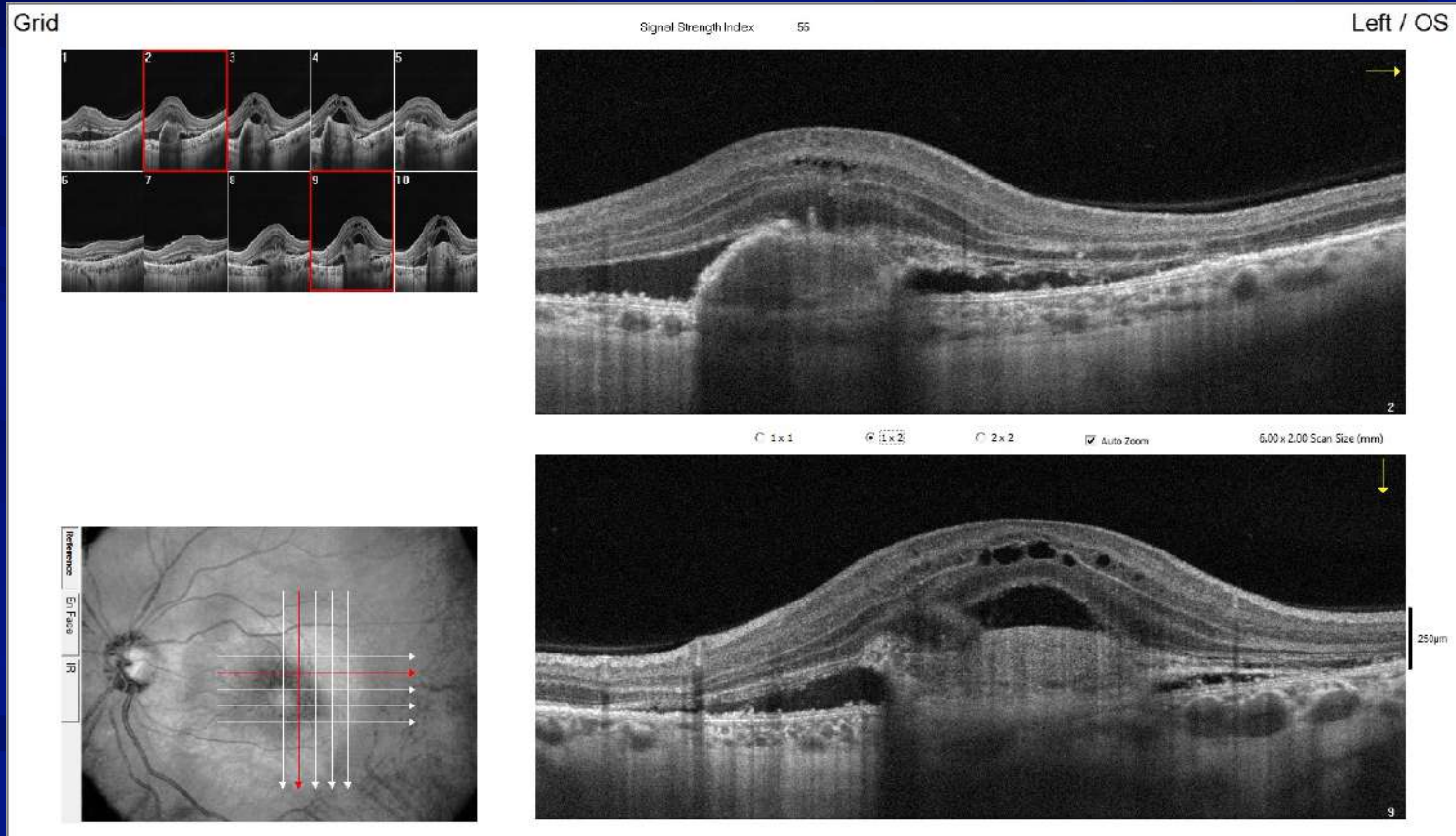
Case 5 - OCT Predictors of Progression



Case 5 - OCT Predictors of Progression



Case 5 - OCT Predictors of Progression



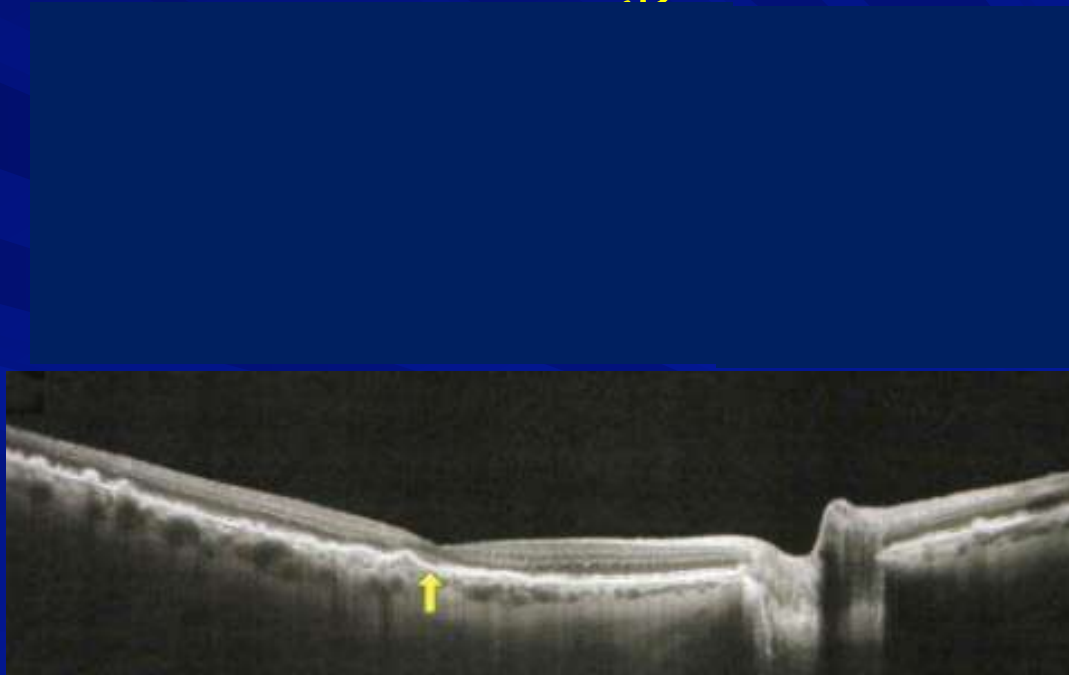
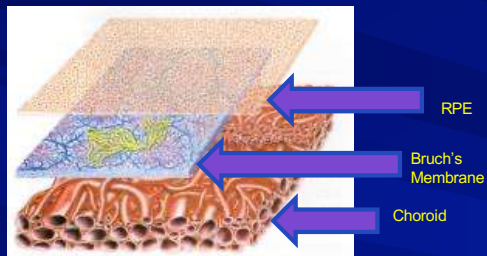
OCT Angiography in AMD

Structure Test

- ✍ Able to identify occult or classic CNV before they leak
- ✍ Non-invasive technique
- ✍ Subclinical CNV or “Occult non-exudative CNV”
 - ★ Risk of exudation at 12 months is 15.2 times greater compared to eyes without subclinical CNV

Type 1 “Occult” CNV

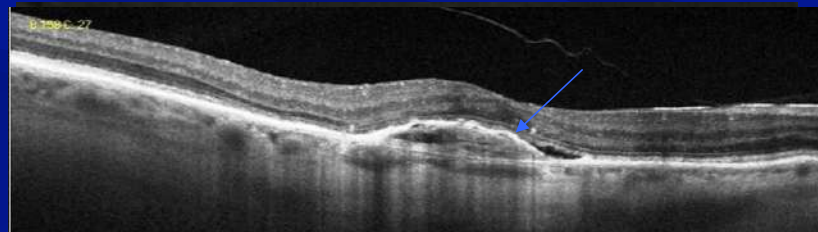
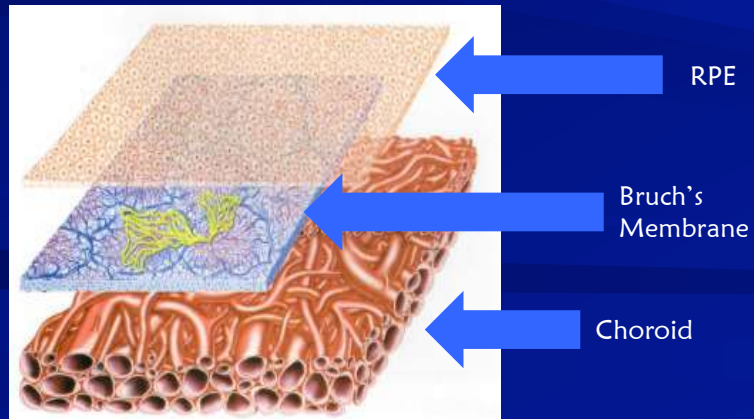
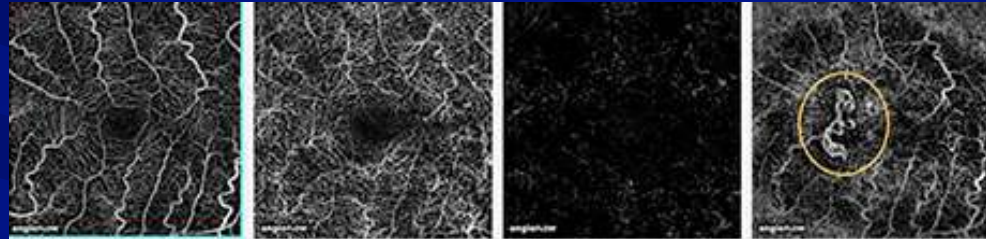
CNV



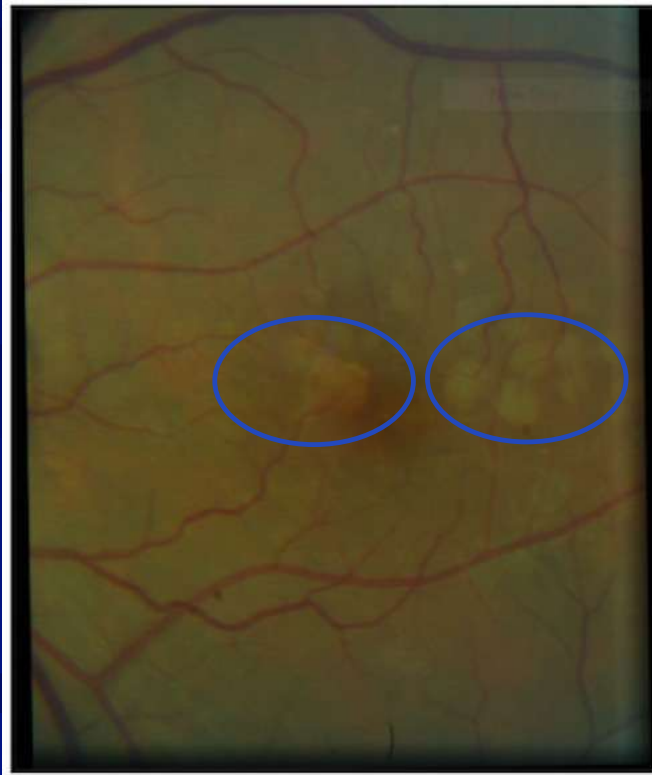
- ▶ New vessels develop in the choroid
- ▶ New vessels located below RPE and above Bruch's membrane

Type 1 “Occult” CNV

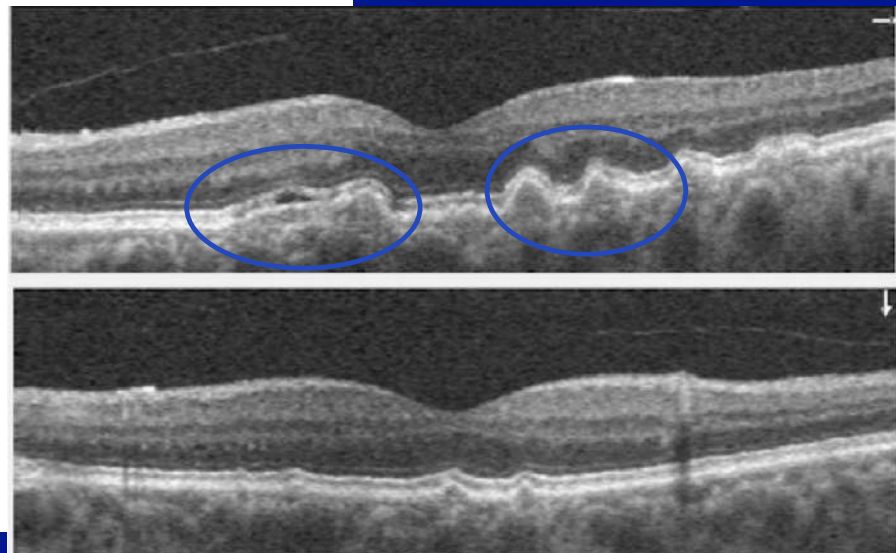
- ↪ New vessels develop in the choroid
- ↪ New vessels located **BELOW RPE** and **ABOVE** Bruch’s membrane



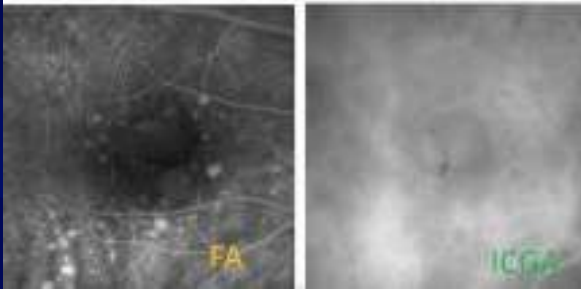
CNV?



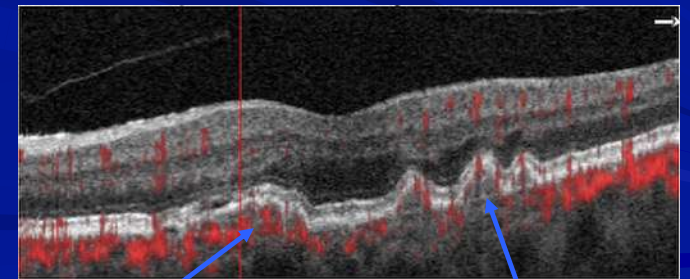
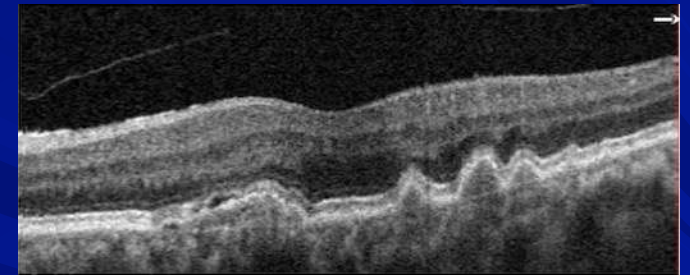
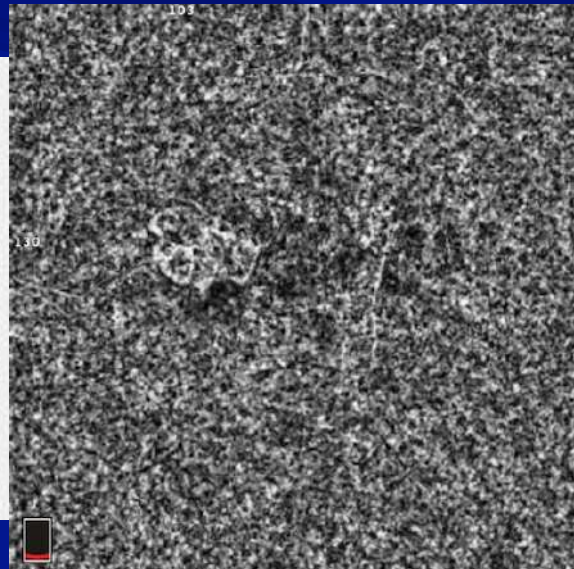
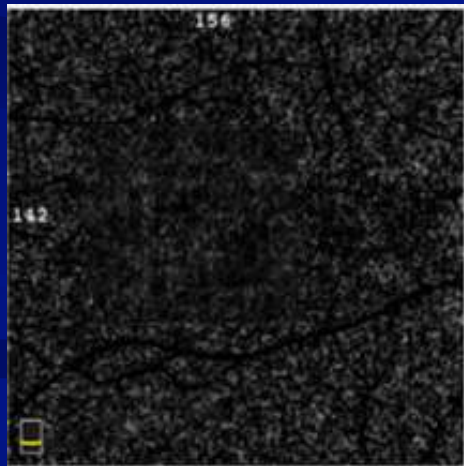
72 y/o Hispanic male
20/30
History of "Dry AMD"



Multimodal imaging and OCTA



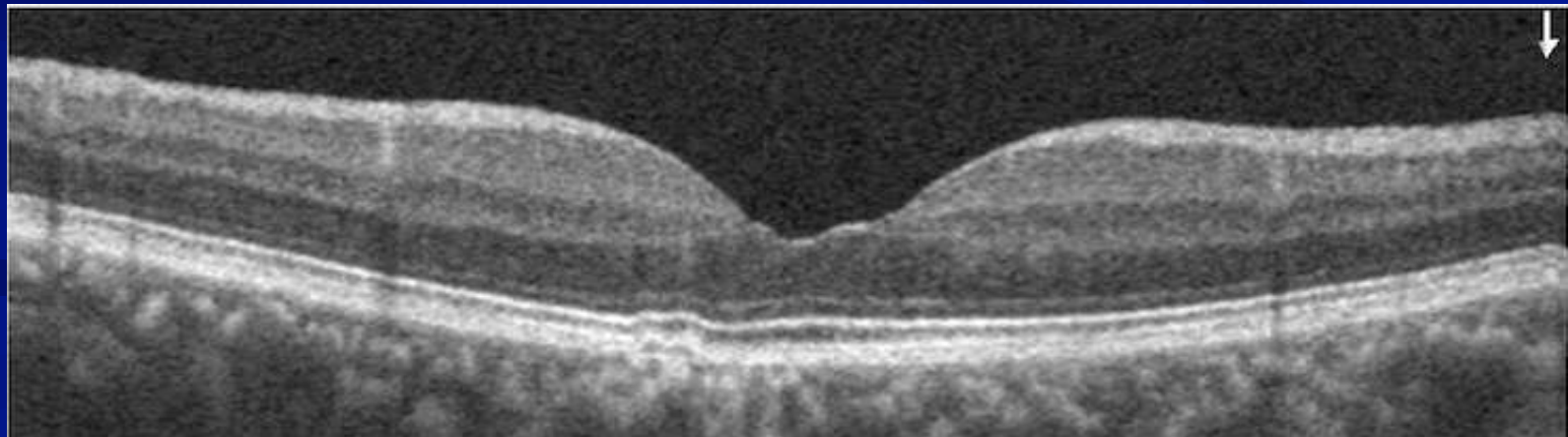
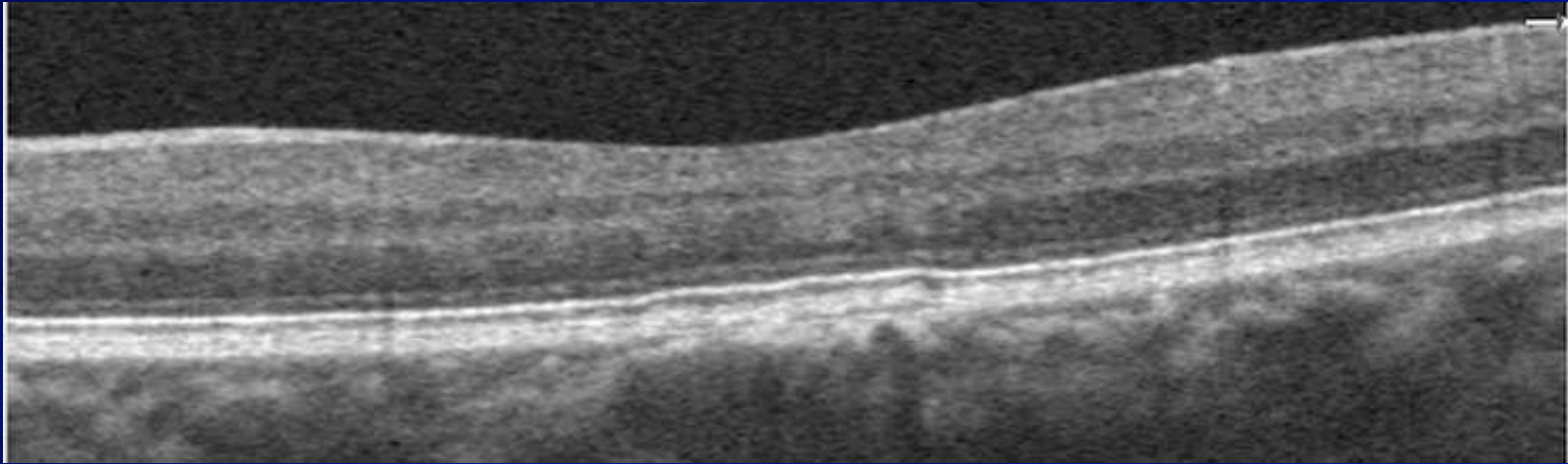
VAGUE???

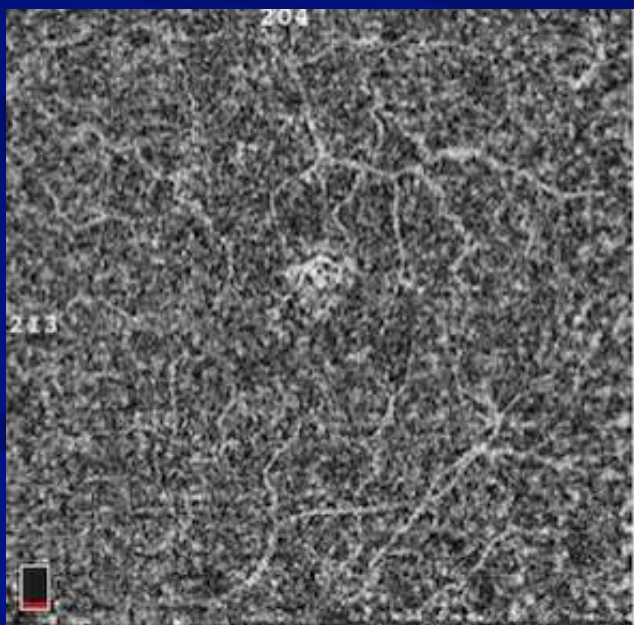
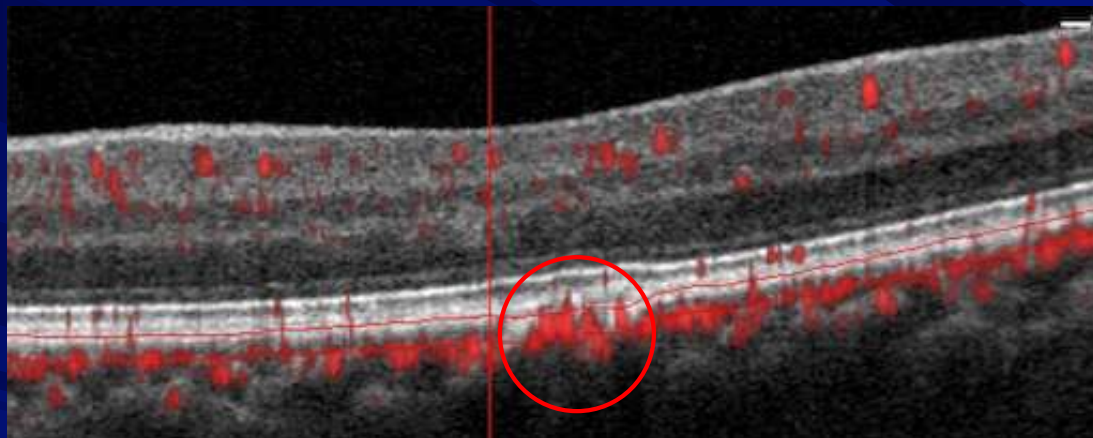


Vascularized

Non-vascularized

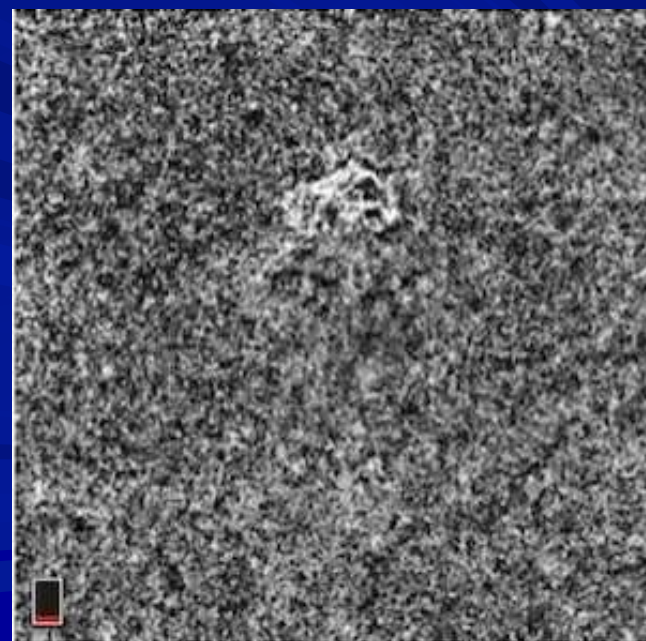
And the not so obvious ones...



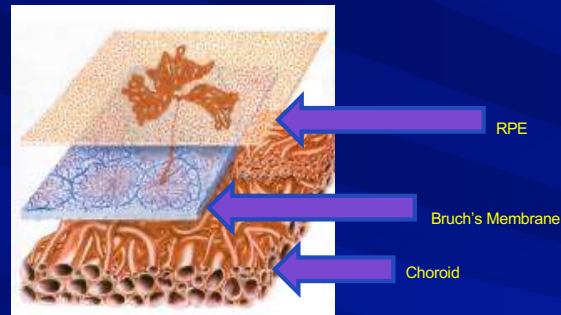


6x6

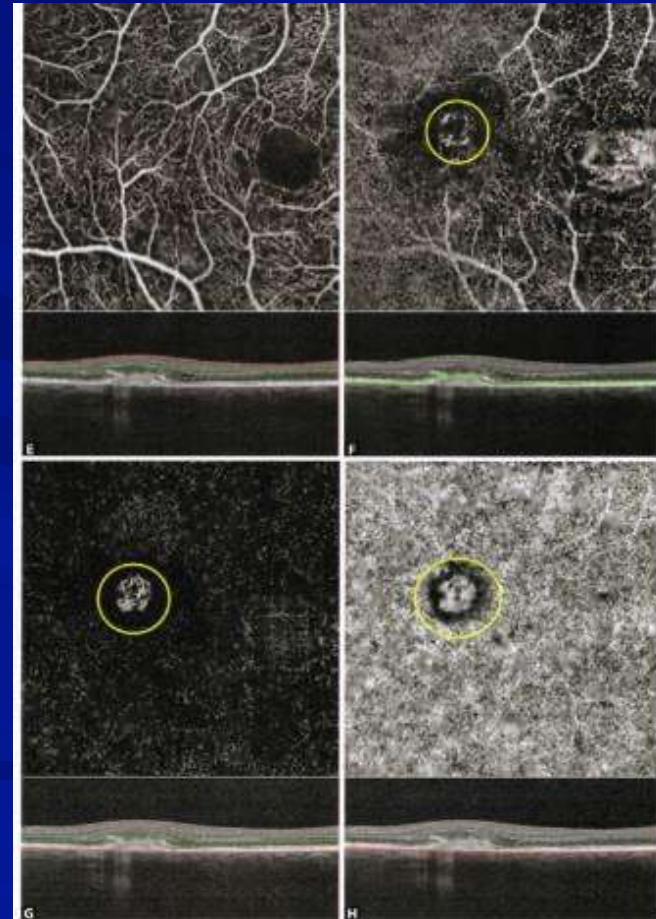
3x3



Type 2 “Classic” CNV

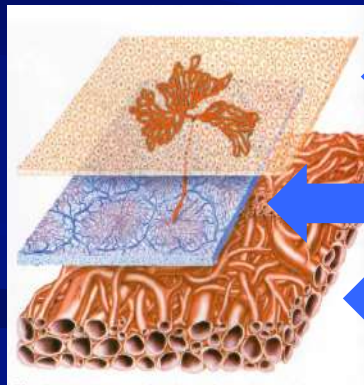


- ✍ New vessels develop in choroid
- ✍ New vessels located above the RPE and above Bruch's membrane



Type 2 “Classic” CNV

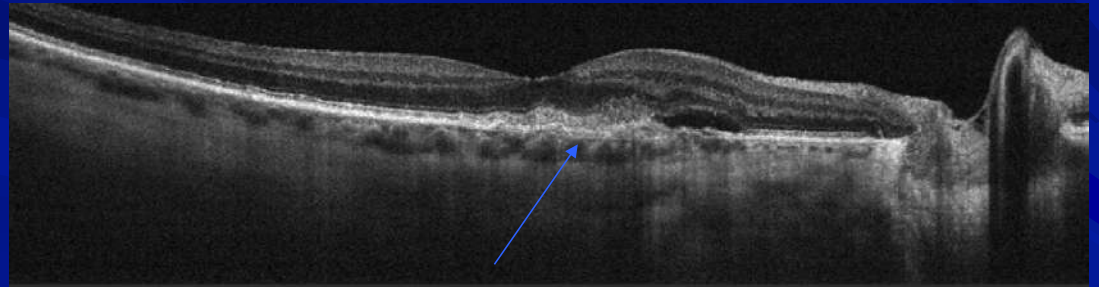
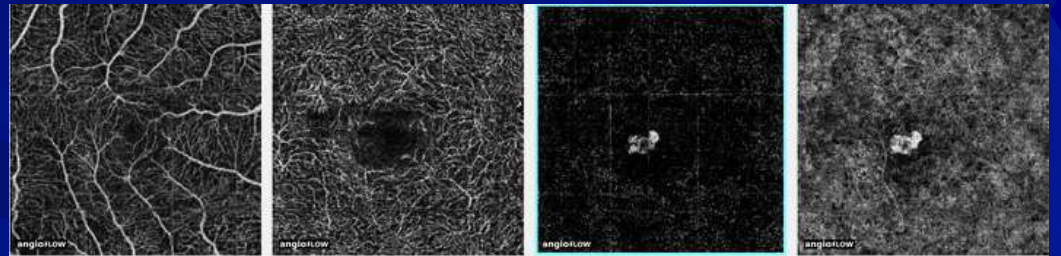
- 🌀 New vessels develop in choroid
- 🌀 New vessels located **ABOVE** the RPE and **ABOVE** Bruch’s membrane



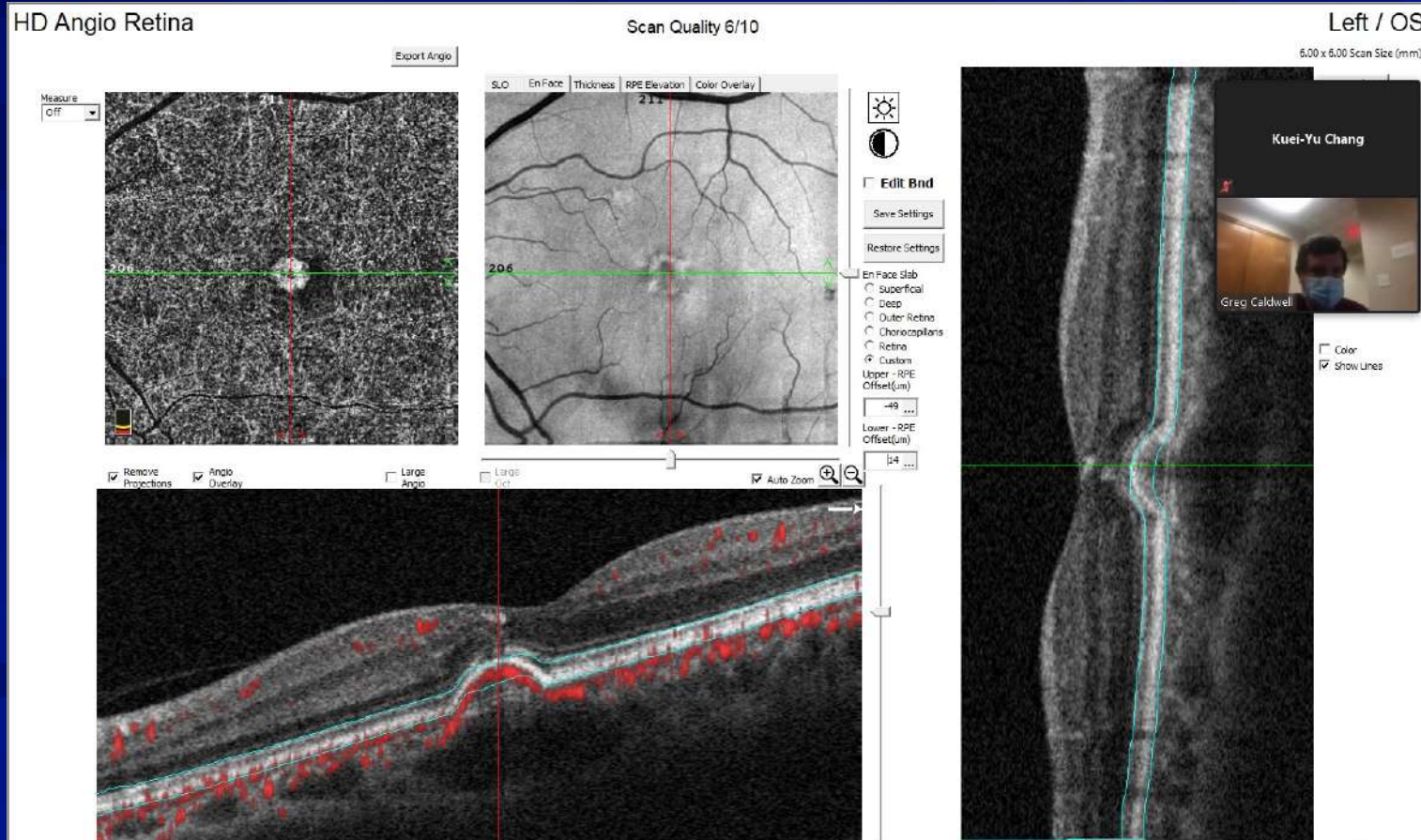
RPE

Bruch's Membrane

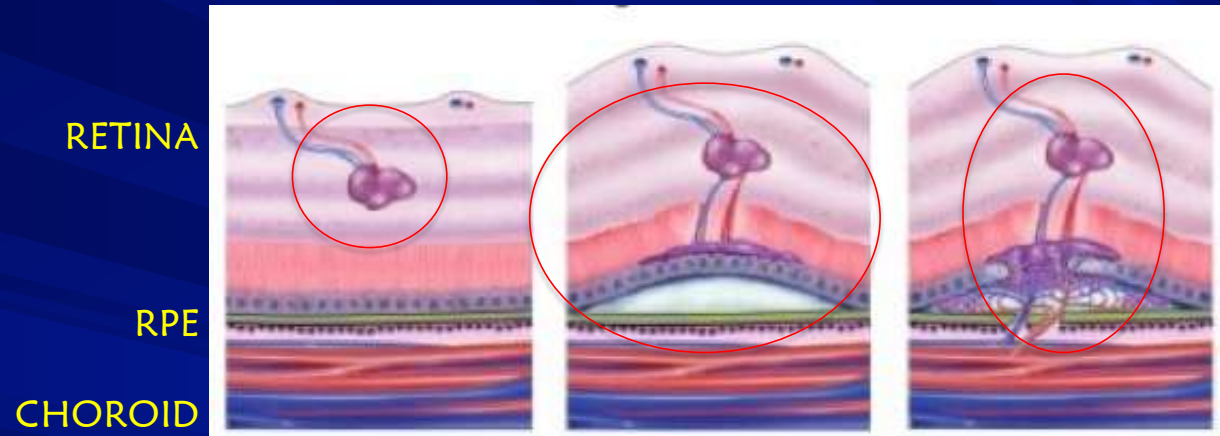
Choroid



Why I Love to Teach



Retinal Angiomatous Proliferation



Stage 1

Intra-retinal
proliferation

- *Hemes
- *Edema
- *Exudate

Stage 2

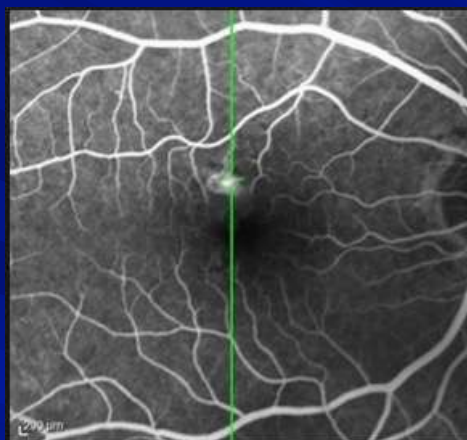
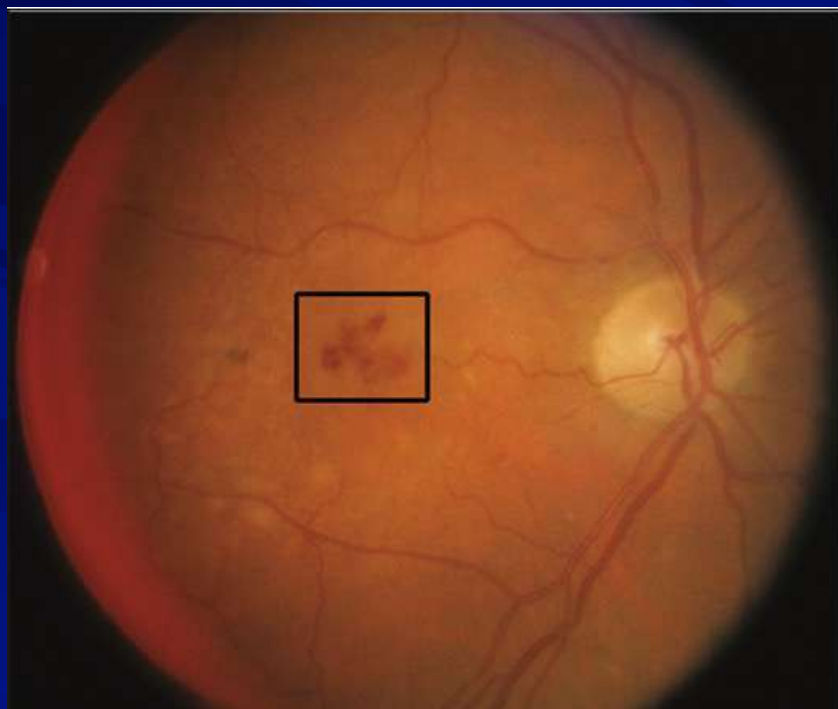
Neovascularization
penetrates the sub-
retinal space

- *Neurosensory
detachment
- *Serous PED

Stage 3

Neovascularization
penetrates the
RPE space

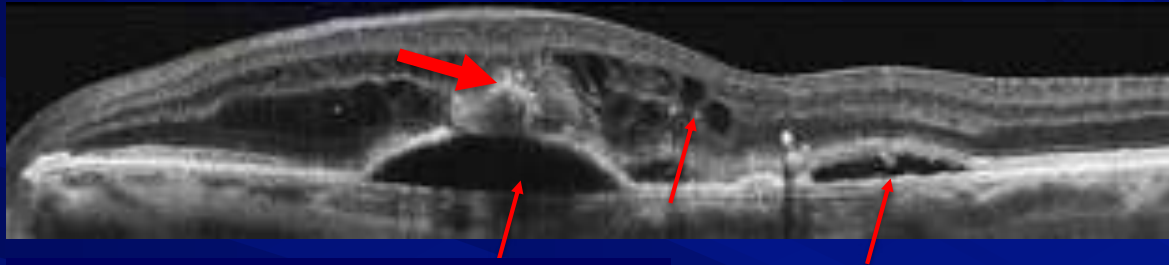
- *Vascularized PED;
CNVM



https://www.researchgate.net/figure/In-retinal-angiomaticous-proliferation-fluorescein-angiography-FA-shows-a-hot-spot-in_fig8_264903506

<https://jamanetwork.com/journals/jamaophthalmology/fullarticle/42089>

Inspect the SD-OCT carefully!!



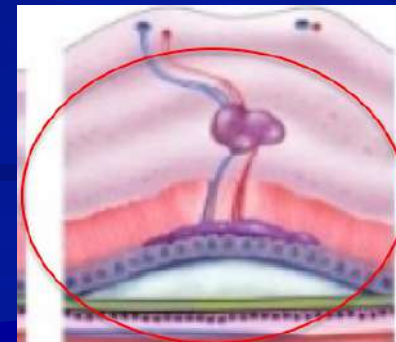
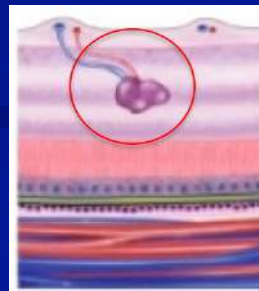
VA 20/40

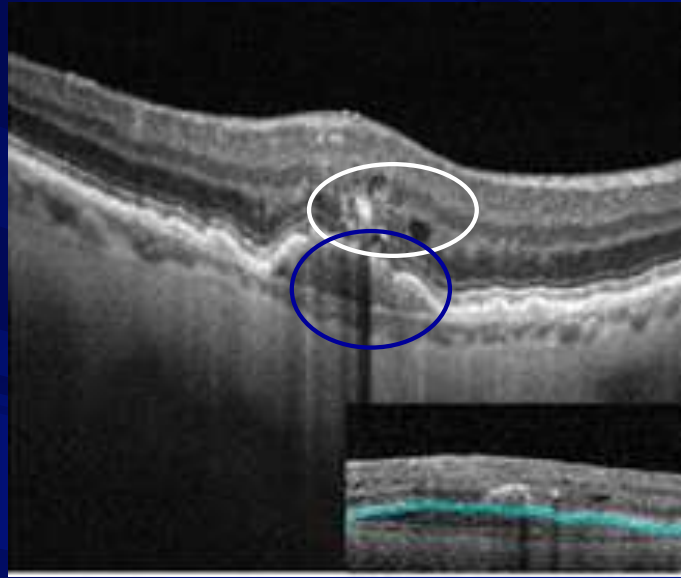
HYPER-REFLECTIVE lesion above
pigment epithelial detachment

Intraretinal cysts

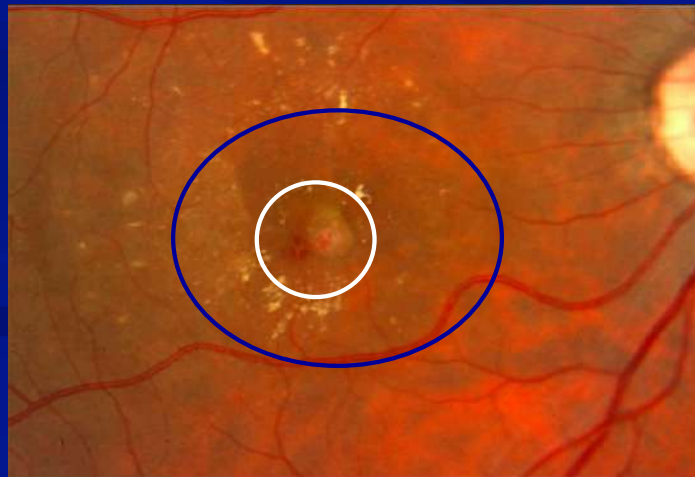
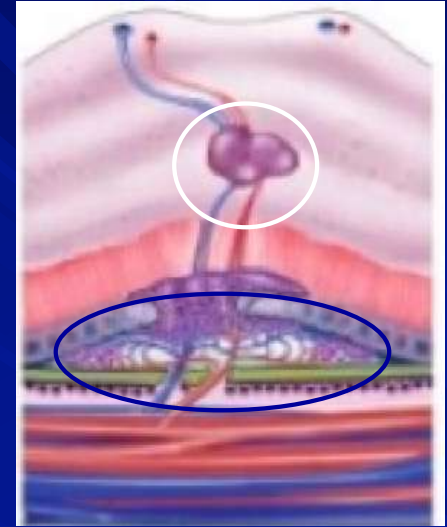
Serous pigment epithelial
detachment/ neurosensory
detachment

Stage 2





Stage 3



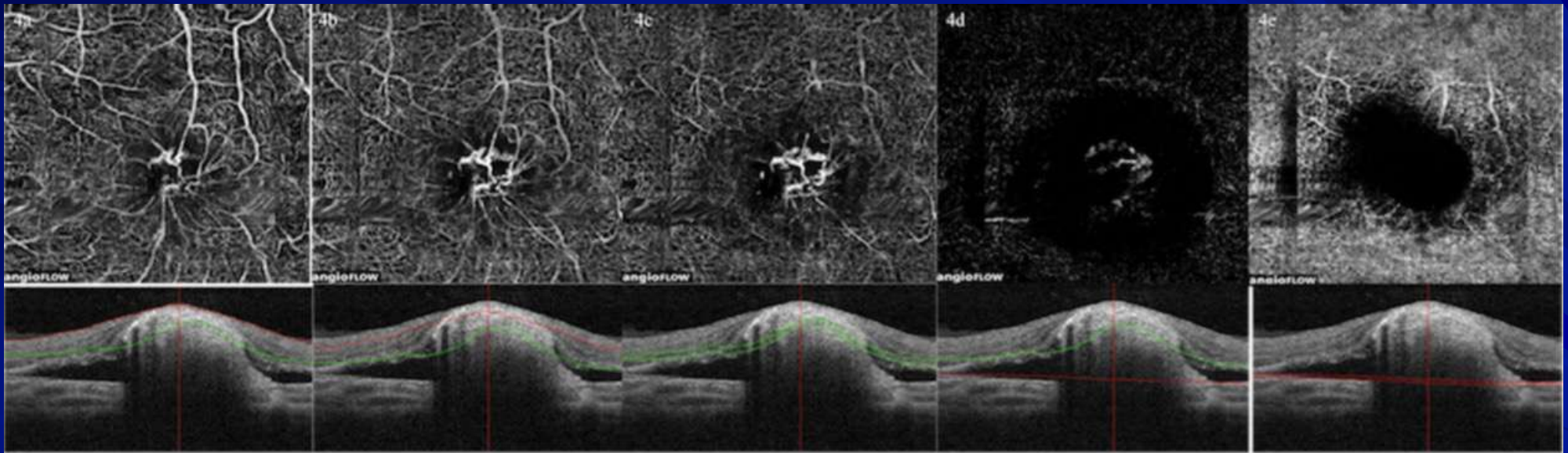
<http://imagebank.asrs.org/file/26943/retinal-angiomas-proliferation>
<https://www.ncbi.nlm.nih.gov/pubmed/29019795>

What about the OCTA?

OCT angiography demonstrates retinal angiomatous proliferation and chorioretinal anastomosis of type 3 neovascularization

Reema Bansal · Varshitha Hemanth · Sunyak Mulkar · Ramandeep Singh · Vishali Gupta · Mangat R. Dogra · Amod Gupta

Type 3 CNV: Intraretinal Anastomosis: THROUGH RPE



Inner retina (SCP+DCP) to Outer retina (Avascular/choriocapillaris)

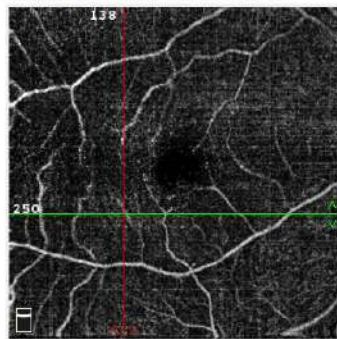
OCT Angiography Evaluation AMD

Angio Retina QuickVue

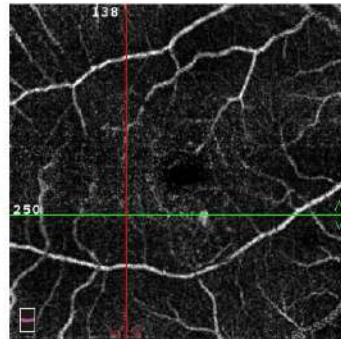
Scan Quality 2/10

6.0 x 6.0 Scan Size (mm)

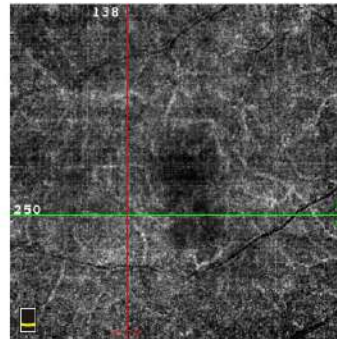
Right / OD



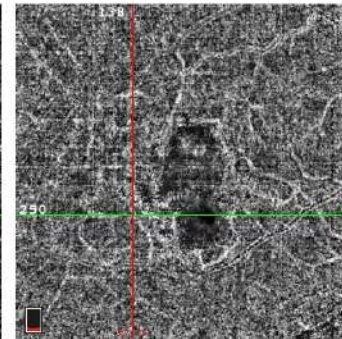
Superficial (ILM - IPL)



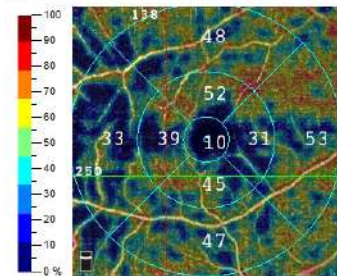
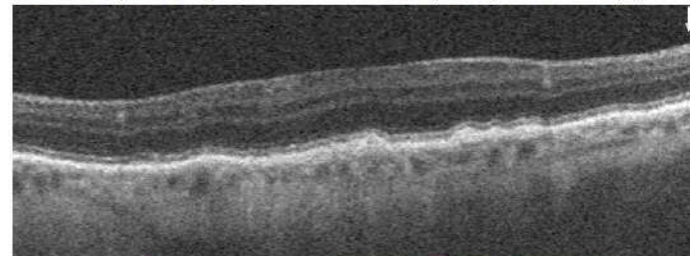
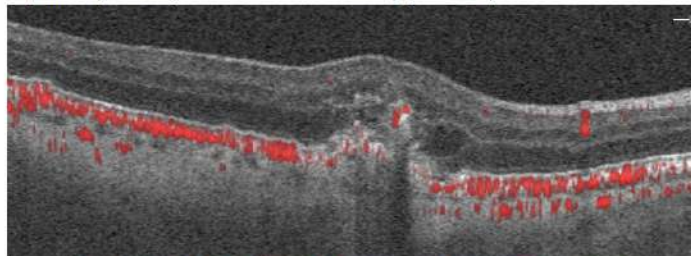
Deep (IPL - OPL)



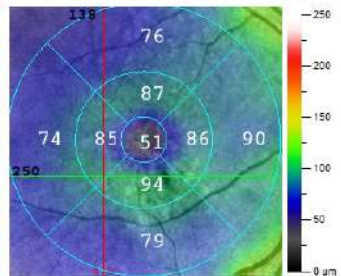
Outer Retina (OPL - BRM)



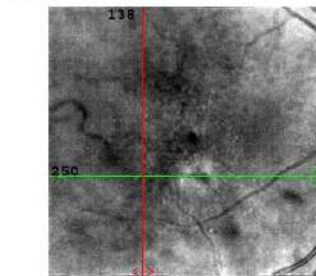
Choriocapillaris (BRM - BRM+30µm)



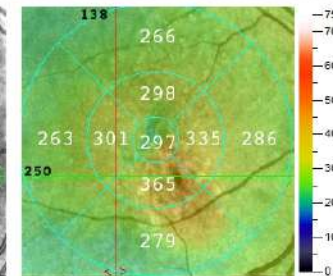
Vessel Density (Superficial)



Inner Thickness (ILM - IPL)



SLO



Full Thickness (ILM - RPE)

Exit
Print
OverVue

☒ Show Lines

☐ Show End

☒ Angio Overlay

☒ Auto Zoom



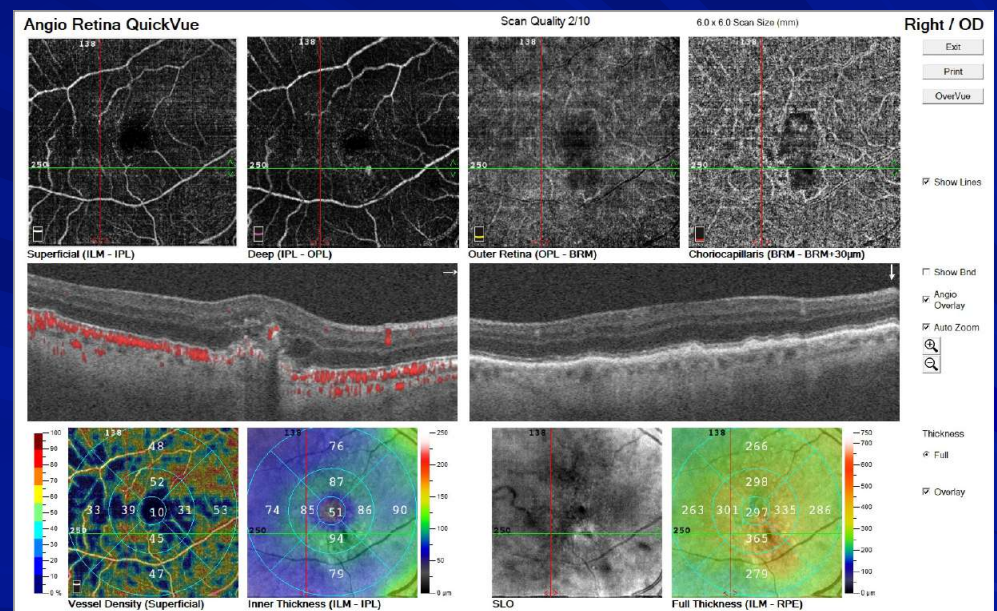
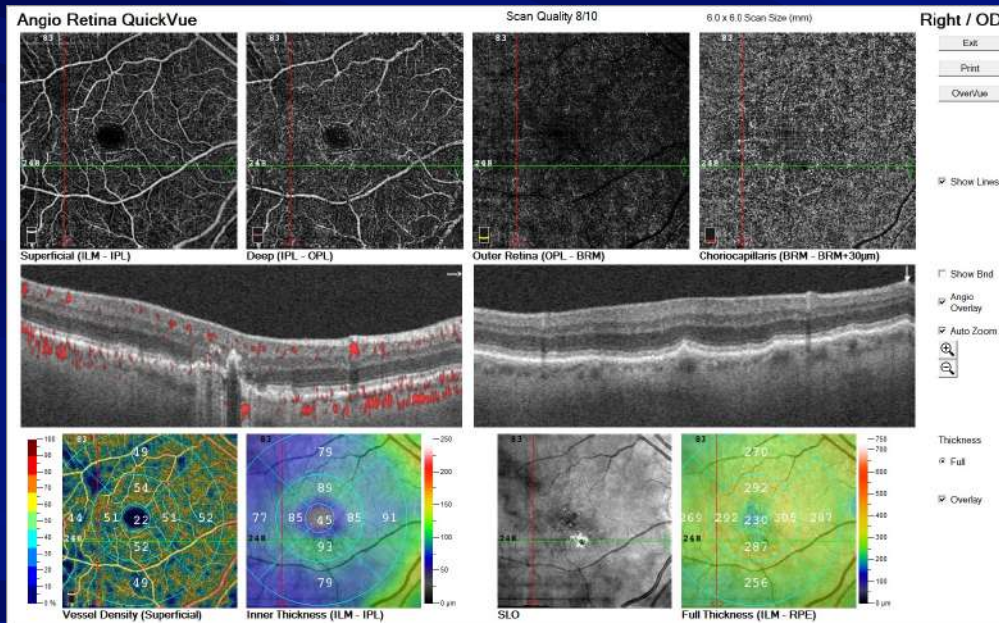
Thickness

☒ Full

☒ Overlay

OCT Angiography Evaluation AMD

After and Before Bevacizumab (Avastin)

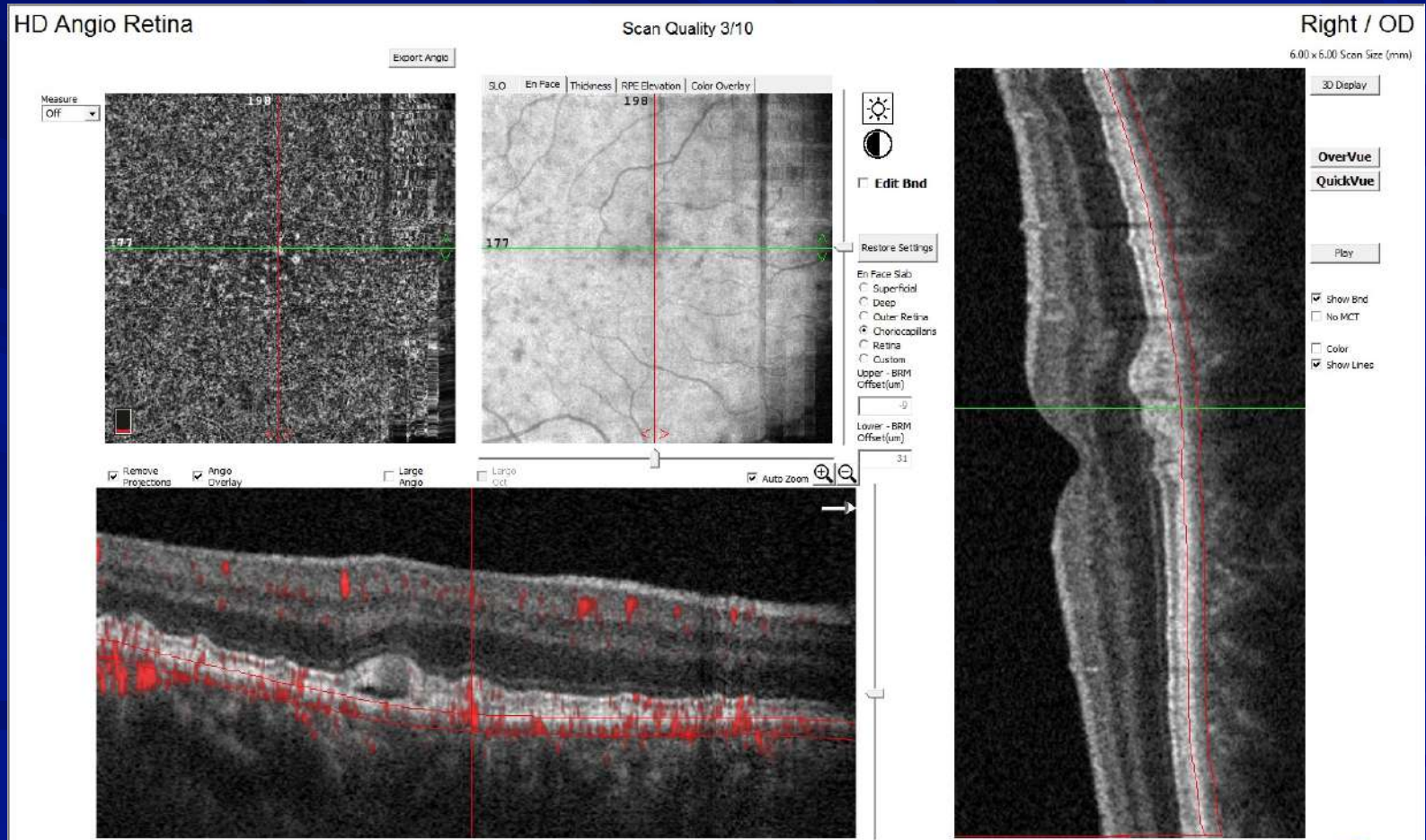


OCT Angiography

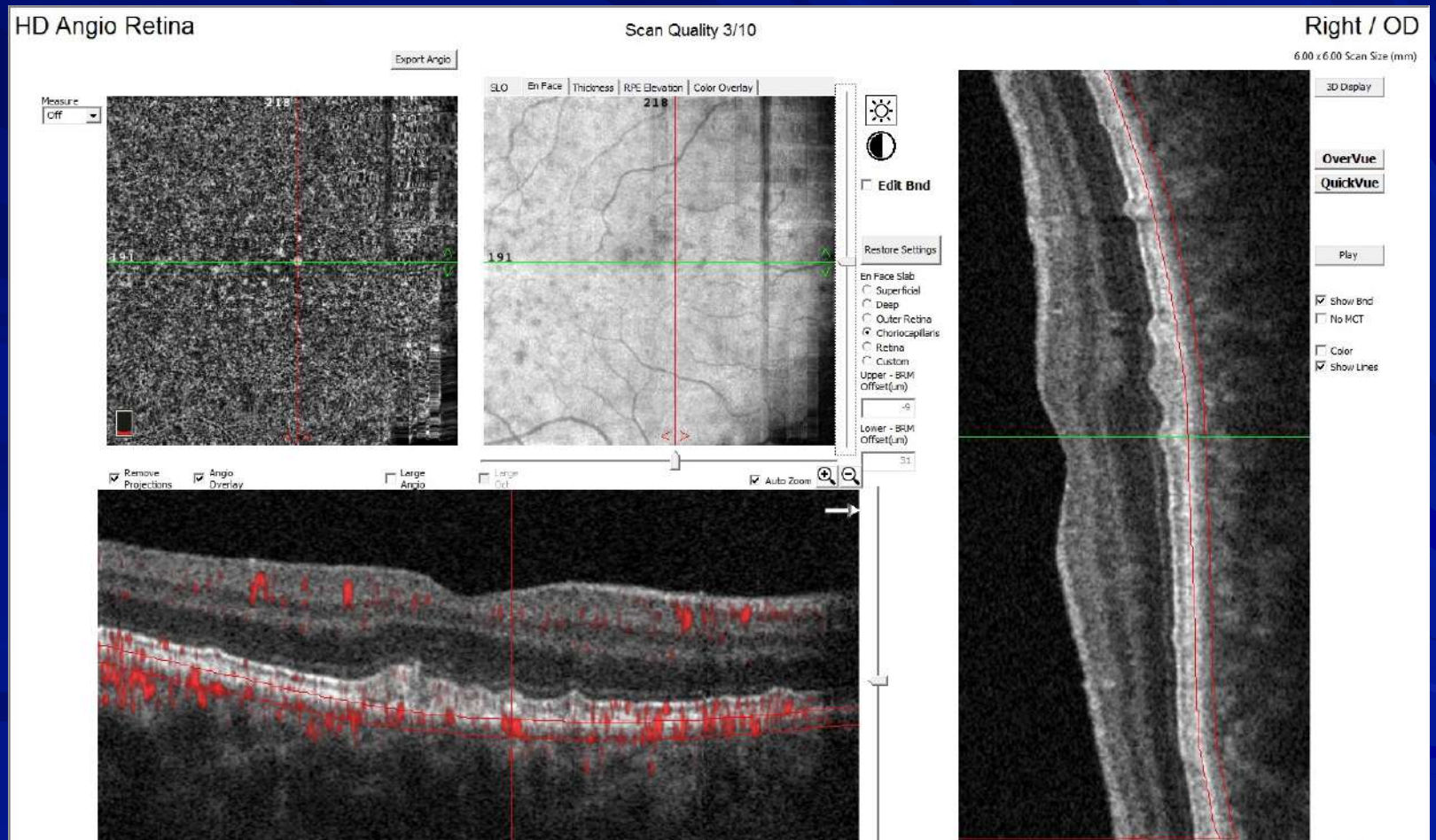
Subclinical CNV or “Occult non-exudative CNV”

Risk of exudation at 12 months is 15.2 times greater compared to eyes without subclinical CNV

Occult
Non-Exudative
CNV
Patient A



Occult
Non-Exudative
CNV
Patient A



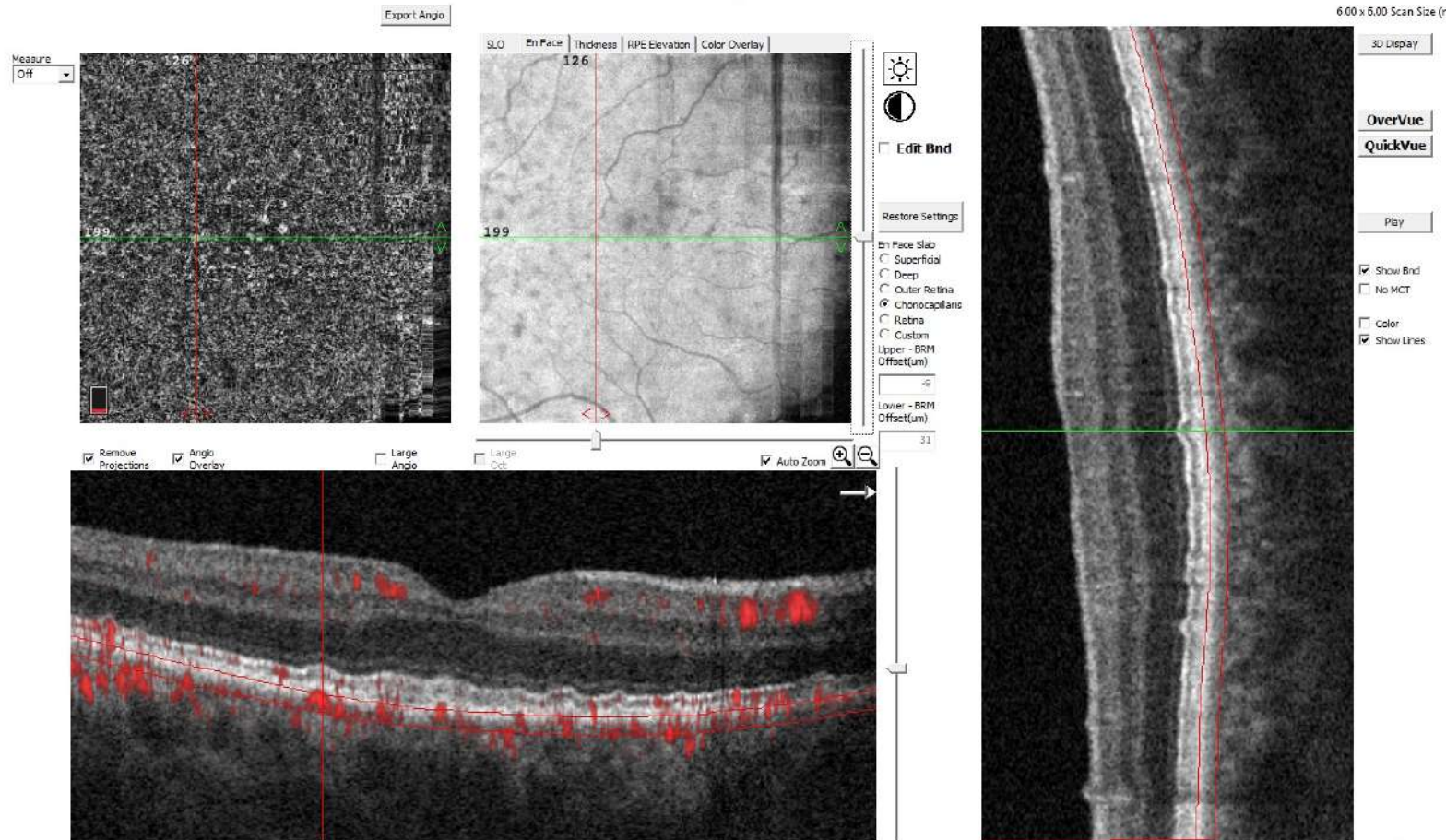
Occult
Non-Exudative
CNV
Patient A

HD Angio Retina

Scan Quality 3/10

Right / OD

6.00 x 5.00 Scan Size (mm)



Which is More Suspicious?

HD Angio Retina

Scan Quality 7/10

Right / OD

Measure
Off

Export Angio

SLO En Face Thickness RPE Elevation Color Overlay

6.00 x 6.00 Scan Size (mm)

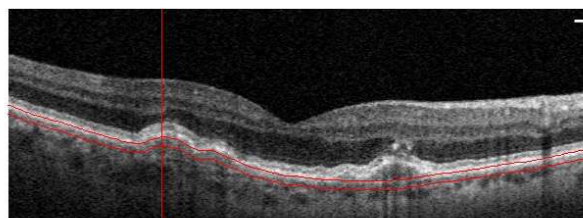
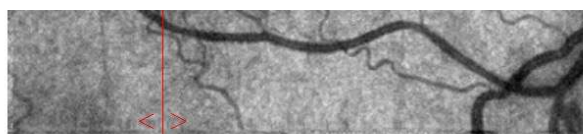
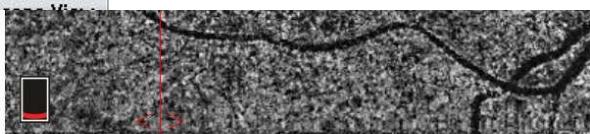
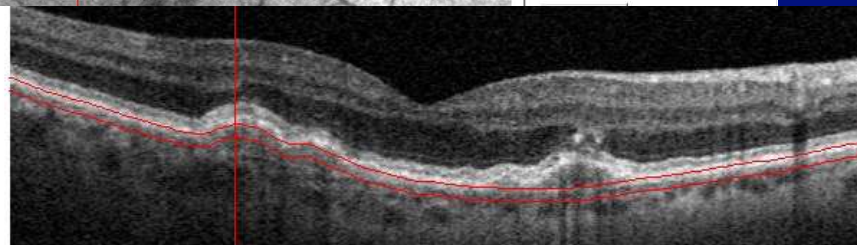
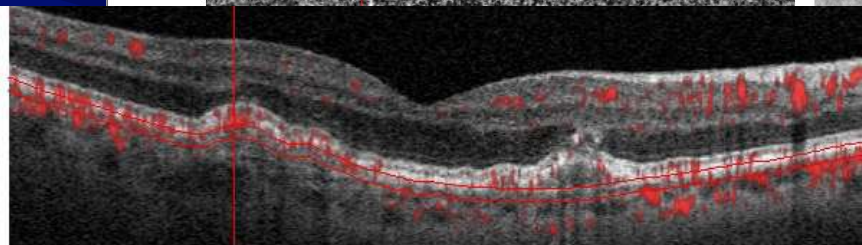
3D Display



☐ Edit Bnd

OverVue

QuickVue



☒ Auto Zoom



Treatments for AMD

🕒 Early detection and meaningful treatments with significant value, do not cure, but have been shown to slow or halt progression. Not limited to early stages but all stages of AMD

- ★ Prescribe smoking cessation programs

- 📋 Smoking and AMD

- Depletes serum antioxidants
 - Decreases pigmentary density
 - Increases risk to advanced AMD

- ★ Lifestyle changes

- 📋 Diet

- 📋 Exercise

- ★ Systemic disease management

- 📋 Cardiovascular disease, DM, obesity, high cholesterol

Treatment for AMD

🕒 Nutritional supplements

★ Sub-clinical/sub-structural or early disease

- 📋 Controversy flourishes
 - No definitive guideline exists
 - Despite consensus evidence suggests using supplements

★ Intermediate – advance disease

- 📋 No controversy on advocating for supplements

★ AREDS 1

- 📋 Contains Beta-carotene and no lutein or zeaxanthin, no longer recommended
- 📋 Investigated early AMD, no statistically significant benefit

★ AREDS 2

- 📋 Recommended for intermediate and advanced AMD, study protocol

★ The Practical Guide for the Treatment of AMD - 3 primary options

- 📋 Macular pigment supplement
 - Carotenoids: lutein, zeaxanthin, meso-zeaxanthin
- 📋 Carotenoids, antioxidants, zinc, and vitamins C & E
 - AREDS 2
- 📋 Carotenoid macular supplement in subclinical and early AMD. Carotenoid and antioxidant is intermediate and AMD that is progressing

Treatment for AMD

Retinal light protection

- ★ Sun exposure

Closer follow up

- ★ 12 months is currently accepted as being too long to detect progression
- ★ 6 months or sooner based on risk of CNV

Low vision and rehabilitation consultation

Macular Pigment



Macular Pigment

Imaging lutein and zeaxanthin in the human retina with confocal resonance Raman microscopy

Binxing Li^a, Evan W. George^a, Gregory T. Rognon^a, Aruna Gorusupudi^a, Arunkumar Ranganathan^a, Fu-Yen Chang^a, Linjia Shi^a, Jeanne M. Frederick^a, and Paul S. Bernstein^{a,1}

^aDepartment of Ophthalmology and Visual Sciences, Moran Eye Center, University of Utah School of Medicine, Salt Lake City, UT 84132

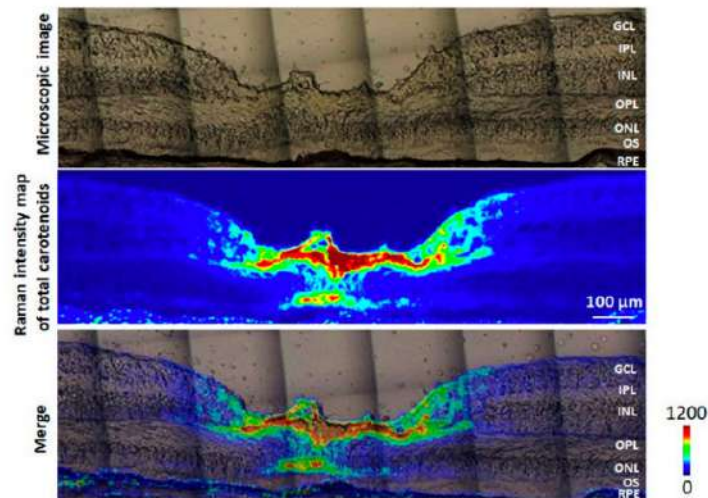
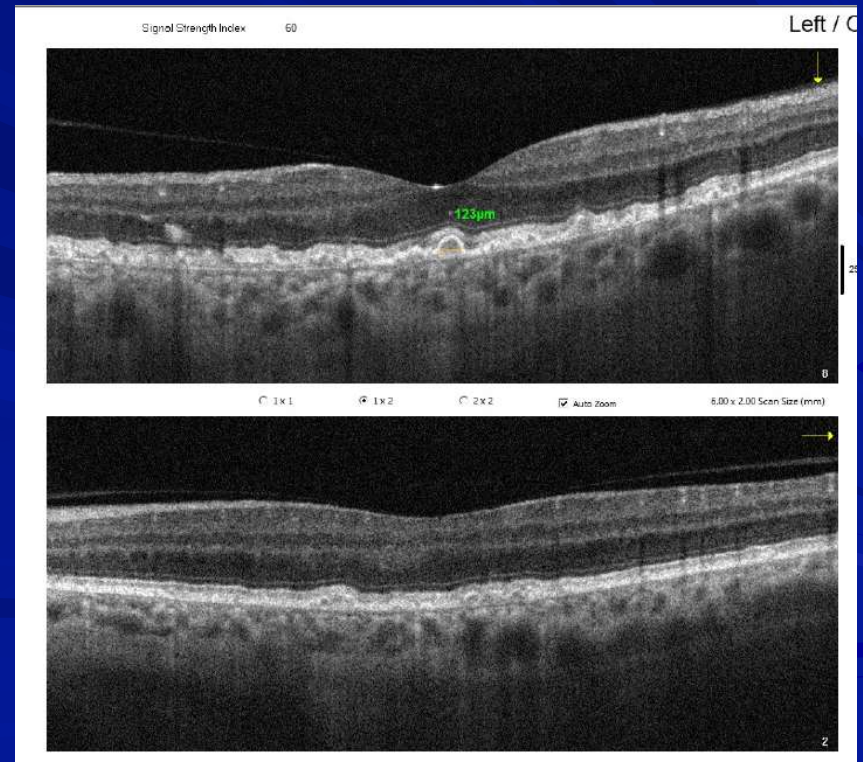


Fig. 4. Distribution of total carotenoids in a human retinal section. (Top) A



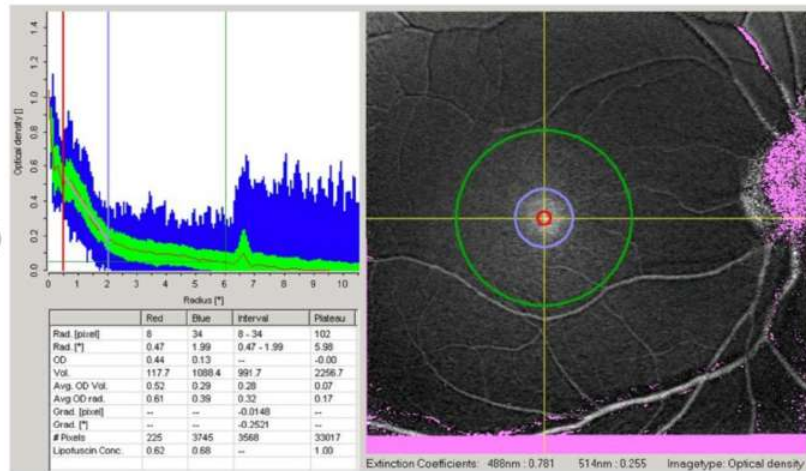
Macular Pigment and the Retina

Figure - uploaded by [Tiago Santos Prata](#)

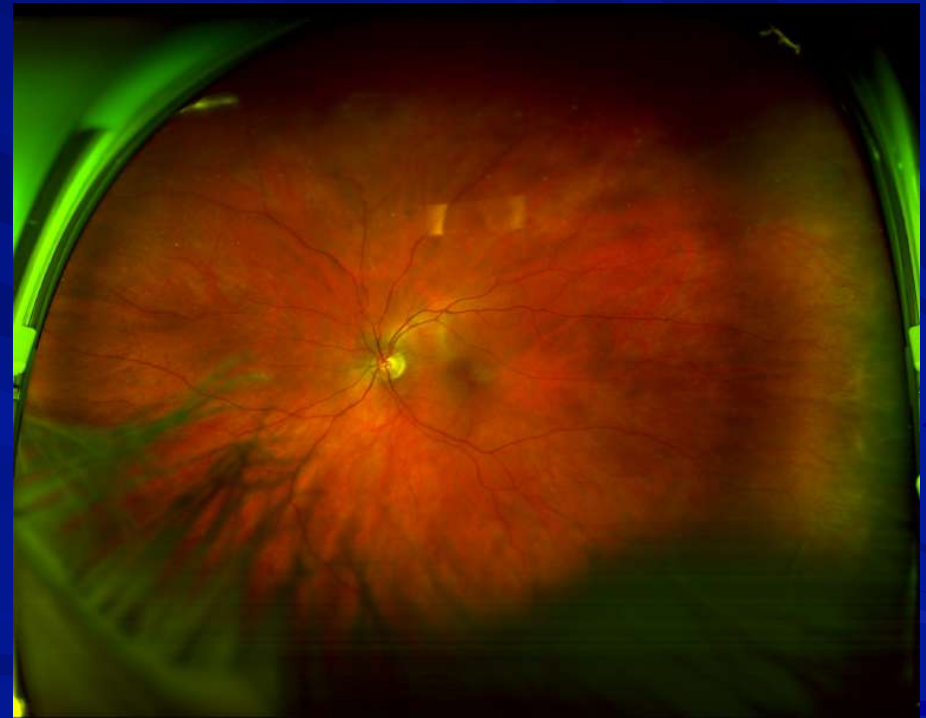
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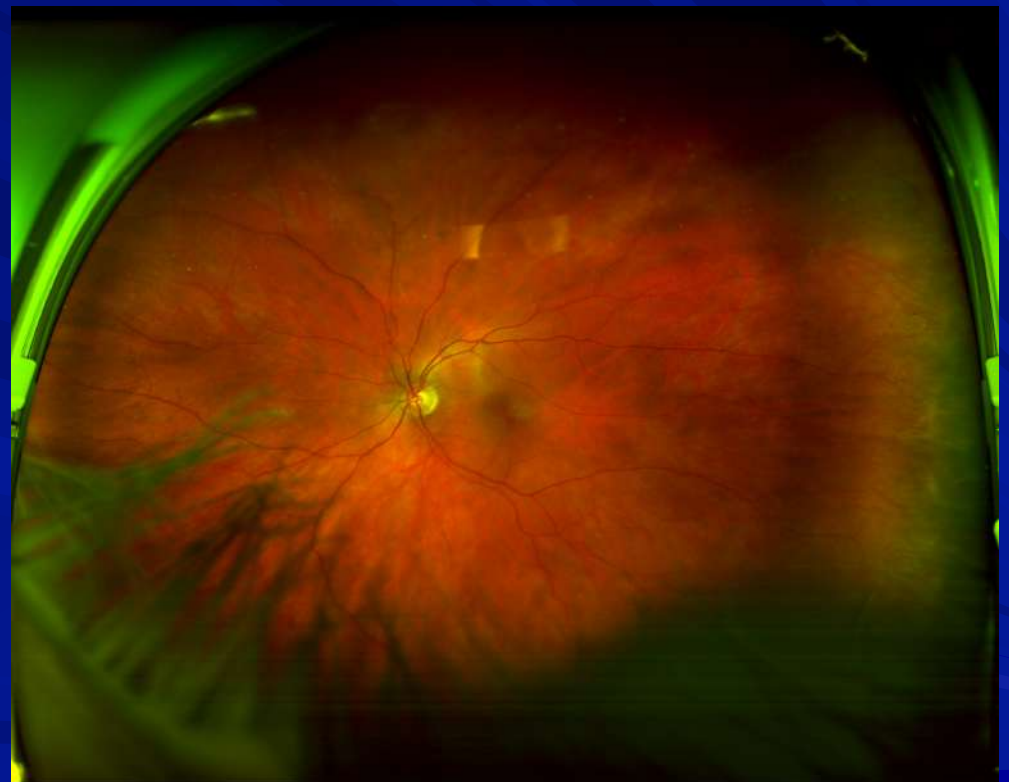
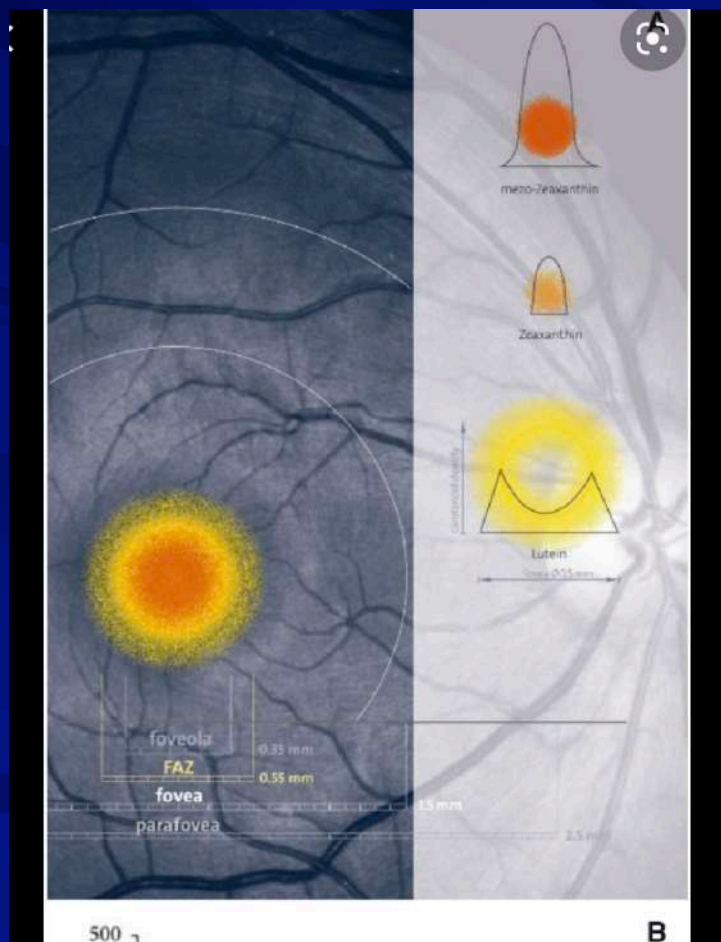
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Macular pigment optical density map of one eye included in the study. Notes: The image analyzed is demonstrated on the right side of the dialog. Two yellow lines mark the point used for radial analysis. The red and blue circles demarcate areas of 0.5 and 2.0 degrees from the center of the fovea, respectively. On the upper left side of the dialog there is a diagram with a normal radial distribution of macular pigment optical density around the center of the fovea. On the lower left side, the box shows numerical values for macular pigment optical density in the specific eccentricities analyzed.





Macular Pigment

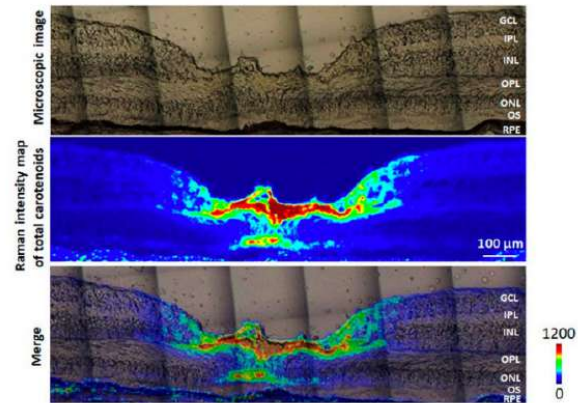
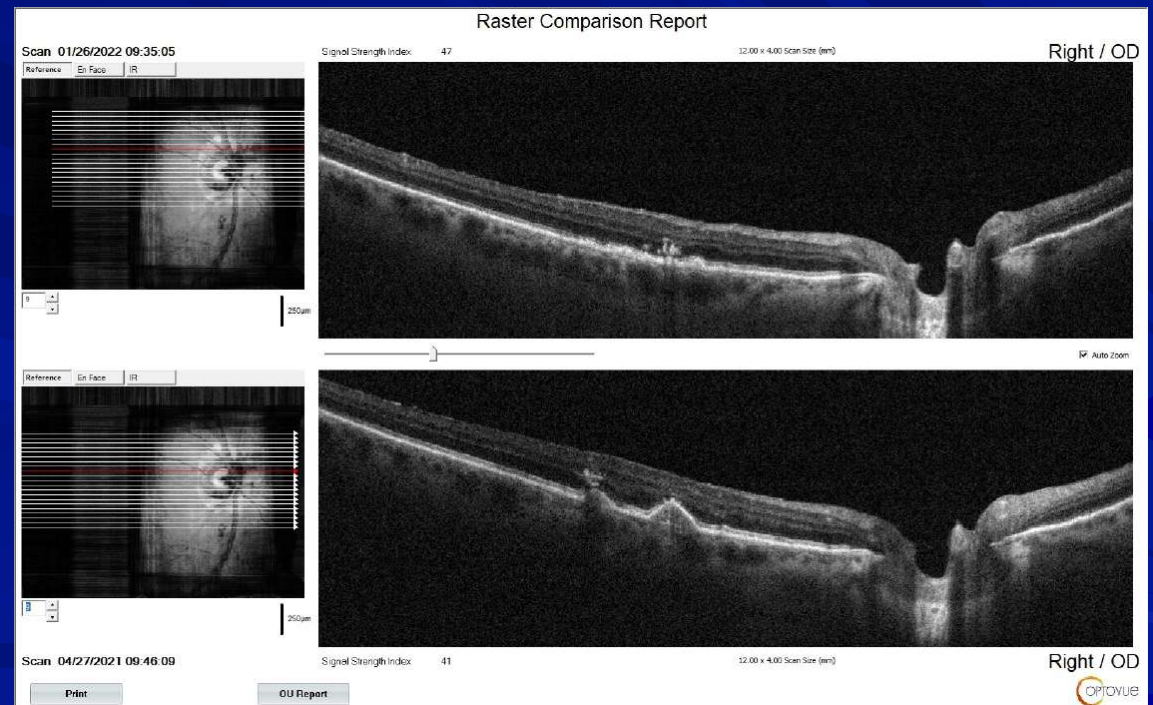
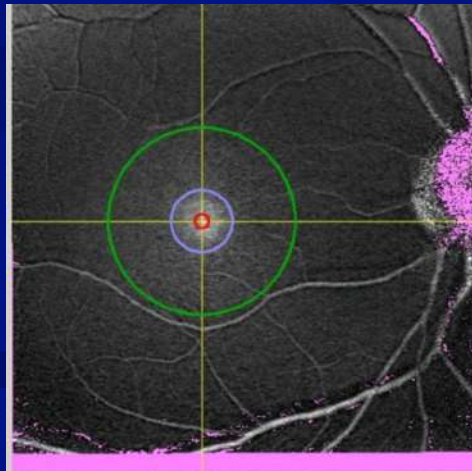


Fig. 4. Distribution of total carotenoids in a human retinal section. (Top) A





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PMID: [30891116](#)

Health Benefits of Polyphenols and Carotenoids in Age-Related Eye Diseases

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Abstract

Go to:

Oxidative stress and inflammation play a critical role in the initiation and progression of age-related ocular abnormalities as cataract, glaucoma, diabetic retinopathy, and macular degeneration. Therefore, phytochemicals with proven antioxidant and anti-inflammatory activities, such as carotenoids and polyphenols, could be of benefit in these diseases. We searched PubMed and Web of Science databases for original studies investigating the benefits of different carotenoids and polyphenols in age-related ophthalmic diseases. Our results showed that several polyphenols (such as anthocyanins, *Ginkgo biloba*, quercetin, and resveratrol) and carotenoids (such as lutein, zeaxanthin, and mezoanthin) have shown significant preventive and therapeutic benefits against the aforementioned conditions. The involved mechanisms in these findings include mitigating the production of reactive oxygen species, inhibiting the tumor necrosis factor- α and vascular endothelial growth factor pathways, suppressing p53-dependent apoptosis, and suppressing the production of inflammatory markers, such as interleukin- (IL-) 8, IL-6, IL-1 α , and endothelial leucocyte adhesion molecule-1. Consumption of products containing these phytochemicals may be protective against these diseases; however, adequate human data are lacking. This review discusses the role and mechanisms of polyphenols and carotenoids and their possible synergistic effects on the prevention and treatment of age-related eye diseases that are induced or augmented by oxidative stress and inflammation.

Treating Half the Retina?

Carotenoids and Polyphenols

www.oncotarget.com

Oncotarget, 2018, Vol. 9, (No. 24), pp: 17181-17198

Review

Oxidative stress: role of physical exercise and antioxidant nutraceuticals in adulthood and aging

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Keywords: exercise training; nutraceuticals; flavonoids intake; aging; antioxidant supplementation

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Resveratrol can be implied in anti-aging actions by influencing the mitochondrial environment and metabolic diseases, by regulating the levels of some inflammatory mediators and cytokines and by modulating lipolysis [125, 152, 153]. Mitochondrial dysfunction has been proved to be associated with aging and disease development [154], and it was seen

Furthermore, resveratrol maintains the vascular fitness through its antioxidant and anticoagulant activities, and on the other hand is relevant in blocking the formation of new blood vessels, in inhibiting the VEGF release and attenuating Hypoxia-Inducible Factor (HIF-1α) in different tumor cells [163].

It is reported that also curcumin possesses anti-

ASSESSMENT OF CAROTENOIDS

Impact of Carotenoid Assessment

Because carotenoids appear to play a key role in retinal diseases, intensive research has resulted in a variety of innovative carotenoid assessment techniques. The breadth of possibilities for assessing retinal carotenoids is often confusing because methodologies, units of measurement, and the presentation of results vary widely. Accurate readings of carotenoid status are important in order to correctly advise individuals with regards to supplementation. Furthermore, in diseases such as macular telangiectasia type 2 (MacTel), the assessment of carotenoids may be crucial to the diagnosis, as reduced MP levels as well as abnormal distributions are among the first signs of the disease. Therefore, the measurement of carotenoids can impact clinical practice, and the evaluation of MP may eventually become an integral part of comprehensive ophthalmological care. The following sections describe and aim to give an organized overview of different MP assessment techniques.

A large variety of methods are used to assess carotenoid status in humans, most of which are focused on the eye, but carotenoids can also be measured in tissue outside of the eye, such as the skin, blood, and the brain. Measurements of ocular carotenoids can be distinguished between subjective (psychophysical) and objective (optical) methods used to assess the amount of MP. In subjective methods, a direct answer from the patient is required, whereas objective measurement methods typically require just enough cooperation to generate an image (73).

Measuring Macular Pigment

👓 Retina macula biopsy

👓 Clinical Imaging

★ Subjective

📋 ZeaVision MPSII

📋 Guardion Mapcat SF

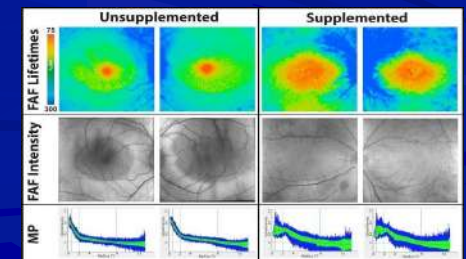
★ Clinical

📋 ZeaVision MPR

📋 Zeiss Visucam 200

📋 Spectralis HRA+OCT

📋 Spectralis MPOV



Thank you! Dr. Chris Putnam

Measuring Macular Pigment

Biophotonic Scanner

- ★ Measures carotenoids
- ★ Based on an optical method known as Resonant Raman Spectroscopy (RSS)
 - 📋 Used for many years in research laboratories
- ★ Skin RRS measurements
 - 📋 Noninvasive
 - 📋 Objective
 - 📋 Reliable methods to assess carotenoid levels
 - Ocular
 - Systemic



ARVO STUDY

Interrelationships between Macula, Skin and Serum Carotenoids- Paul Bernstein, Werner Gellerman et al
ARVO May 2016

Conclusions:

"Our results emphasize the importance of measuring the total amount of carotenoids in the macula region using an objective image based modality such as AFI w Spectralis rather than subjective MPOD."

Skin resonance Raman Spectroscopy of skin carotenoids is a reasonable biomarker of macula carotenoid status. and correlates better than than subjective MPOD tests.



The objective hand scanner is better than the subjective Macuscope, QuantifEYE, and Densitometer for estimating macula pigment.

Carotenoid Levels



Quick Test
(approx. 30 sec)

Portable

Cost Effective

Remeasure in 60 days

Reassurance to you and patient

Vulnerable to Oxidation



Betacarotene



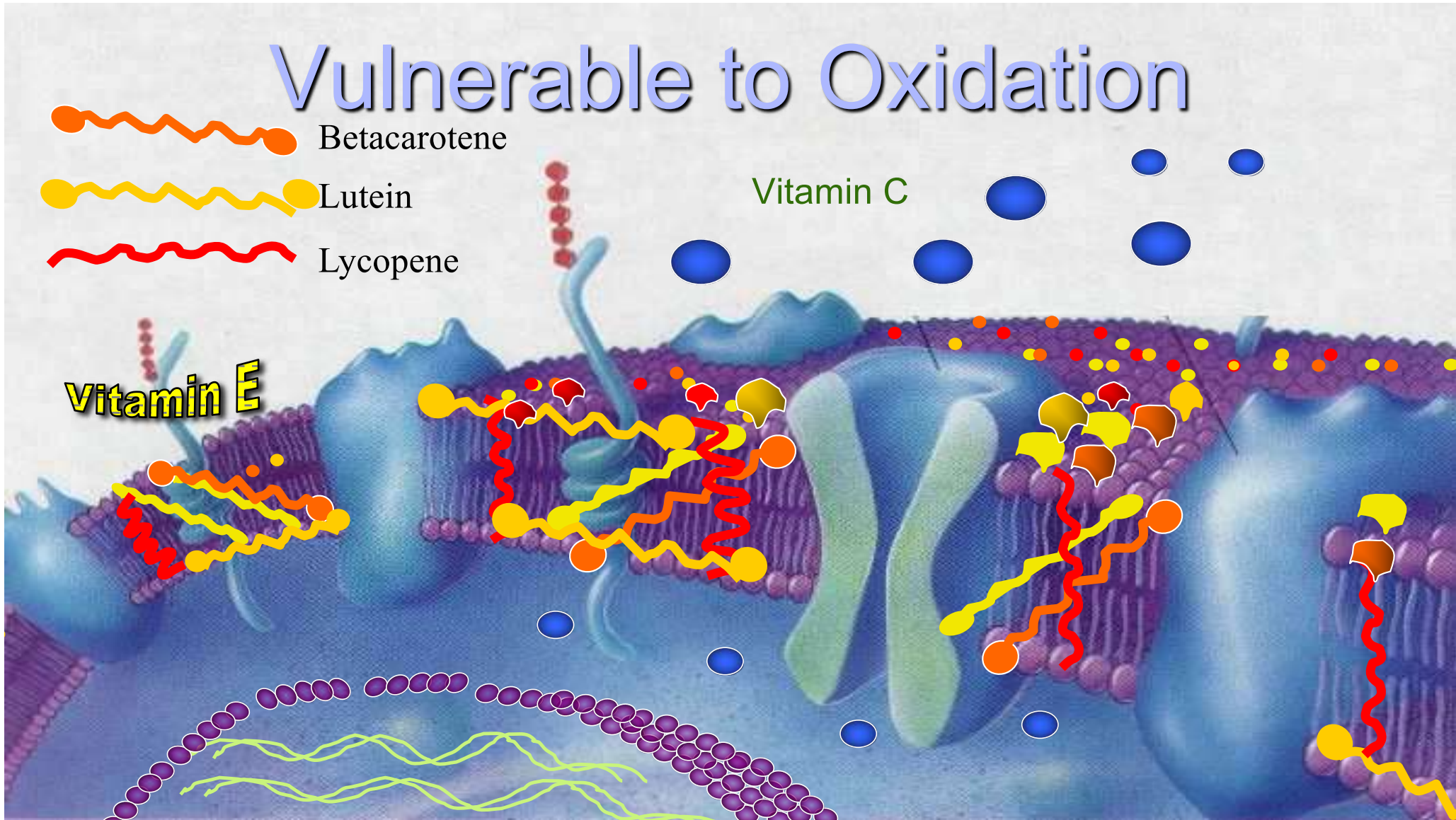
Lutein



Lycopene

Vitamin C

Vitamin E



53-year-old man

👓 Family history of AMD

- ★ Dad with 43 injections for AMD

👓 Pre-diabetic with borderline HbA1c

👓 Vision 20/20 OU

👓 DFE- retina clear

👓 OCT normal

👓 Passes dark adaptation

CONGRATULATIONS ON TAKING THE FIRST STEPS TOWARDS OPTIMIZING YOUR SCS

Dear [REDACTED]

Recently, on 12/15/2020, you met with me and I scanned the palm of your hand with the [REDACTED] BioPhotonic Scanner. Your scan returned a Skin Carotenoid Score (SCS) of 26000.

This score represents the current carotenoid level of your skin. The higher the score, the more carotenoids your body is receiving.



26000

Ingredients

| Ingredients | Amount | % Daily Value |
|--|----------------------------------|---------------|
| Serving Size: 1 Packet | | |
| Vitamin A (83% as Beta Carotene (1875 mcg RAE) from <i>Blakeslea trispora</i> , and Vitamin A palmitate) (375 mcg RAE) | 2250 mcg RAE | 250% |
| Vitamin C (as Calcium Ascorbate) | 200 mg | 222% |
| Vitamin D (as Cholecalciferol) | 5 mcg (200 IU) | 25% |
| Vitamin E (as D-Alpha-Tocopheryl Acetate, D-Alpha Tocopherol, Tocotrienols) | 50.3 mg | 335% |
| Vitamin K (as Phytonadione) | 20 mcg | 17% |
| Thiamin (as Thiamine Mononitrate) | 3.75 mg | 313% |
| Riboflavin (as Riboflavin) | 4.25 mg | 327% |
| Niacin (as Niacinamide) | 17.5 mg NE | 109% |
| Vitamin B6 (as Pyridoxine Hydrochloride) | 5 mg | 294% |
| Folate | 500 mcg DFE (300 mcg folic acid) | 125% |
| Vitamin B12 (as Cyanocobalamin) | 15 mcg | 625% |
| Biotin (as Biotin) | 75 mcg | 250% |
| Pantothenic Acid (as D-Calcium Pantothenate) | 15 mg | 300% |
| Calcium (as Calcium Carbonate, Di-Calcium Malate, Calcium Ascorbate) | 250 mg | 19% |

| | | |
|--|-----------|------|
| Calcium (as Calcium Carbonate, Di-Calcium Malate, Calcium Ascorbate) | 250 mg | 19% |
| Iodine (as Potassium Iodide) | 50 mcg | 33% |
| Magnesium (as Magnesium Glycinate, Magnesium Oxide) | 125 mg | 30% |
| Zinc (as Zinc Bisglycinate) | 7.5 mg | 68% |
| Selenium (as L-Selenomethionine, Sodium Selenite) | 70 mcg | 127% |
| Copper (as Copper Bisglycinate) | 0.5 mg | 56% |
| Manganese (as Manganese Bisglycinate) | 1 mg | 43% |
| Chromium (as Chromium Nicotinate Glycinate) | 100mcg | 286% |
| Molybdenum (as Molybdenum Bisglycinate) | 37.5 mcg | 83% |
| Polyphenol and Flavonoid Blend | 97.5 mg | * |
| Catechins (from <i>Camellia sinensis</i> Leaf Extract) | (45 mg) | * |
| Quercetin | (25 mg) | * |
| Grape Seed Extract (min. 95% Polyphenols) | (12.5 mg) | * |
| Citrus Bioflavonoids (from Citrus Fruits) | (12.5 mg) | * |
| Resveratrol (from <i>Polygonum cuspidatum</i> root extract) | (2.5 mg) | * |
| Mixed Tocopherols (Gamma, Delta & Beta Tocopherols) | 53 mg | * |
| Alpha-Lipoic Acid | 15 mg | * |
| Inositol (as Inositol) | 5 mg | * |
| Carotenoid Blend | 3.5 mg | * |
| Lycopene (as Lycopene) | (2.5 mg) | * |
| Lutein (from Marigold Flower Extract) | (1 mg) | * |
| Boron (as Boron Citrate) | 1.5 mg | * |
| Vanadium (as Vanadyl Sulfate) | 10 mcg | * |

OTHER INGREDIENTS: Gelatin, Microcrystalline Cellulose, Croscarmellose Sodium, Stearic Acid, Magnesium Stearate, Silicon Dioxide, Titanium Dioxide.

CONTAINS: Fish (Cod, Pollack, Haddock, Hake, Cusk, Redfish, Sole, Flounder).

SUPPLEMENT FACTS

Supplement Facts

Serving Size 2 Softgels

Servings Per Container 60

| Amount Per Serving | | % DV |
|---|-------------------|------|
| Total Calories | 15 | |
| Total Fat | 1 g | 1%* |
| Saturated Fat | 0 g | 0%* |
| Trans Fat | 0 g | |
| Vitamin D ₃ (as cholecalciferol) | 12.5 mcg (500 IU) | 63% |
| Vitamin K ₂ (as menaquinone-7) | 20 mcg | 17% |
| Ultra-pure fish oil concentrate: | 1055 mg | ** |
| EPA (Eicosapentaenoic acid) | 300 mg | ** |
| DHA (Docosahexaenoic acid) | 200 mg | ** |
| Citrus Bioflavonoids | 100 mg | ** |
| (including hesperidin and naringin) | | |
| Purple corn (<i>Zea mays</i> L.) cob extract | 66.67 mg | ** |
| including anthocyanins | | |
| Alpha Lipoic Acid | 50 mg | ** |
| Quercetin (from <i>Dimorphandra mollis</i> fruit extract) | 37.5 mg | ** |
| D-Limonene (from <i>Citrus sinensis</i> peel) | 25 mg | ** |
| Rosemary (<i>Rosmarinus officinalis</i> L.) leaf extract | 18.75 mg | ** |
| including carnosic acid | | |
| Resveratrol (from <i>Polygonum cuspidatum</i> root) | 15 mg | ** |
| Coenzyme Q10 | 15 mg | ** |
| Lycopene | 2.5 mg | ** |
| Lutein (from marigold flower (<i>Tagetes erecta</i>)) | 2 mg | ** |
| Astaxanthin (from <i>Haematococcus pluvialis</i> algae) | 0.5 mg | ** |

* Percent Daily Values are based on a 2,000 Calorie Diet.

** Daily Value (DV) not established.

OTHER INGREDIENTS: Gelatin, Glycerin, Beeswax, Sunflower Lecithin, Vanillin.

CONTAINS: Fish (anchovies, sardines, mackerel).

53-year-old man

CONGRATULATIONS ON TAKING THE FIRST STEPS TOWARDS OPTIMIZING YOUR SCS

Dear [REDACTED]

Recently, on 12/27/2020, you met with me and I scanned the palm of your hand with the BioPhotonic Scanner. Your scan returned a Skin Carotenoid Score (SCS) of 33000.

This score represents the current carotenoid level of your skin. The higher the score, the more carotenoids your body is receiving.



33000

CONGRATULATIONS ON TAKING THE FIRST STEPS TOWARDS OPTIMIZING YOUR SCS

Dear [REDACTED]

Recently, on 01/23/2021, you met with me and I scanned the palm of your hand with the BioPhotonic Scanner. Your scan returned a Skin Carotenoid Score (SCS) of 47000.

This score represents the current carotenoid level of your skin. The higher the score, the more carotenoids your body is receiving.

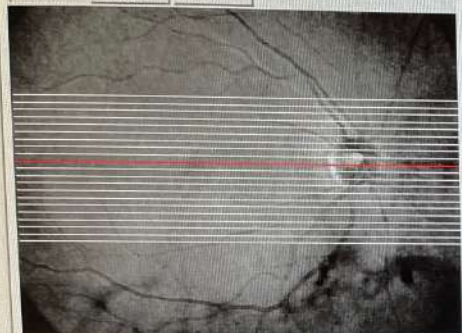


47000

Raster Comparison Report

Scan 09/29/2020 13:20:09

Reference En Face IR



10

250µm

Signal Strength Index

55

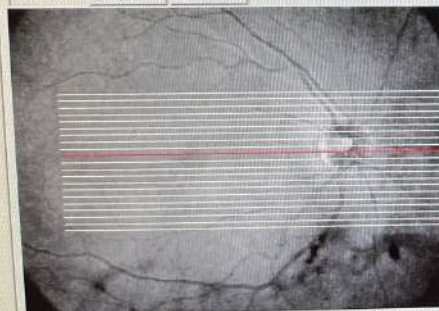
12.00 x 4.00 Scan Size (mm)

Right / OD



Auto Zoom

Reference En Face IR



10

250µm

Signal Strength Index

43

12.00 x 4.00 Scan Size (mm)

Right / OD

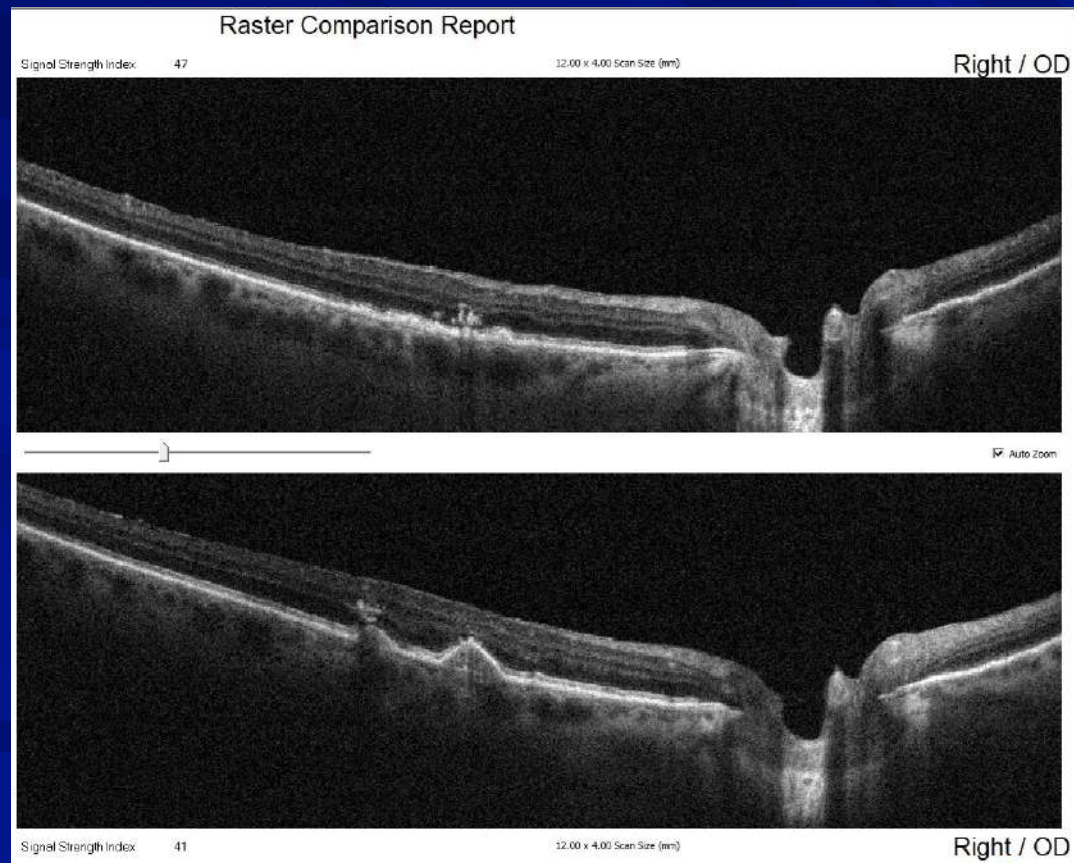
Optovue

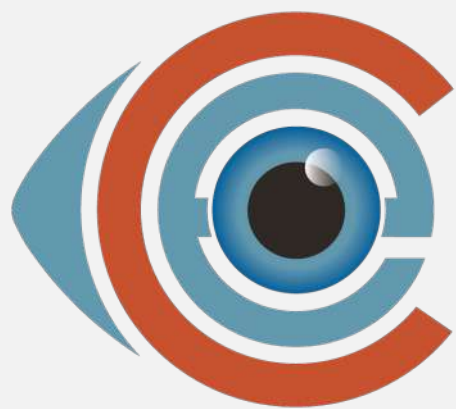
Scan 06/23/2021 10:22:11

OU Report

10:46 AM

April 27, 2021 – January 26, 2022 (9 months)





Optometric
Education
Consultants

Questions? Thank You!

OCT and OCT Angiography
Something Old and Something New
Retina Pearls

Greg Caldwell, OD, FAAO

Nashville – Music City Fall Classic 2022
Optometric Education Consultants

Saturday, October 22, 2022

