Optometric Education Consultants

OCT-Angiography
What You Need to Know with this New Technology

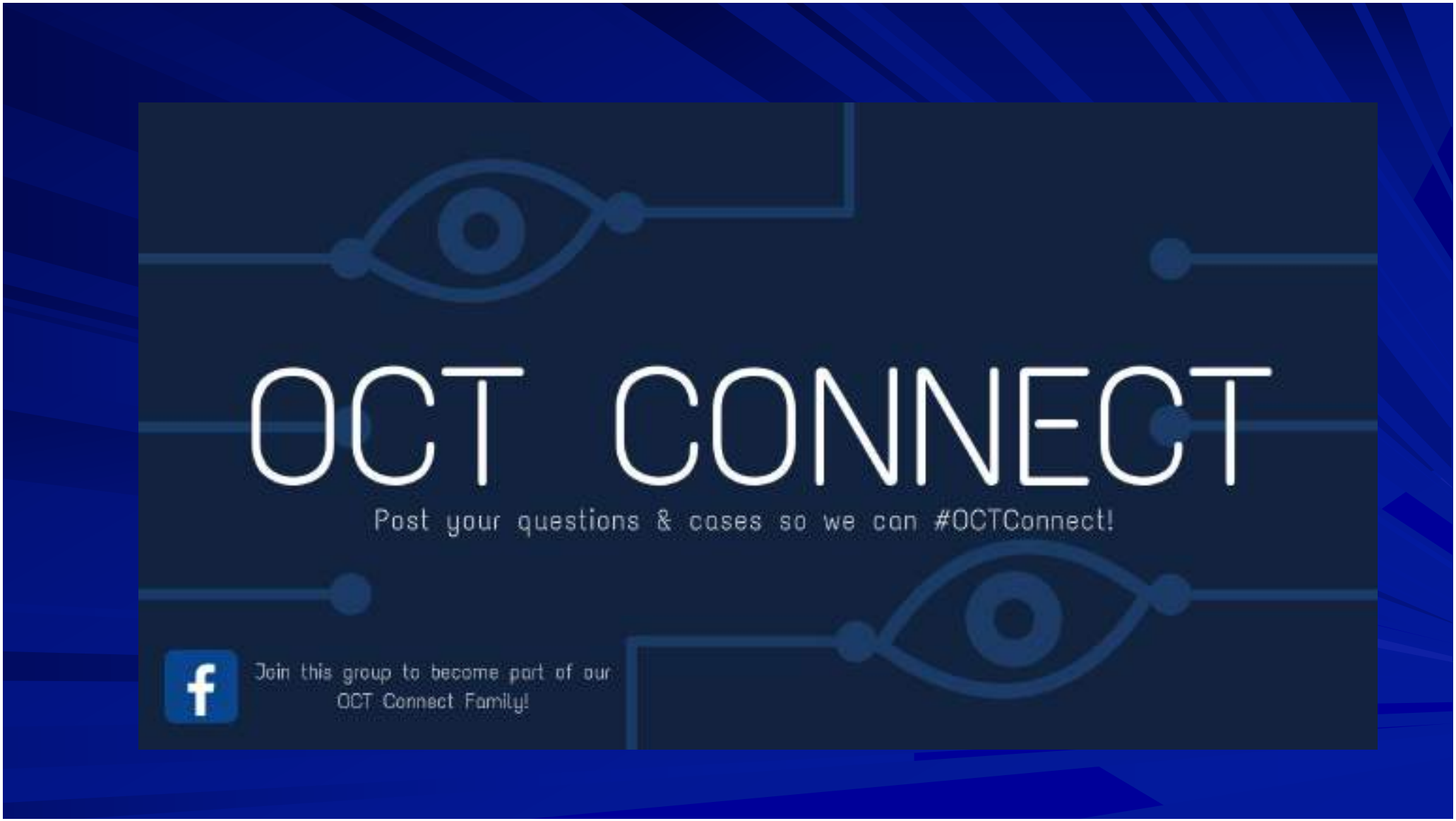
Greg Caldwell, OD, FAAO

November 14, 20/20

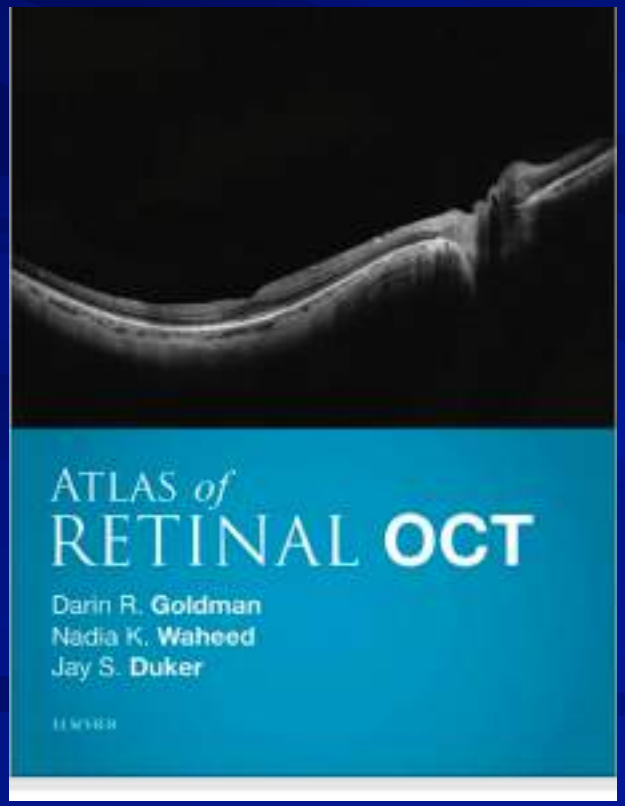
Disclosures- Greg Caldwell, OD, FAAO

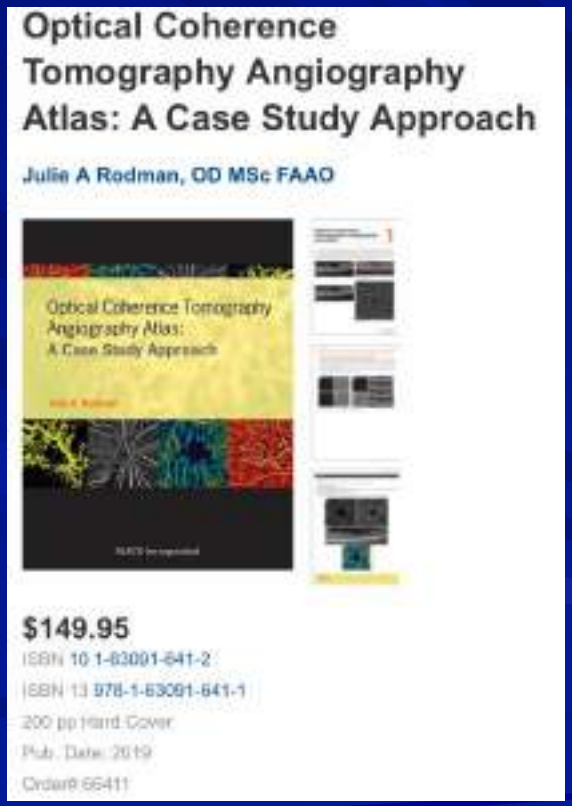
- Will mention many products, instruments and companies during our discussion
  - I don't have any financial interest in any of these products, instruments or companies
- Pennsylvania Optometric Association –President 2010
  - POA Board of Directors 2006-2011
- American Optometric Association, Trustee 2013-2016
- I never used or will use my volunteer positions to further my lecturing career
- Lectured for: Alcon, Allergan, Aerie, BioTissue, Maculogix, Optovue
- Advisory Board: Allergan, Maculogix, Sun, Kala
- Envolve: PA Medical Director, Credential Committee
- HealthCare Registries: Consultant
- Optometric Education Consultants - Scottsdale, WDW, St. Paul, Quebec City, and Nashville, Owner

Optometric Education Consultants


OCT CONNECT
Post your questions & cases so we can #OCTConnect!
Join this group to become part of our
OCT Connect Family!

Book Resources





How Many People Here Have an OCT?

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

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ELSEVIER
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Thresholds Found for Unilateral Optic Nerve Lesions in MS

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Detection of Choroidal Neovascularization in Pigment Epithelial Detachment
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TAKE-HOME MESSAGE
This study evaluated the agreement between OCTA and multimodal imaging for the detection of choroidal neovascularization (CNV) in patients with pigment epithelial detachment with and without subretinal/intraretinal fluid (PED+F and PED-F). OCTA demonstrated concordance with the other modalities in determining the presence of CNV in patients with PED+F, with an accuracy of 95.45%.
The authors suggest that the diagnosis of PED can be made without the need for dye angiography in eyes indicating signs of CNV on OCTA.
– Raza Shah, MD
Abstract

Macular and Peripapillary Angiographic Changes With Intravitreal Injections

Retina (Philadelphia, Pa.)

TAKE-HOME MESSAGE

- This retrospective observational study of 39 patients with various retinopathies assessed retinal perfusion density changes on OCT. Results showed that an acute change in intraocular pressure due to intravitreal injections was associated with a decrease in macular and peripapillary perfusion density.
- These findings suggest that intravitreal injections may lead to the development of glaucoma, causing damage to the macula and optic nerve.

– Raza M. Shah, MD

Abstract

PURPOSE

Intravitreal injections acutely and temporarily increase intraocular pressure (IOP), and this may have cumulative long-term effects including an increased risk for glaucoma surgery. This study was designed to measure retinal perfusion density changes on optical coherence tomography (OCT) angiography and OCT thickness alterations associated with acutely increased IOP after intravitreal injections.

METHODS

Retrospective observational clinical study of 40 eyes (39 patients) with various retinopathies from October

Published in Eye Care

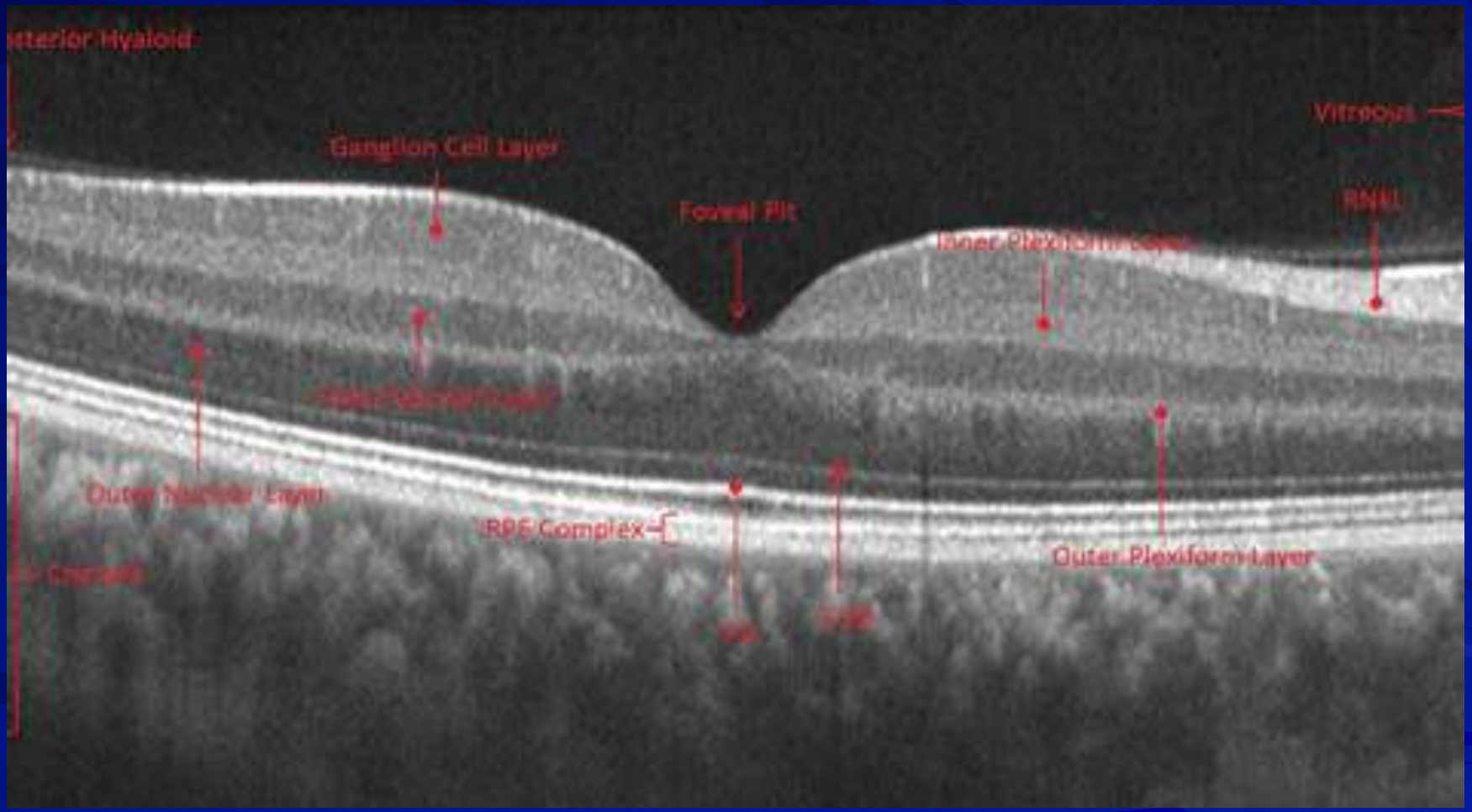
Journal Scan / Research · March 30, 2019

Detection of Clinically Unsuspected Retinal Neovascularization With Wide-Field OCTA

Retina (Philadelphia, Pa.)

TAKE-HOME MESSAGE

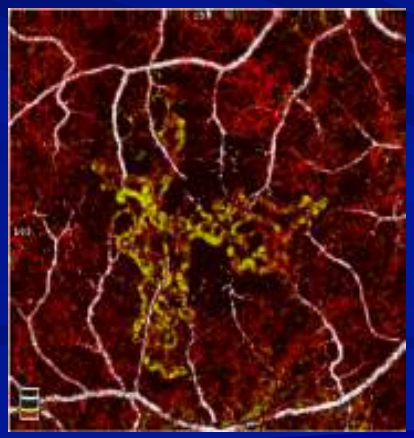
- This study evaluated the accuracy of wide-field optical coherence tomography angiography (OCTA) for detection of clinically unsuspected neovascularization (NV) in patients with diabetic retinopathy. There were 27 participants, who underwent a clinical examination, standard 7-field color photography, and OCTA with commercial and prototype swept-source devices. Nonproliferative diabetic retinopathy was found to be mild in 13 patients, moderate in 7, and severe in 7 based on photographic grading. The conventional 6- × 6-mm OCTA detected NV in 2 eyes (7%) and the 3- × 3-mm scan detected none. Both prototype and commercial wide-field OCTA detected NV in 2 additional eyes. All eyes with OCTA-detected NV were photographically graded as severe nonproliferative DR.
- Wide-field OCTA can aid in the detection of retinal changes that would seemingly escape detection otherwise. However, the study population in this study was small, and the positive findings were particularly few, which makes it difficult to draw any significant conclusions.


Ganglion Cell Layer
Foveal Pit
Vitreous
RNFL
Outer Plexiform Layer
RPE Complex

OCT Angiography
A New Approach to Protecting Vision

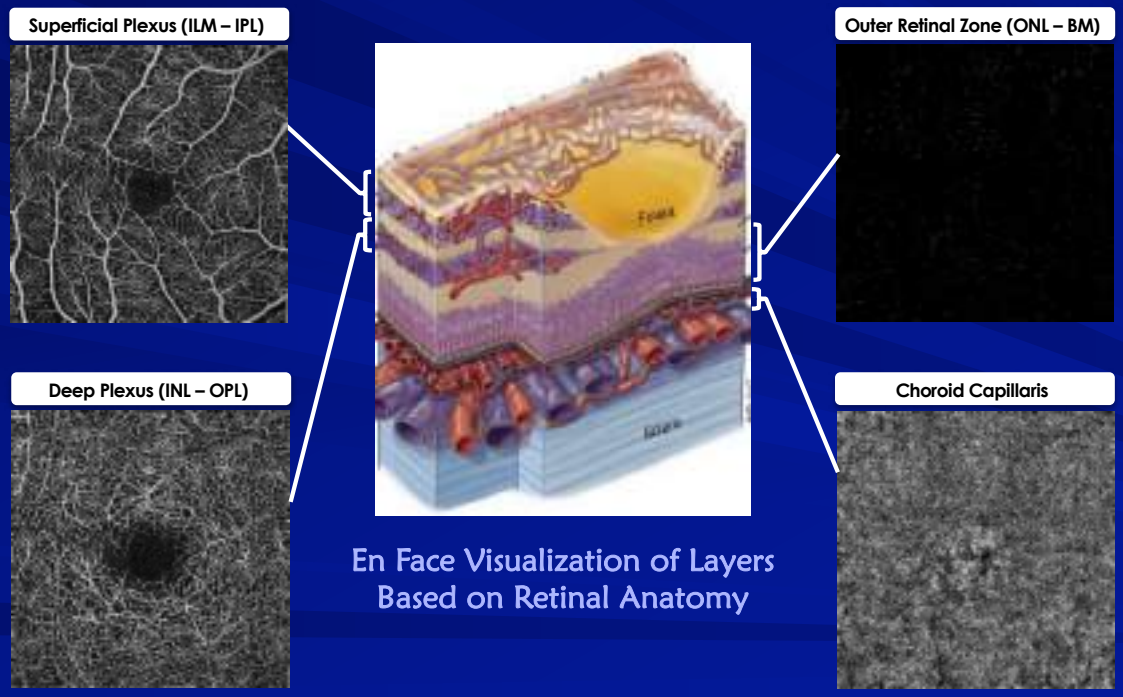
- Non-invasive visualization of individual layers of retinal vasculature
- Pathology not obscured by fluorescein staining or pooling
- Image acquisition requires less time than a dye-based procedure
- Reduced patient burden allows more frequent imaging to better follow disease progression and treatment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

FA of CNV



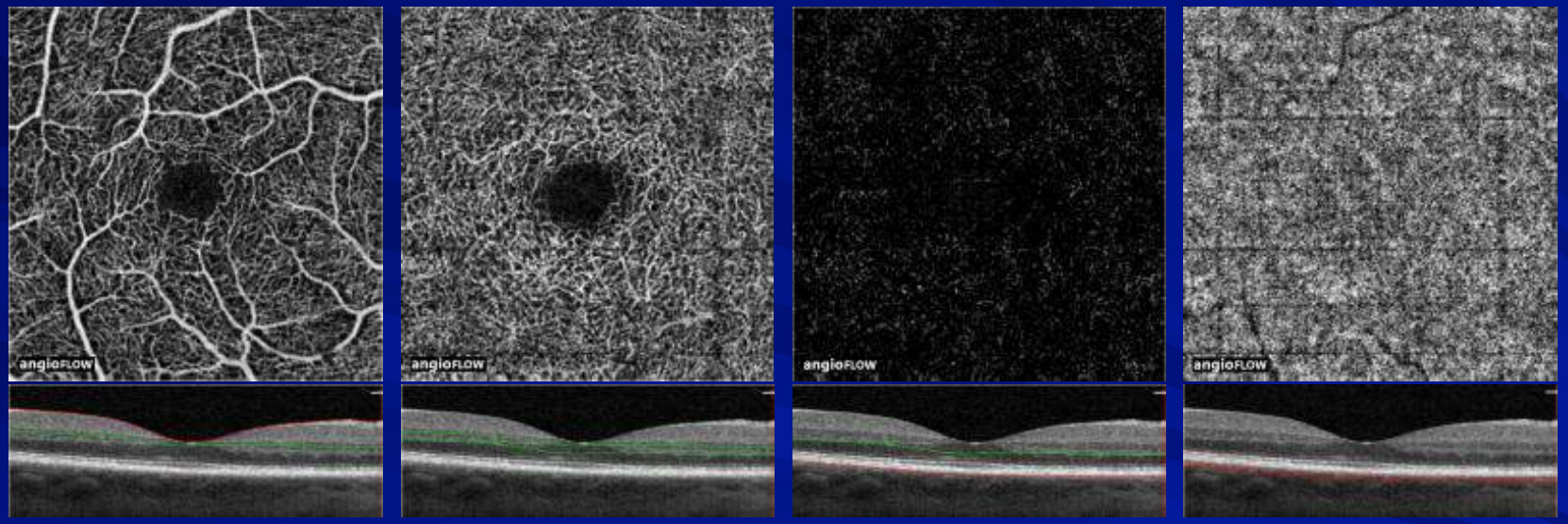
OCTA of CNV

Enface OCT-A Slabs Based on Retinal Anatomy



En Face Visualization of Layers Based on Retinal Anatomy

Normal Retinal Vasculature



Superficial Capillary Plexus

3μm Below ILM → 15 μm Below IPL

Deep Capillary Plexus

15μm Below ILM → 70 μm Below IPL

Outer Retina

70μm Below IPL → 30 μm Below RPE Reference

Choriocapillaris

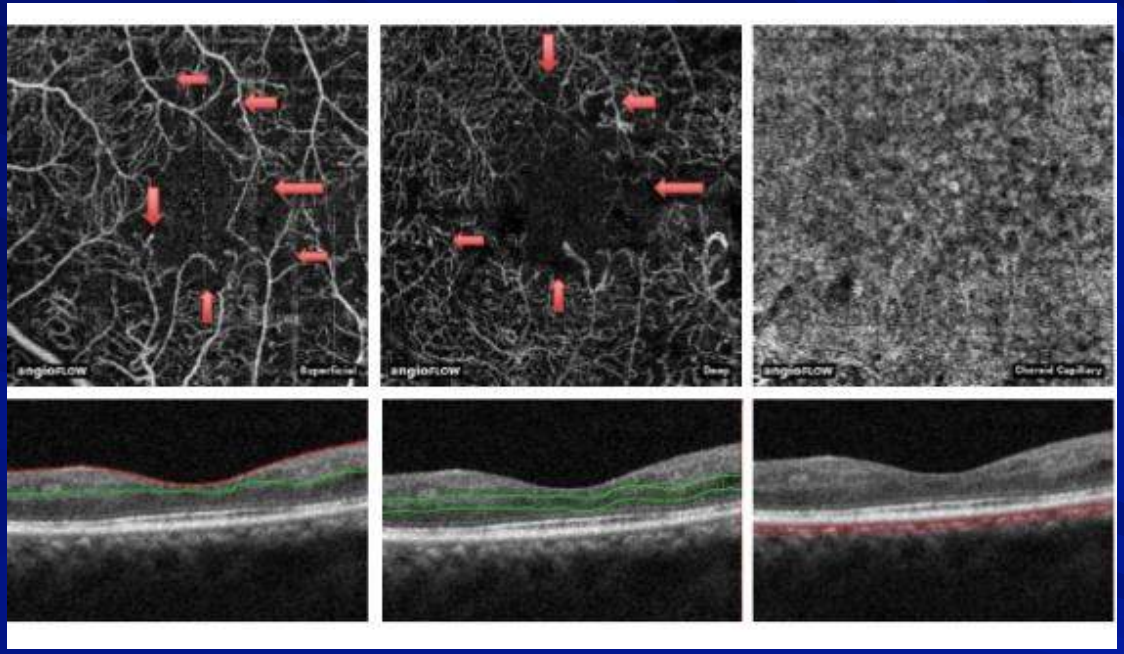
30 μm Below RPE Reference → 60 μm Below RPE Reference

Metrics and Analytics

Make a Difference

Important

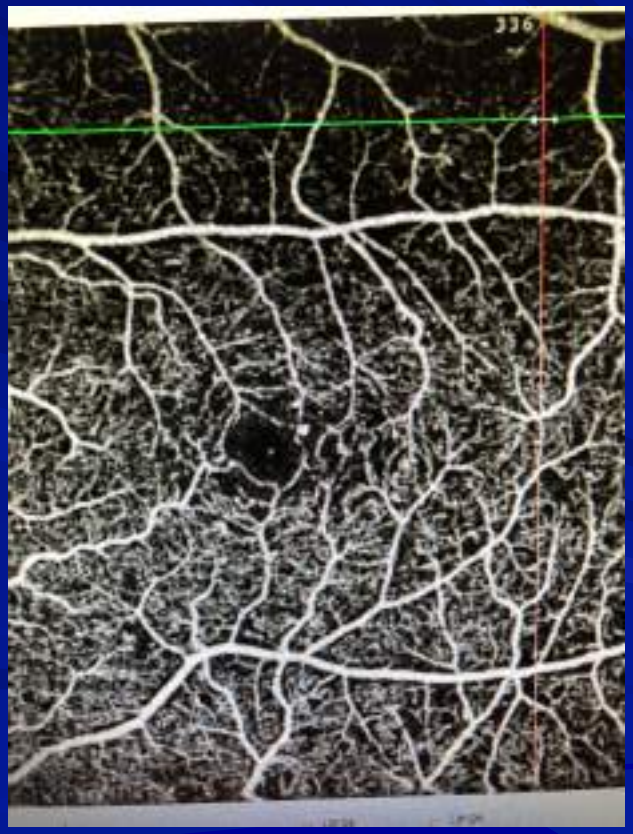
Diabetic Retinopathy



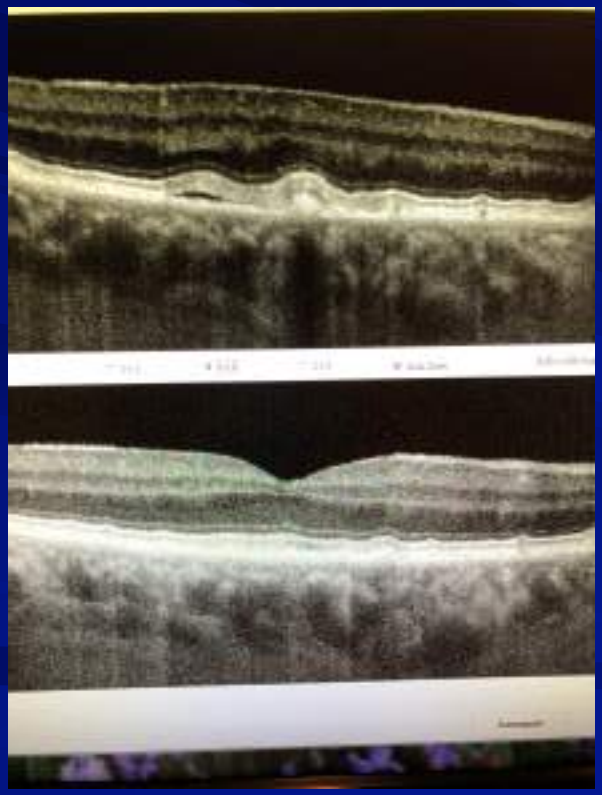
Superficial Capillary Plexus | Deep Capillary Plexus | Choriocapillaris

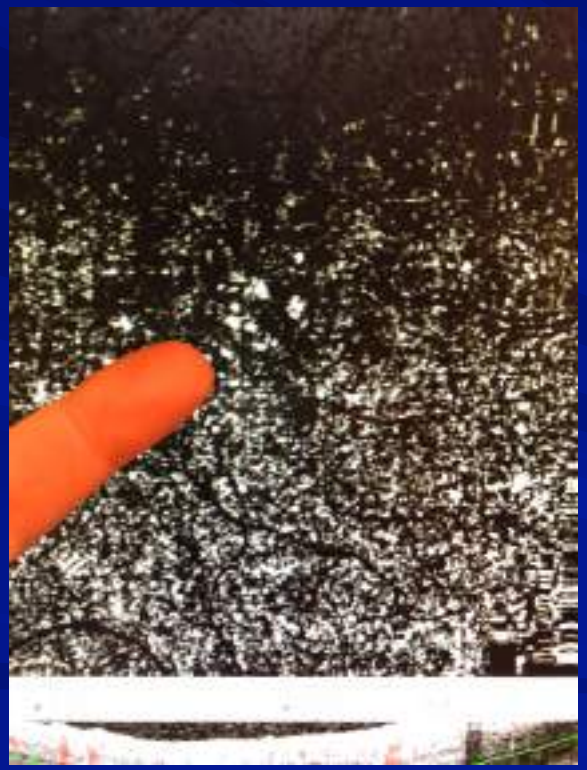
- Retinal capillary non-perfusion – seen as blackened area without blood flow outside FAZ
- Microaneurysms
- Enlarged FAZ

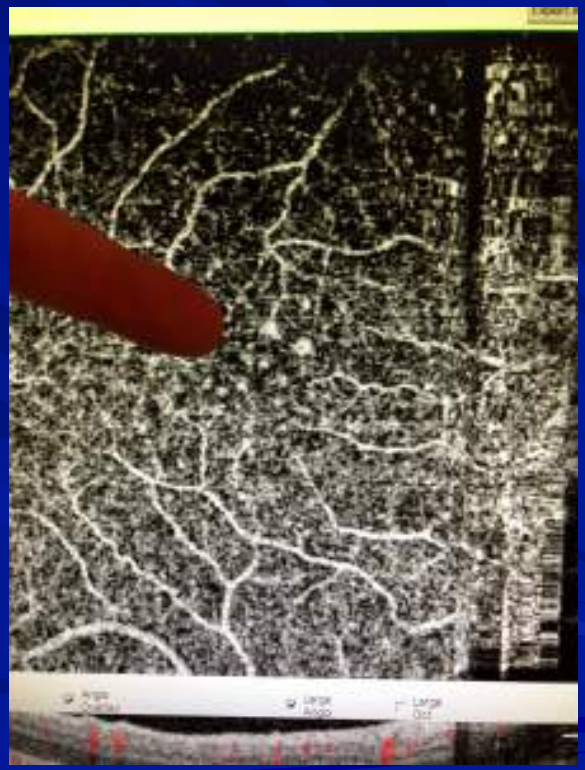
Diabetes



Wet AMD

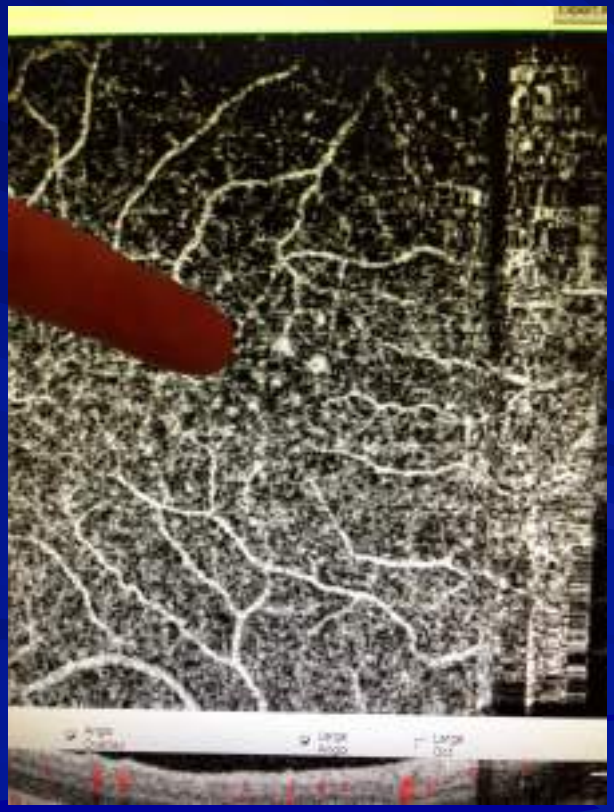






Glad to Have it in the Office

Disappointing without Quantitative Measurements



AngioAnalytics

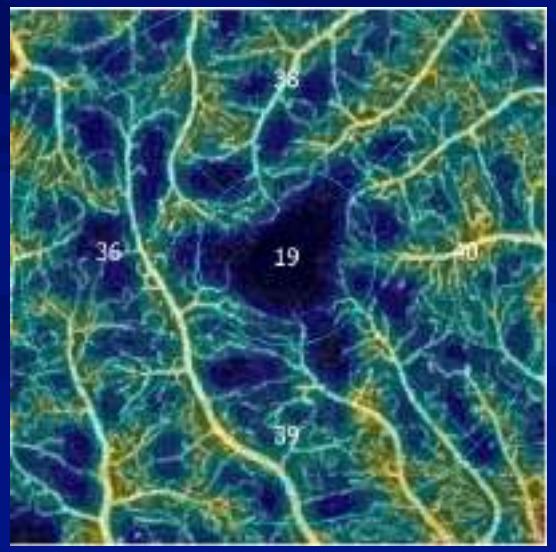
- AngioAnalytics is the world's first OCTA metrics
- The package includes the following tools:
  - **Foveal Avascular Zone (FAZ) measurements**
    - FAZ area, perimeter, A-circularity index and foveal vessel density
  - **Flow and Non-Flow Area measurements**
    - Measure the area of abnormal flow by outlining a region for vessel detection. The extracted Flow Area measurement is based on the Outer Retina slab (OPL ~ BRM)
  - **Vessel Density mapping**
    - Measures the vessel density of the superficial and deep plexi of the retina as well as the radial peripapillary capillary layer of the optic disc

Clinical Applications of AngioAnalytics

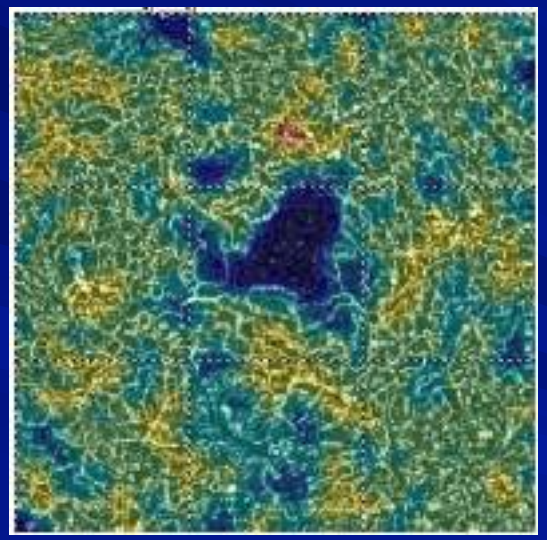
- Identify early vascular changes in diabetic eyes
- Assess disease progression
- Compare structure and vasculature in glaucoma
- Assess rate of change in optic disc vessel density

AngioAnalytics

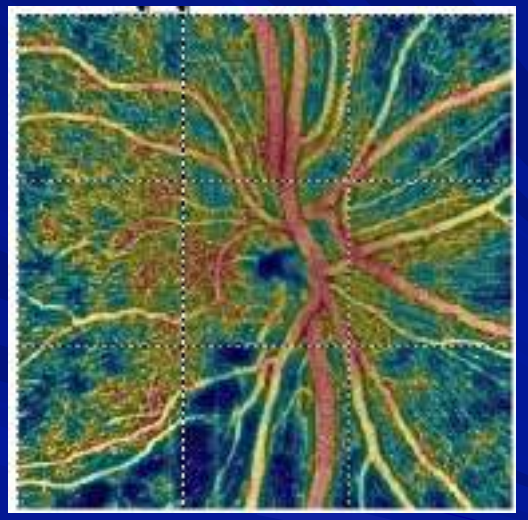
Vessel Density Mapping



Vessel Density
Superficial Plexus

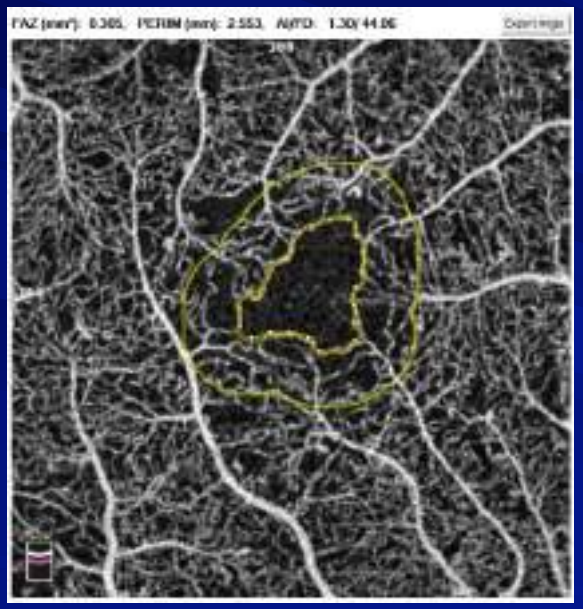


Vessel Density
Deep Plexus

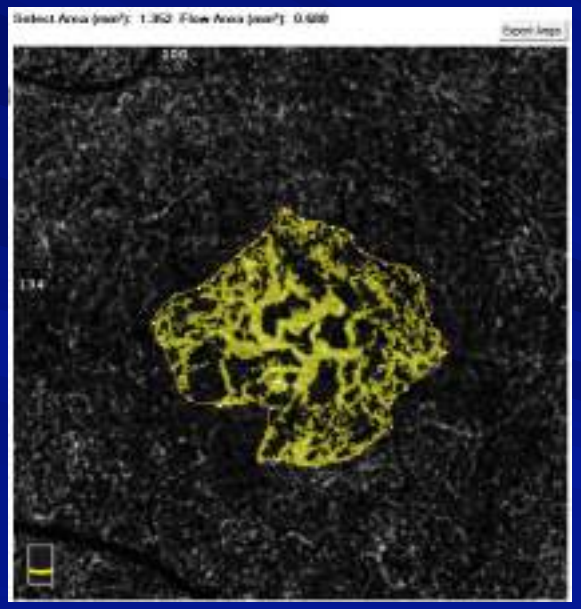


Vessel Density
Radial Peripapillary Capillaries

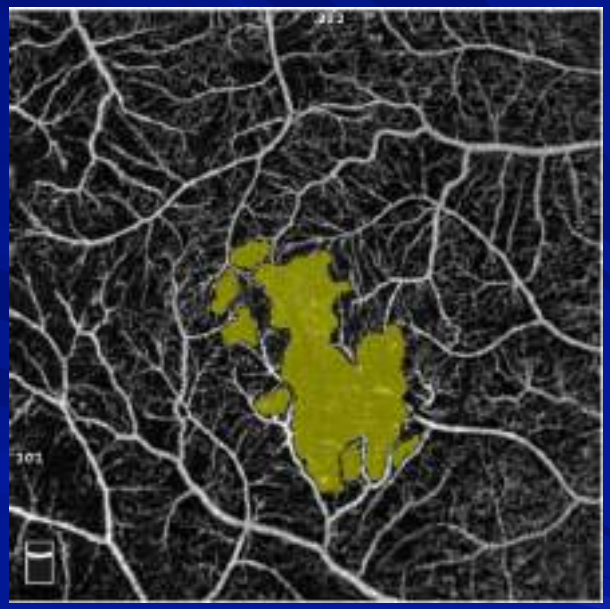
AngioAnalytics
FAZ, Flow & Non-Flow Area Measurements



Foveal Avascular Zone Metrics



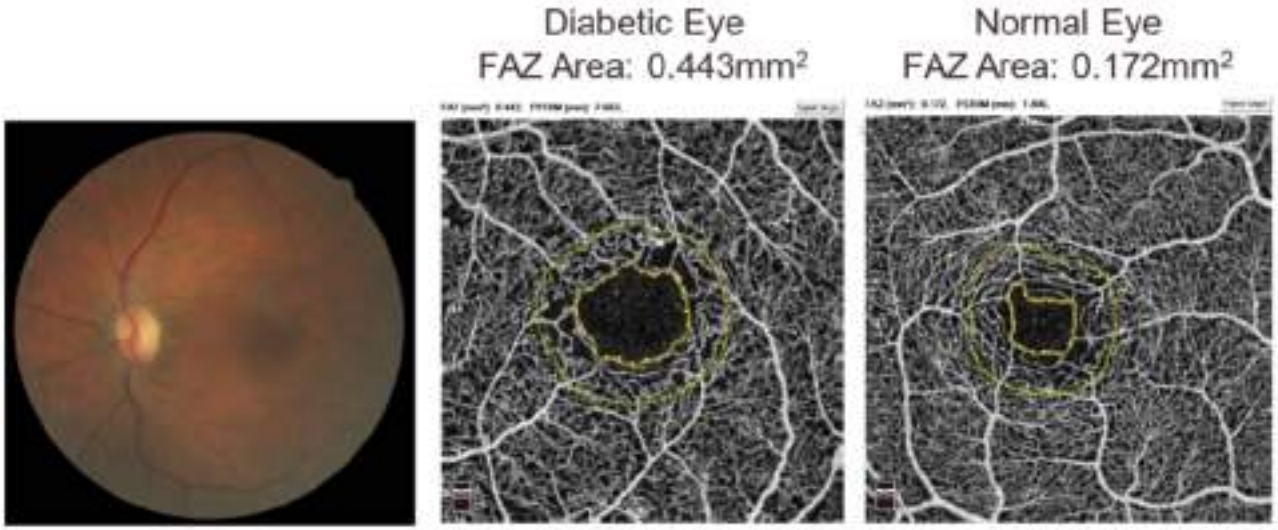
Flow Area Measurements



Non-Flow Area Measurements

Identify Early Vascular Changes in Diabetic Eyes

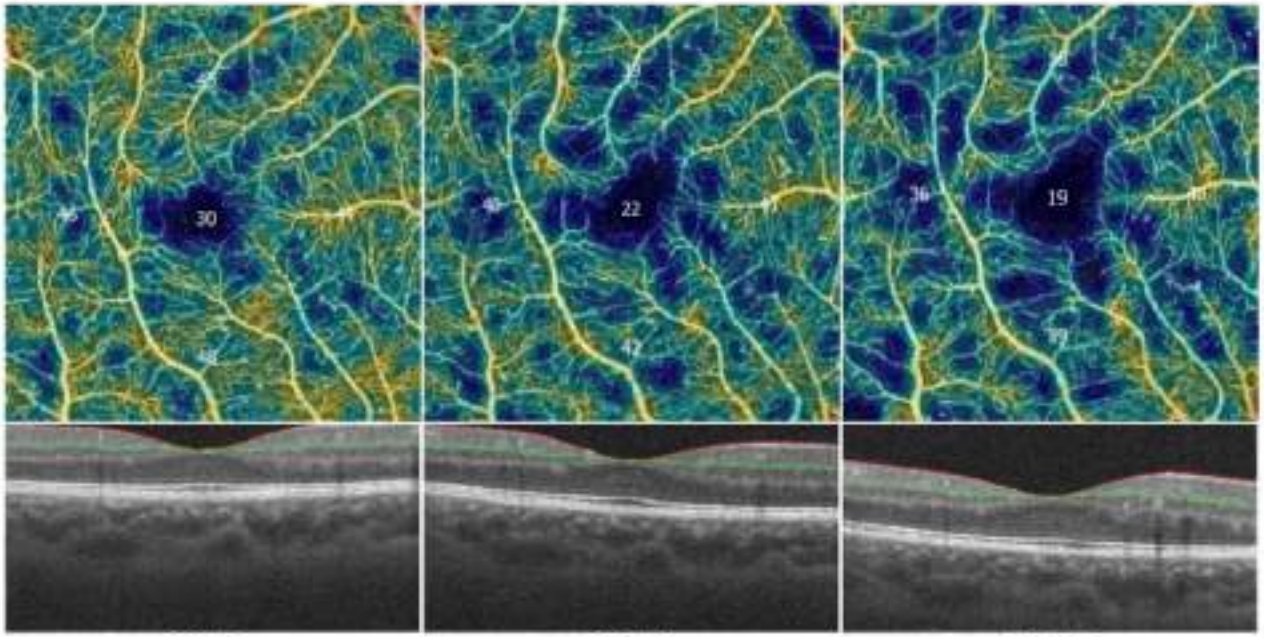
Patients with DM have a larger FAZ than healthy eyes.[3]



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

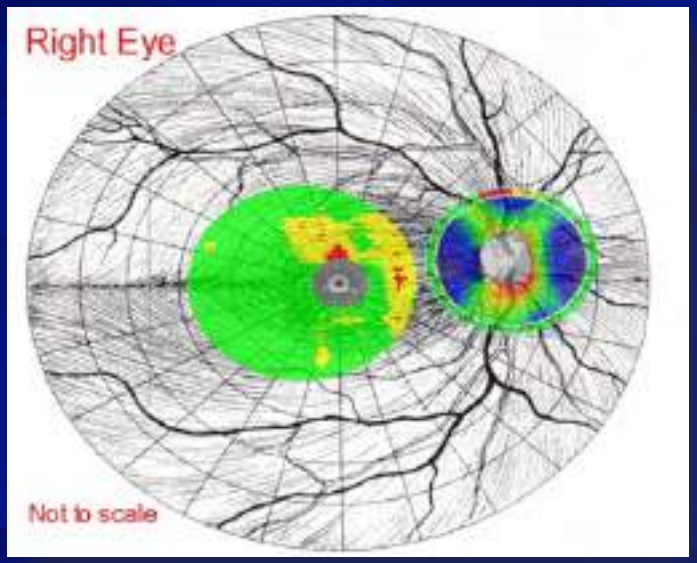
Assess Disease Progression with Multiscan View

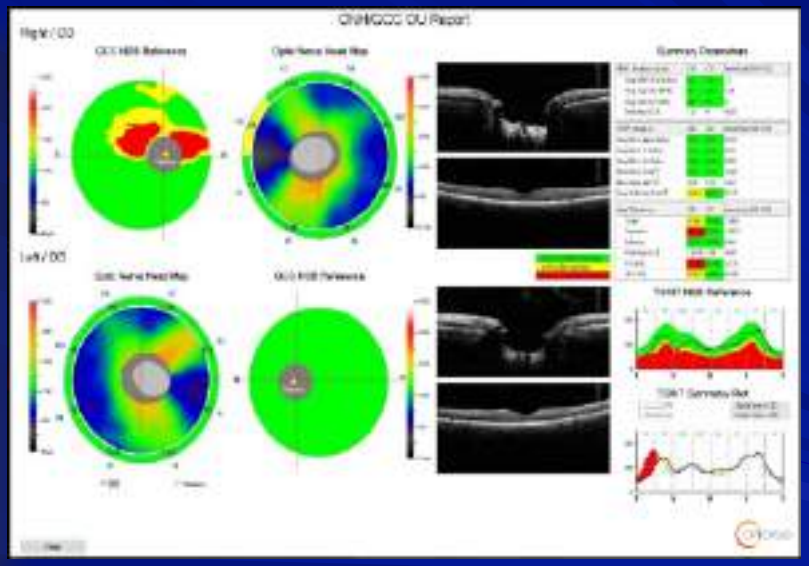
Vessel Density Decreases Significantly with Disease Severity[4]



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/iovs.17-21787.

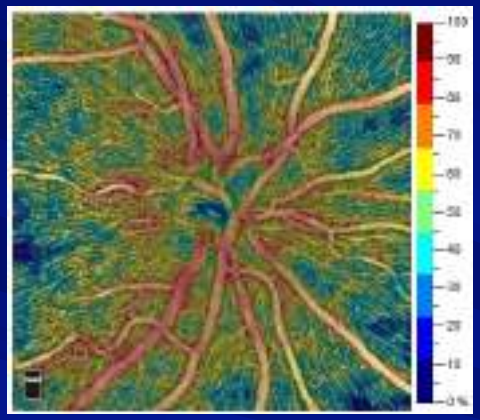
Next Generation Glaucoma Analysis with OCT + OCTA

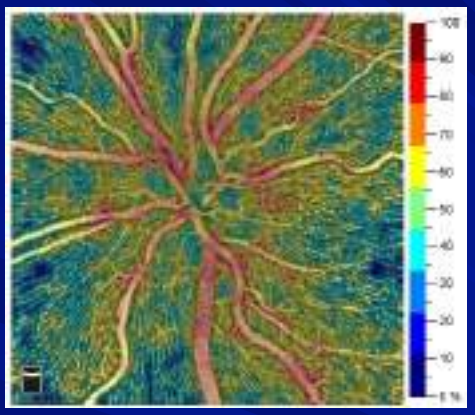




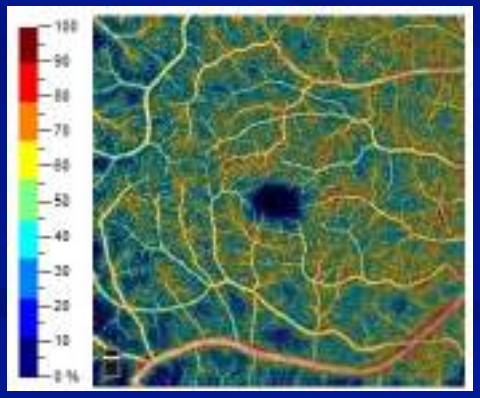
Learn What Normal Looks Like

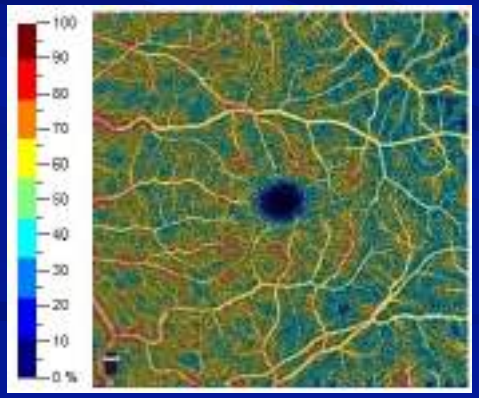
Disc:
Radial Peripapillary
Capillaries





Retina:
Superficial Vascular
Complex

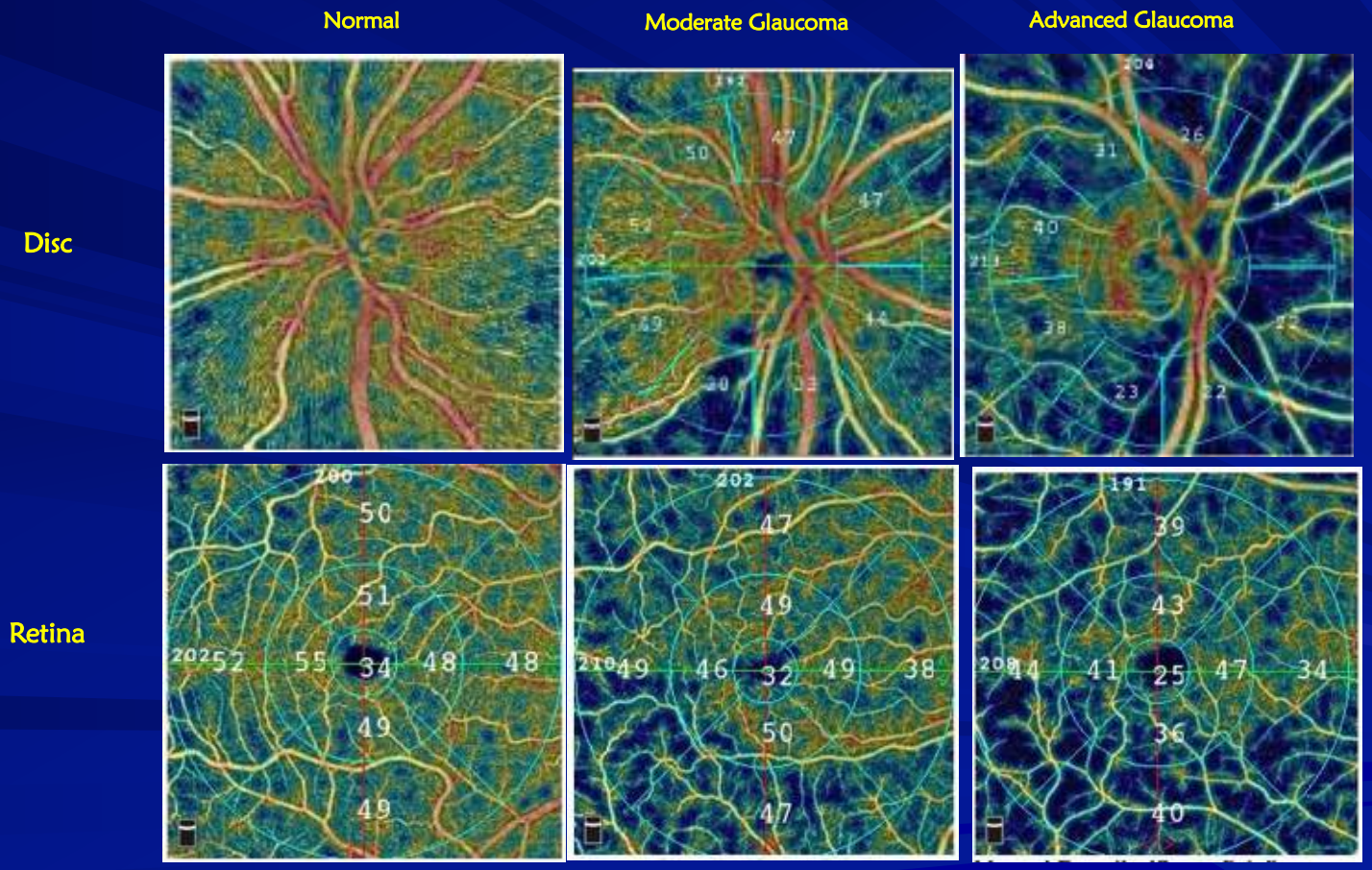




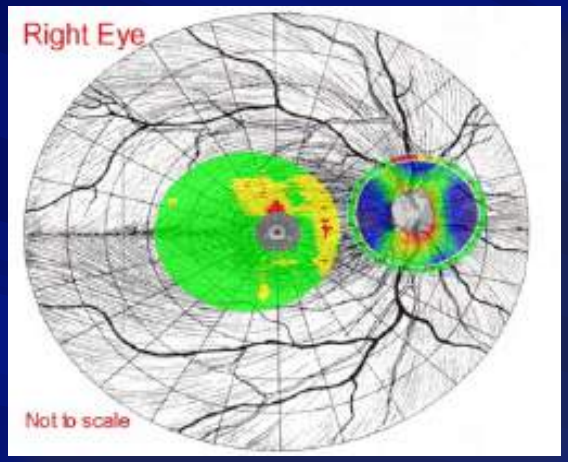
OD

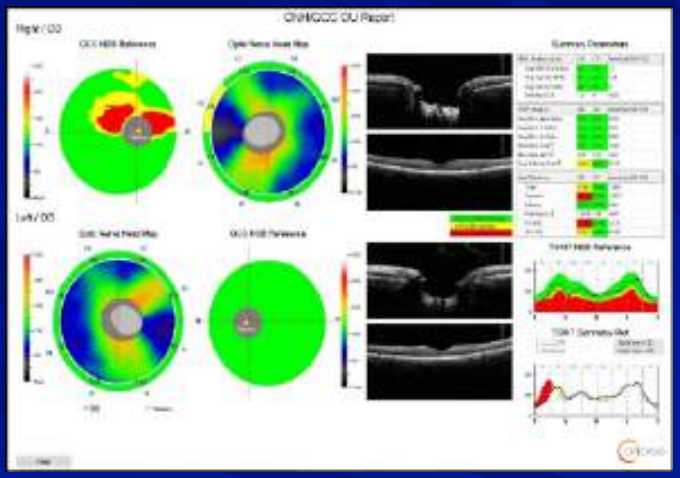
OS

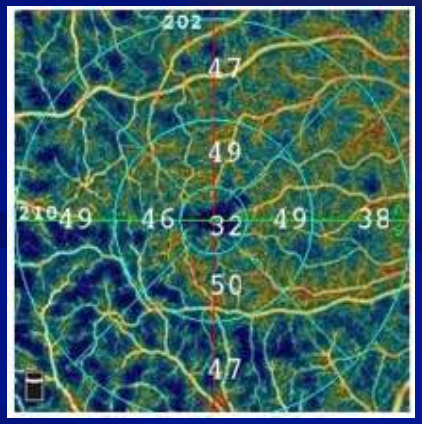
What Does Glaucoma Look Like?



Glaucoma


Right Eye
Not to scale

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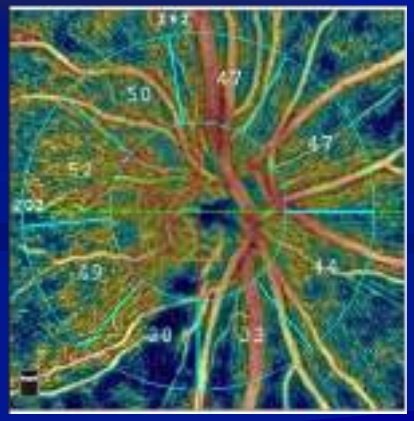
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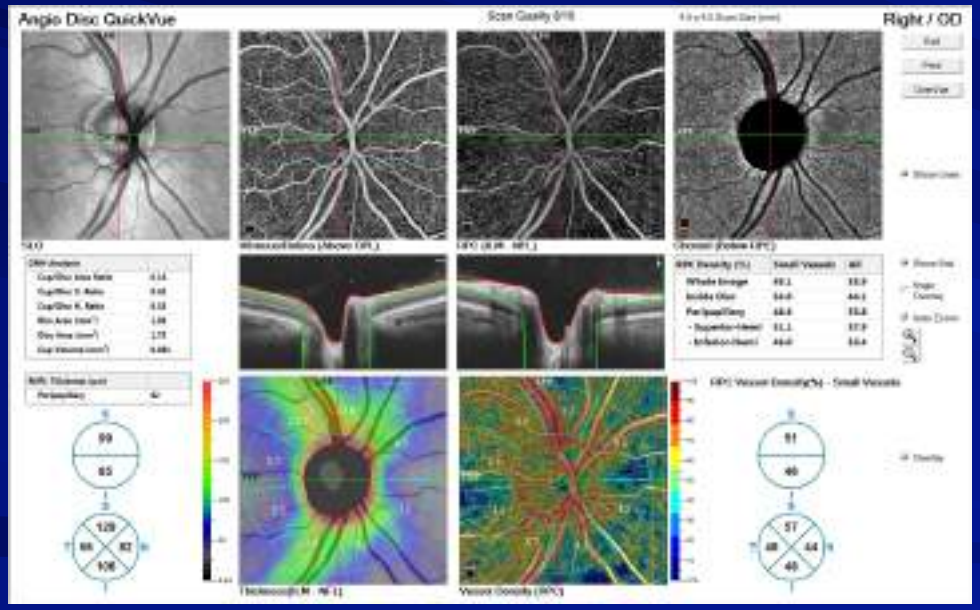
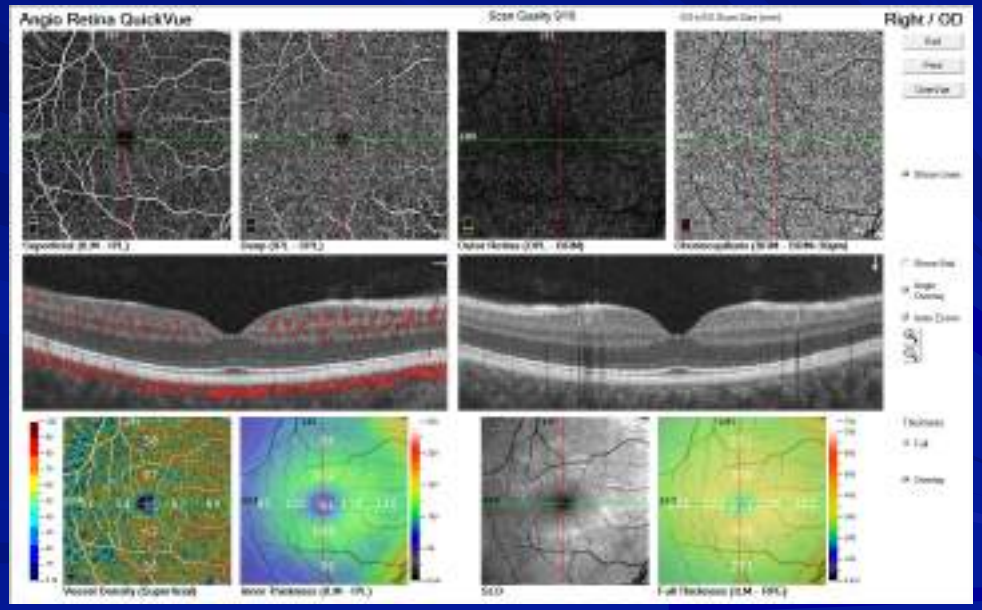
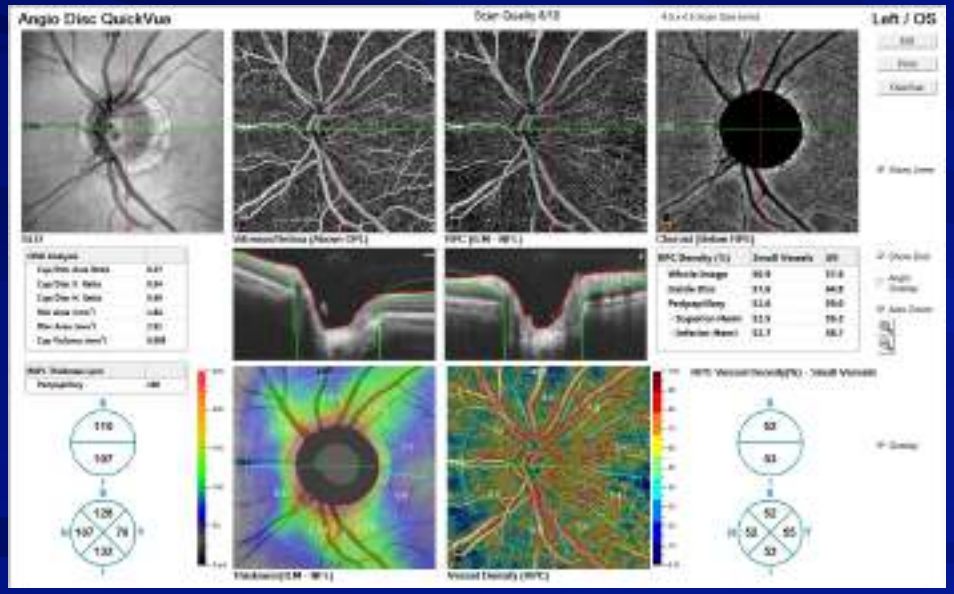
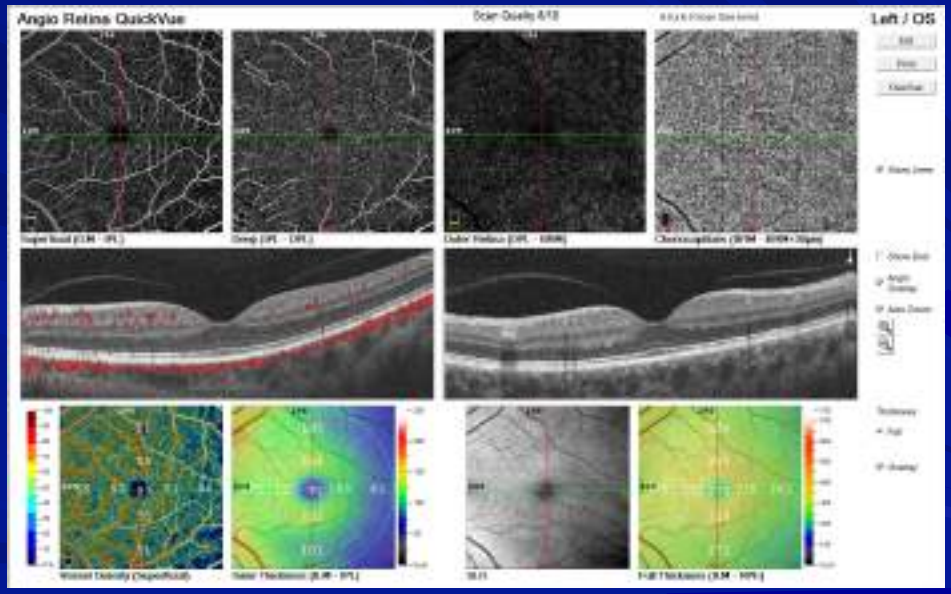
Review of Normal
25 year old man





Review of Normal
60 year old man

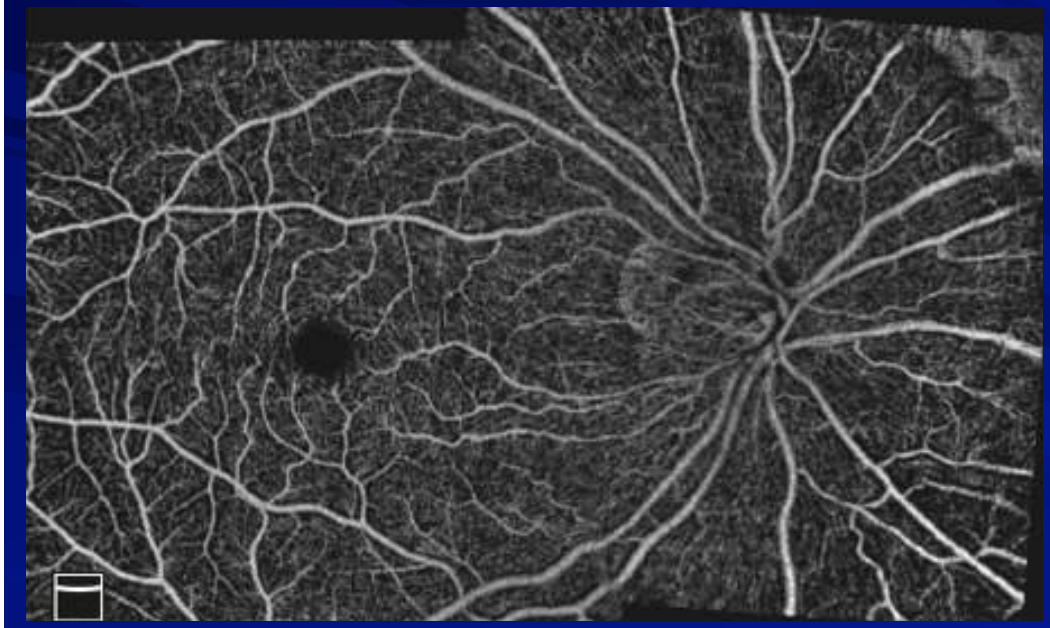


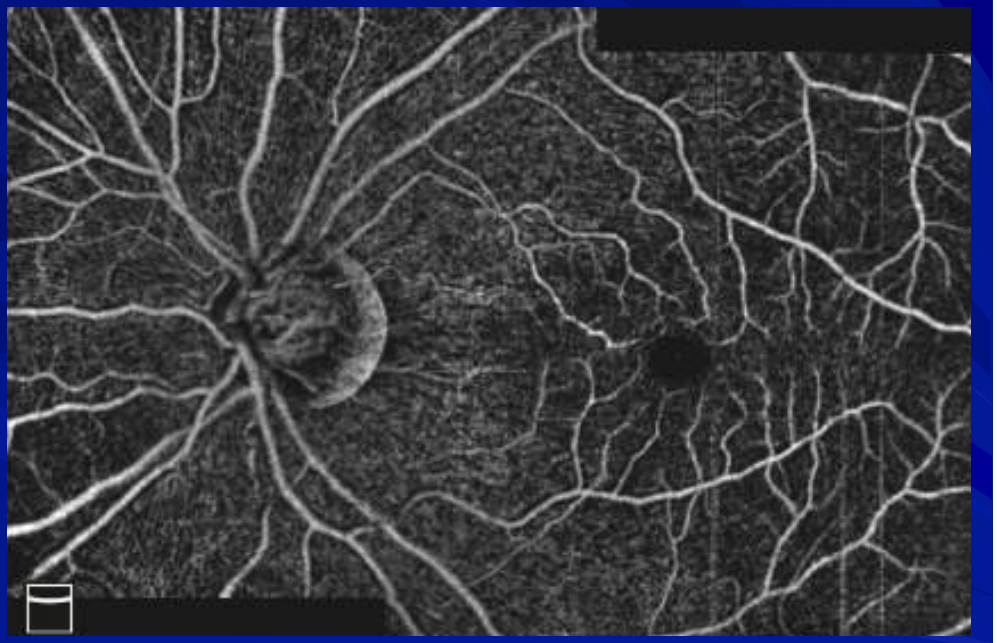


60 Year Old Montage OD

60 Year Old Montage OS

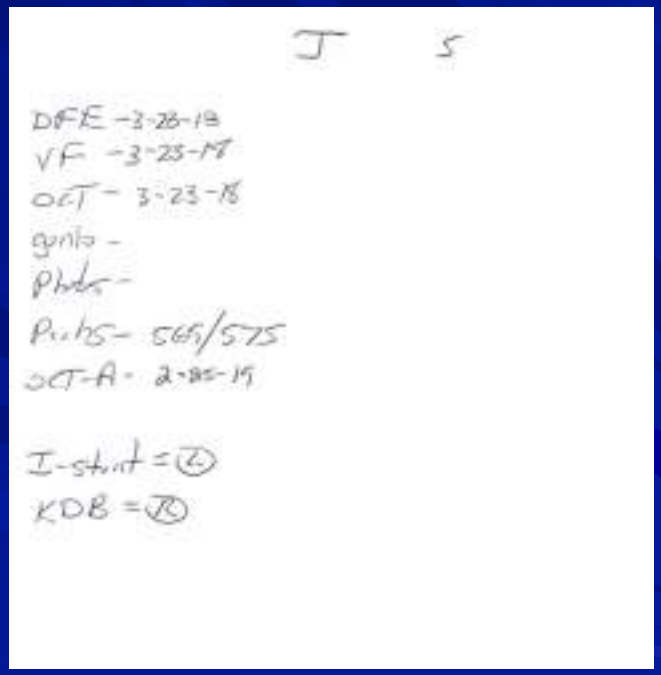
60 Year Old Montage OU



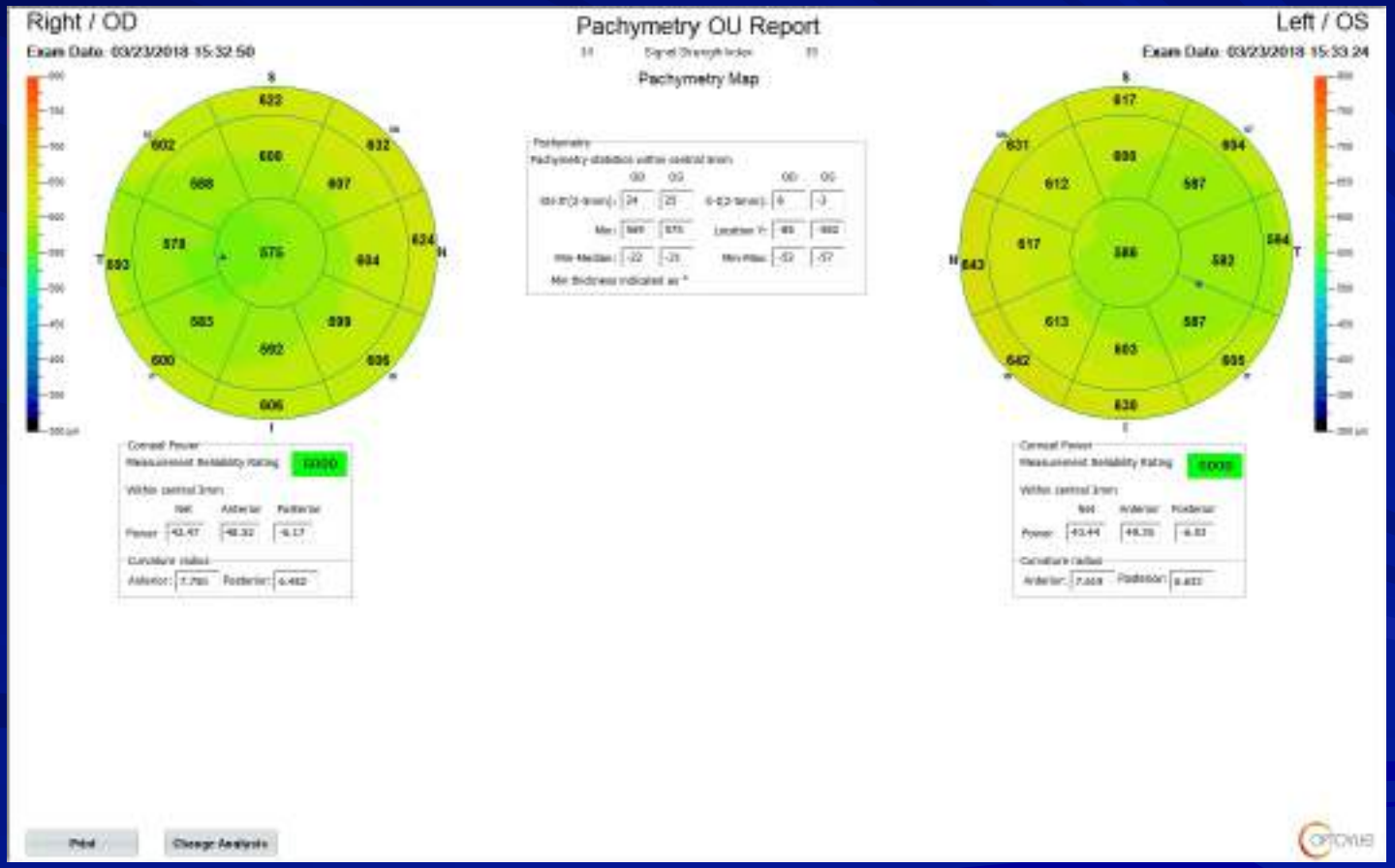


68 year old woman with glaucoma

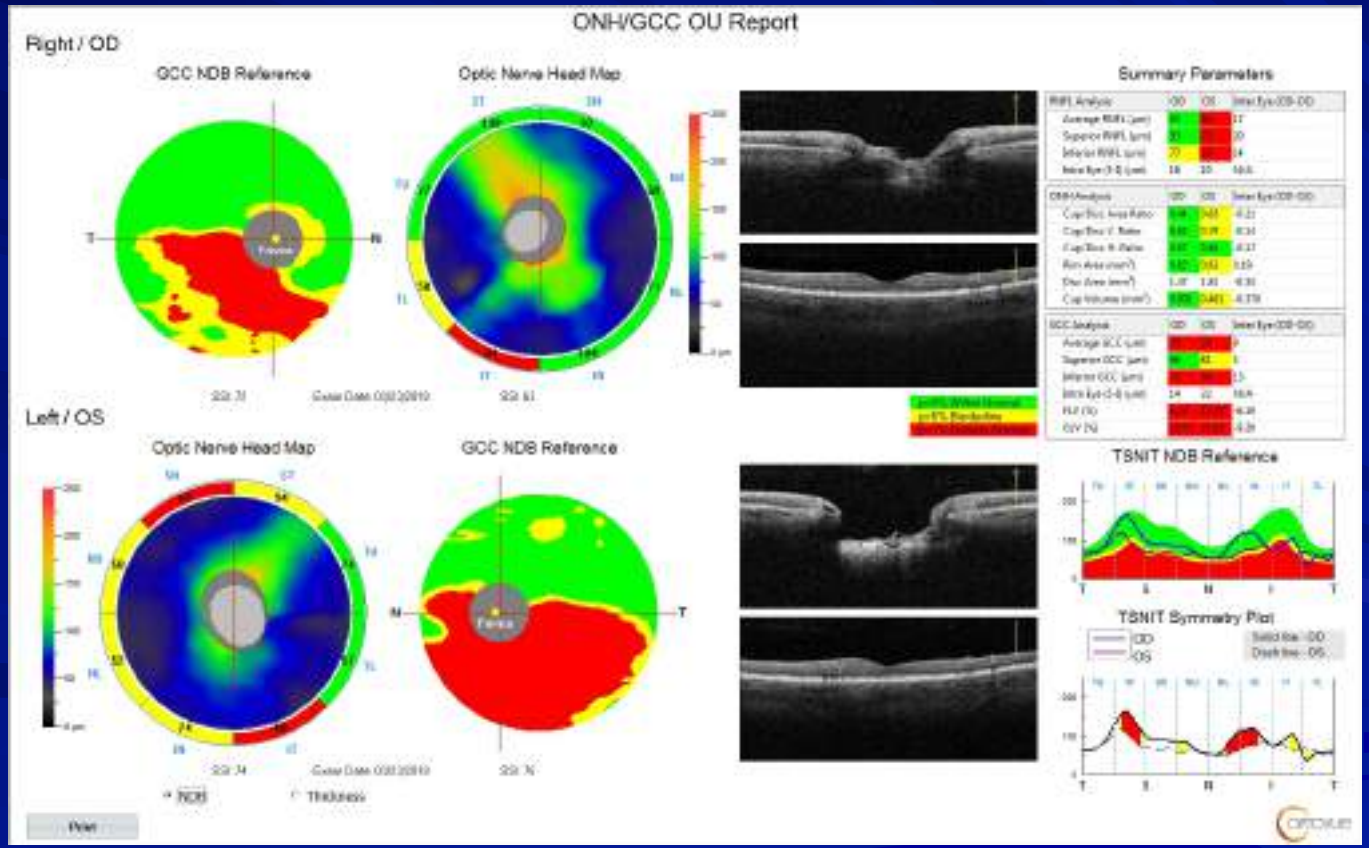
- Wants second opinion for glaucoma management
- Recently had cataract surgery OS with iStent
  - ★ September 25, 2017
  - ★ Dorzolamide 2% BID OS, Lumigan 0.01% QD OS
- Our practice recently performed cataract surgery and Kahook dual blade (KDB) MIGS
  - ★ July 24, 2018
- IOP_{GAT}: 12 and 16 at 11:27 am



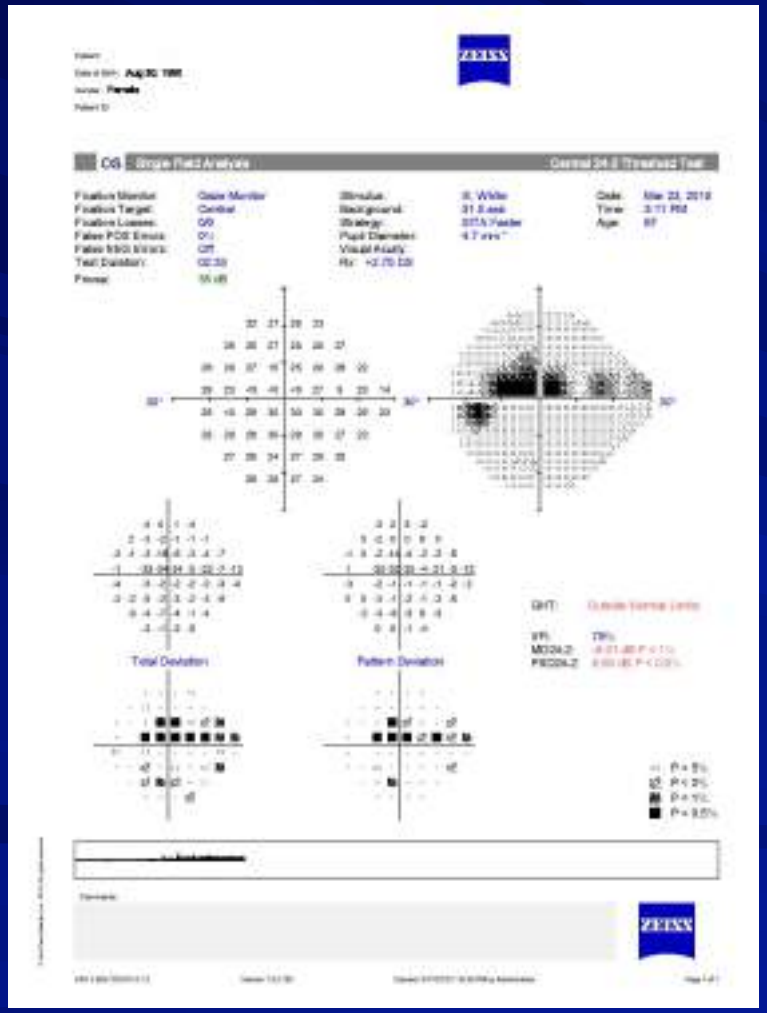
OCT for Pachymetry in Glaucoma

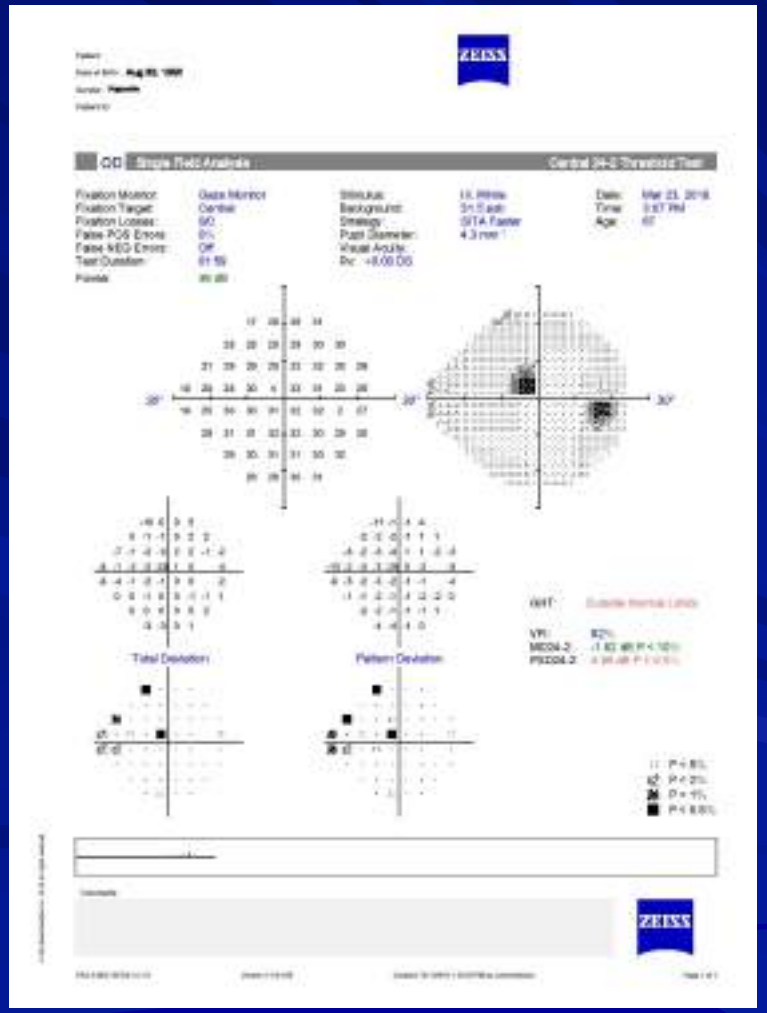


OCT GCC and NFL

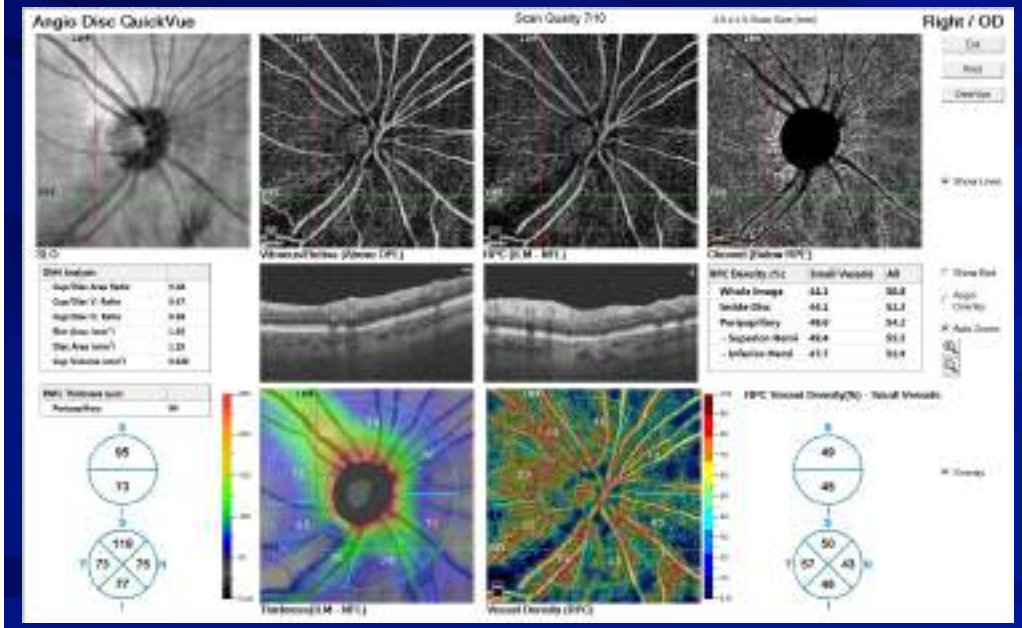


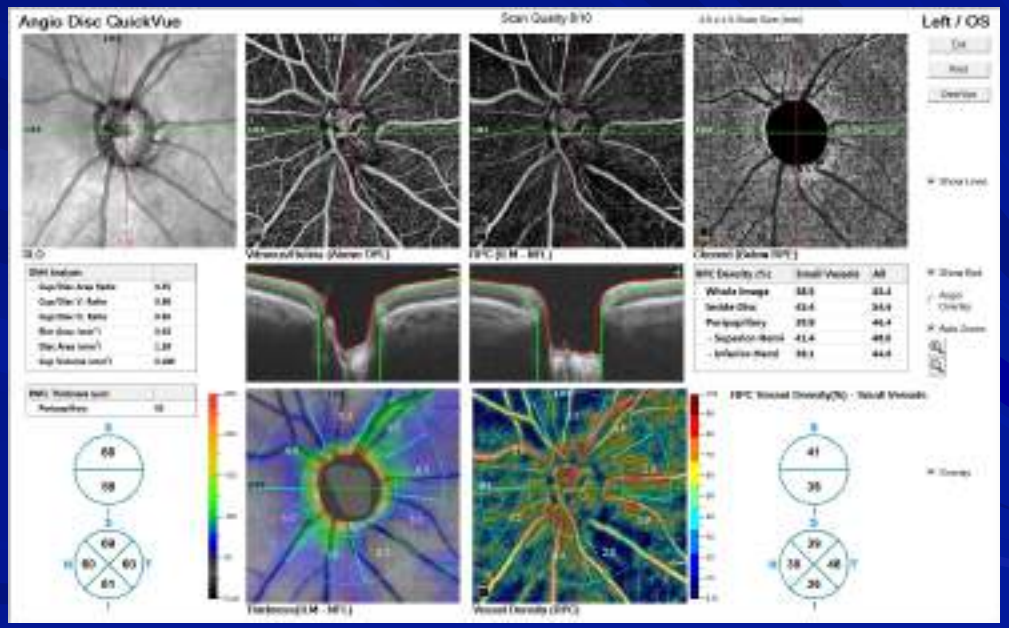
Visual Fields



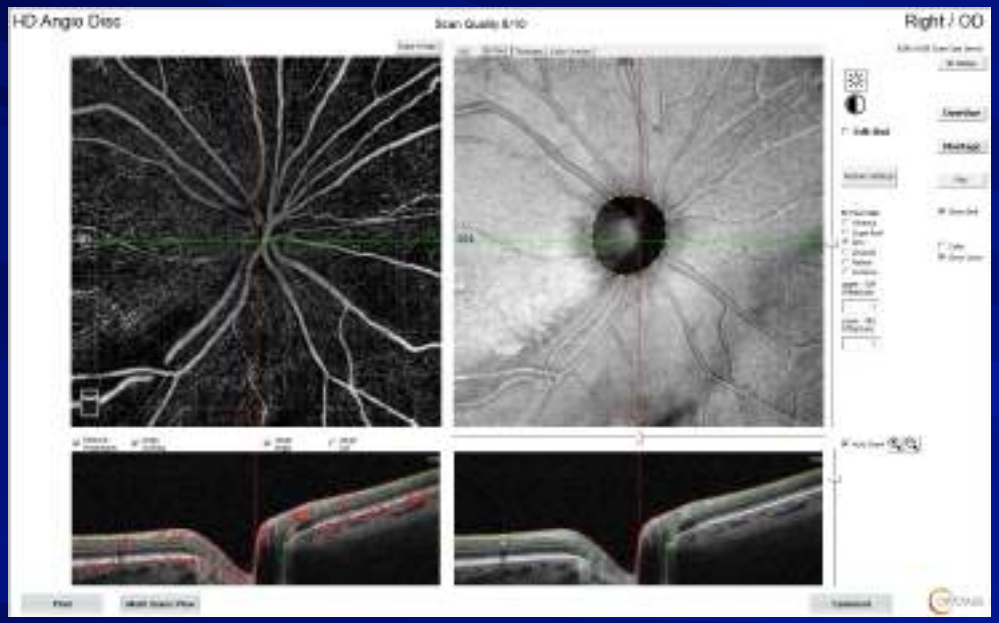


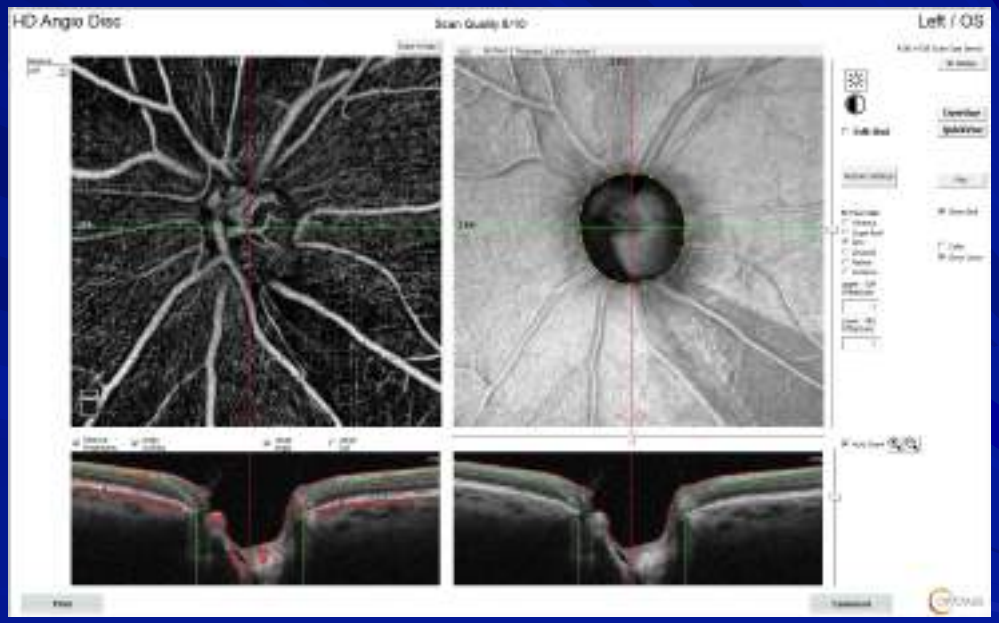
Angiography and AngioAnalytics of Disc



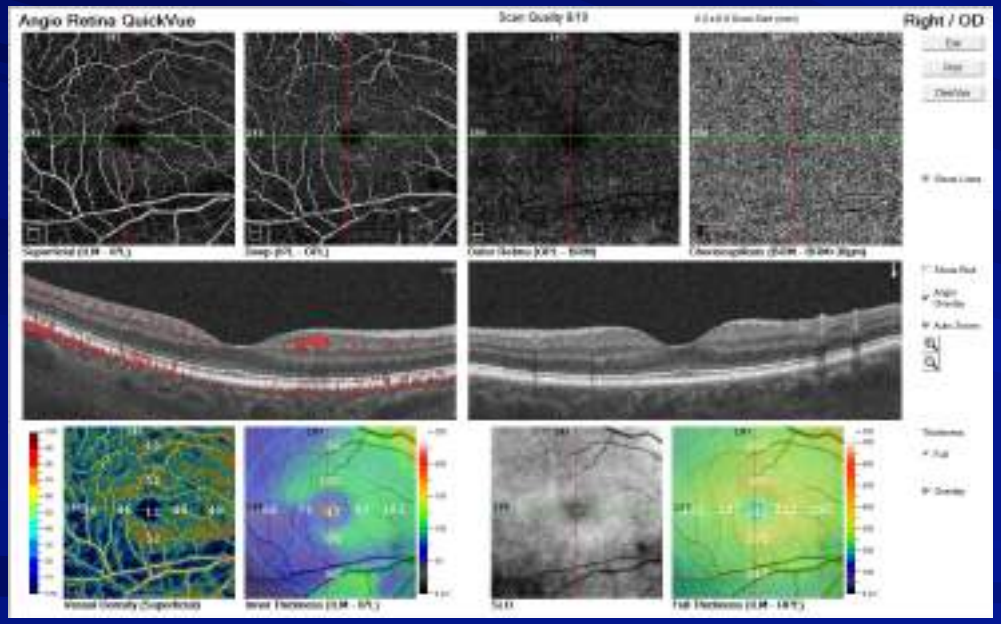


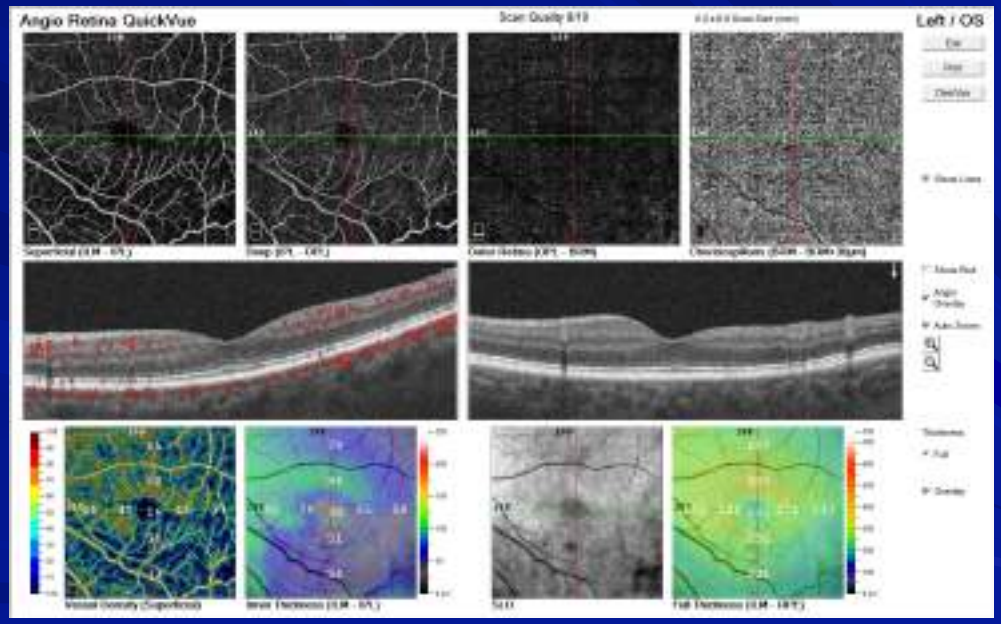
En Face Radial Peripapillary Capillaries (RPC)





Angiography and AngioAnalytics of Retina





Montage OD


Angio Montage
Right / OD
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Print
Reset View
Edit
Vitreous/Retina
Outer/Choroid
Layers
Superficial
Greyscale
Click image to
select layer.
Use scrollwheel
to adjust layer.

Montage OS


Angio Montage
Left / OS
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QuickVue
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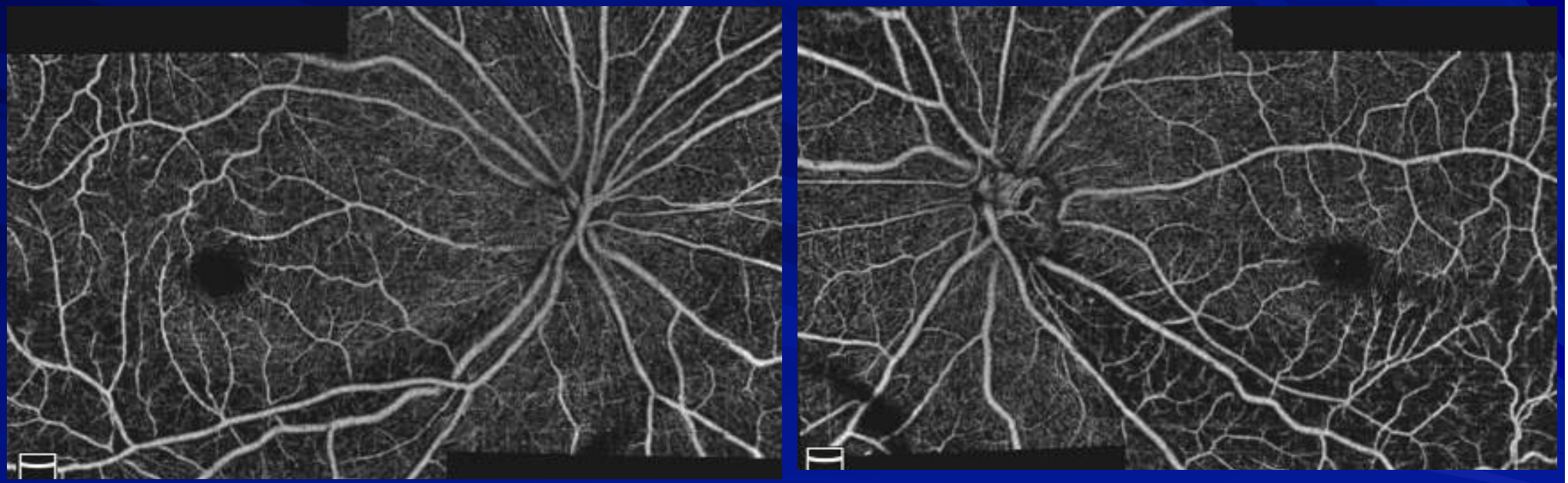
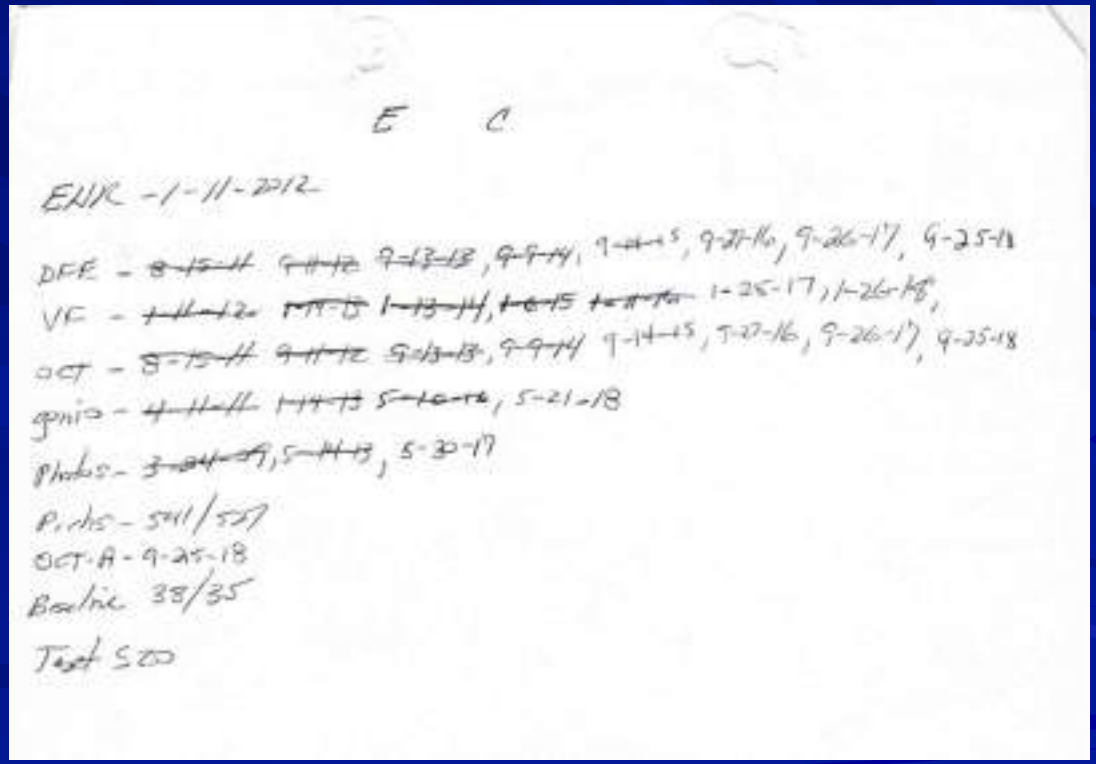
Layers:
Superficial
Greyscale
Click image to
select layer.
Use scrollwheel
to adjust layer.

Montage OU

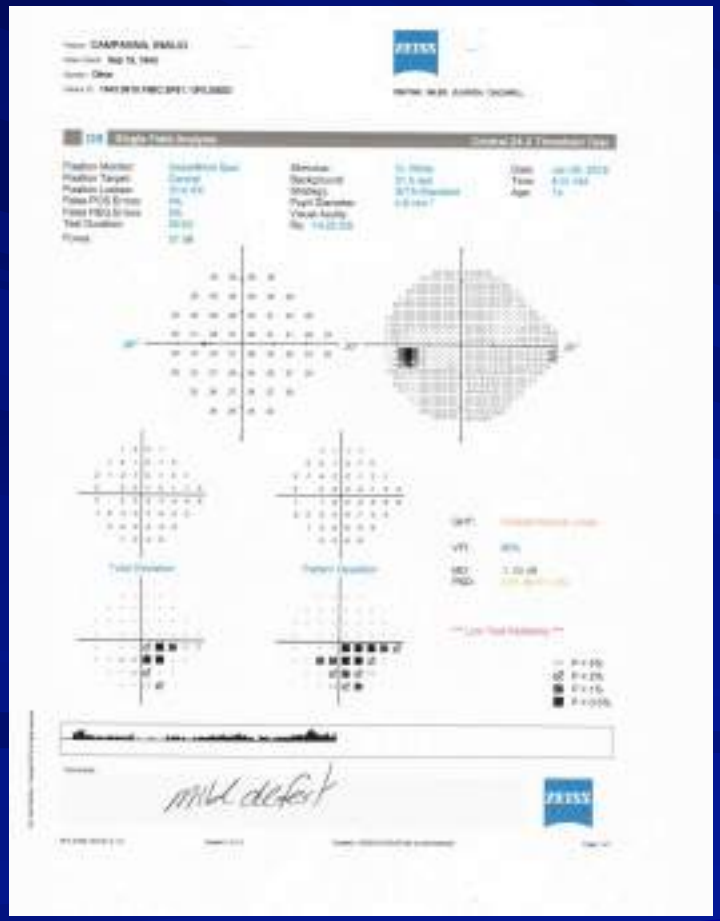


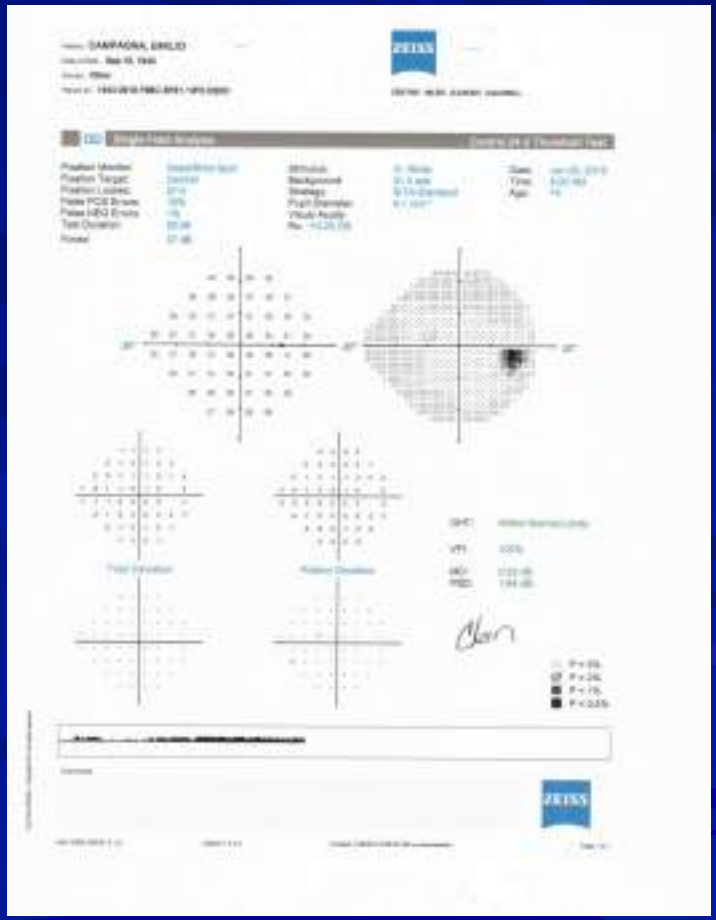
74 year old man

- POAG, OS > OD
- Lumigan 0.01% QD OU
- Combigan BID OU



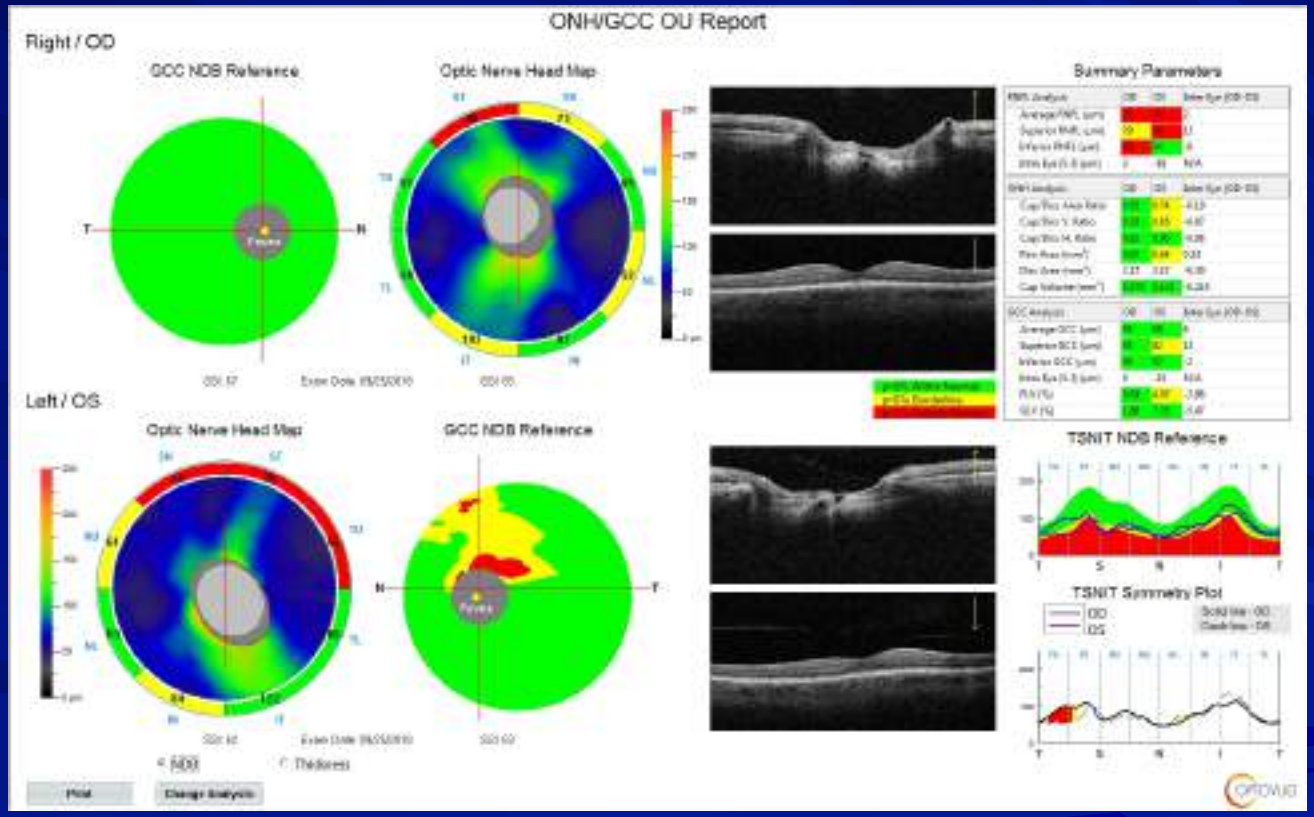
VF OD and OS 1-26-2018



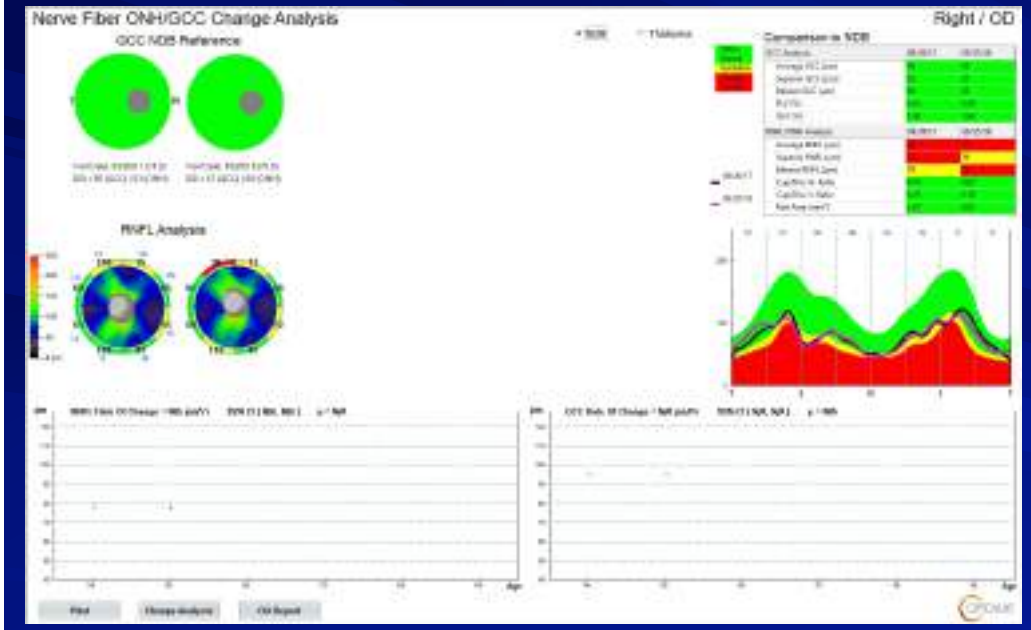


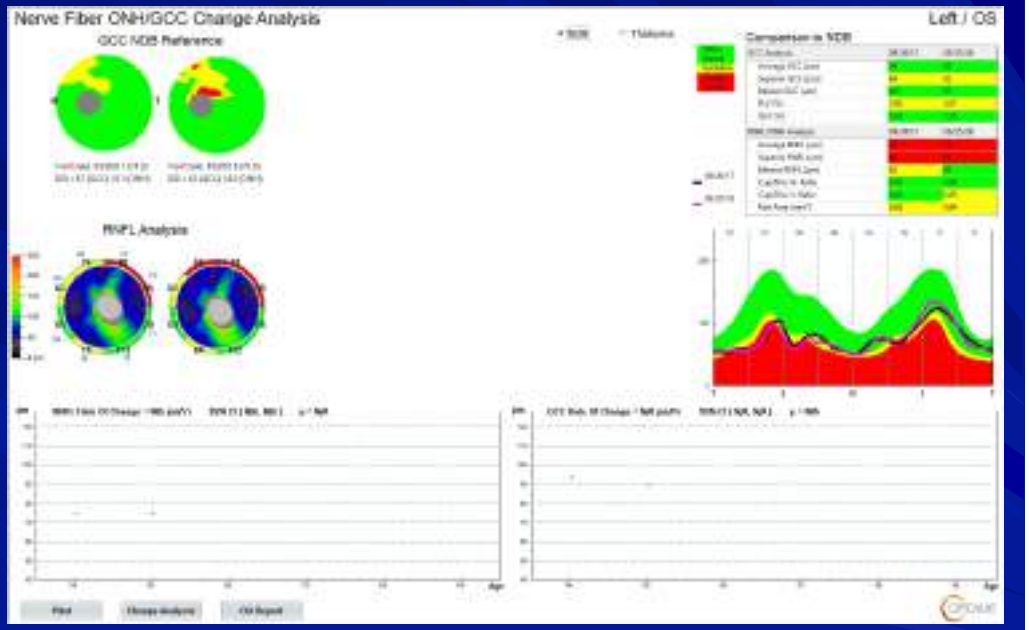
VF OD and OS GPA 1-26-2018

OCT NFL and GCC 9-25-2018

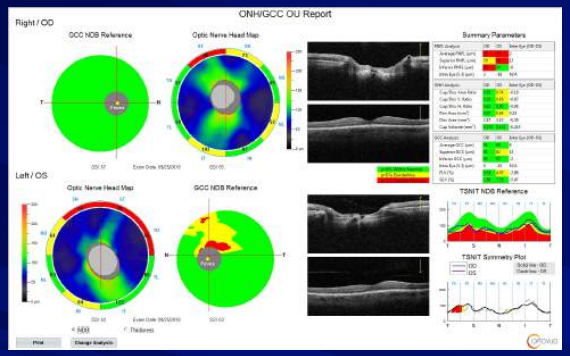


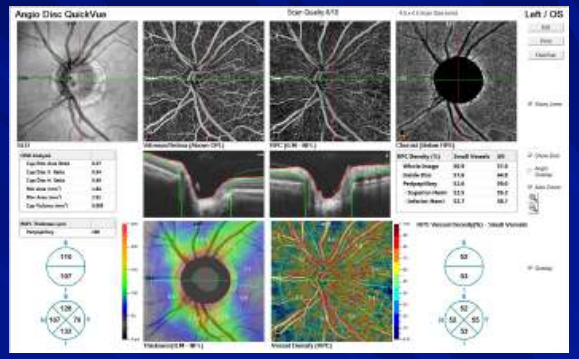
Change Analysis NFL-GCC

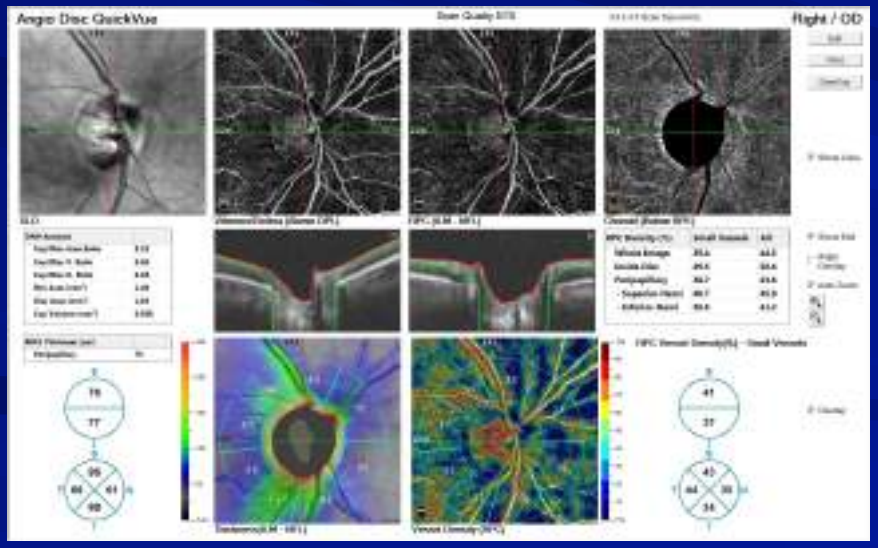


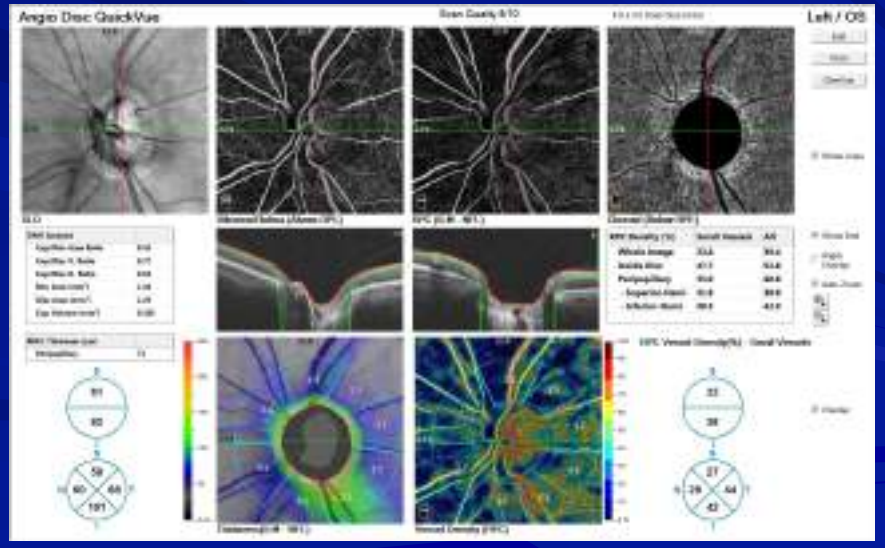


OCT-A 9-25-2018
POAG OS > OD

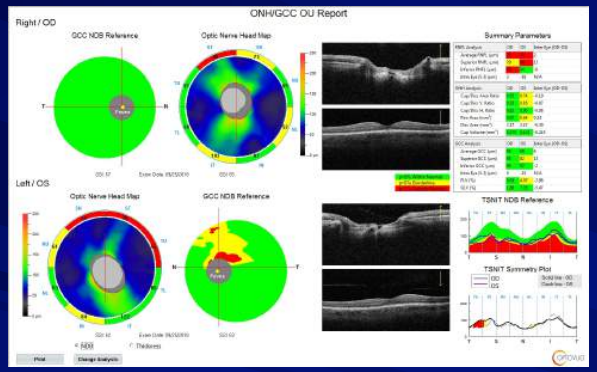


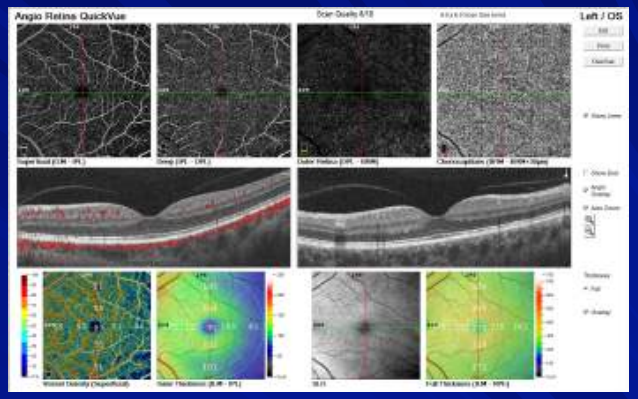


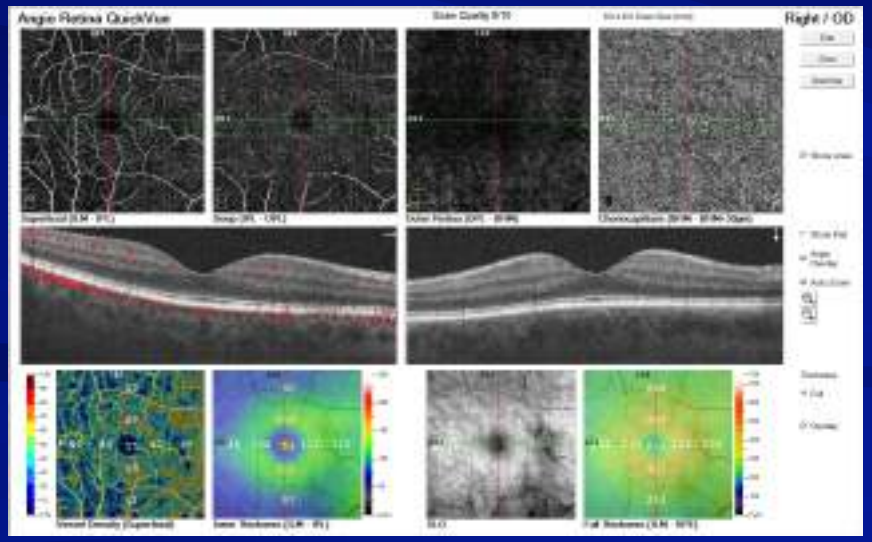


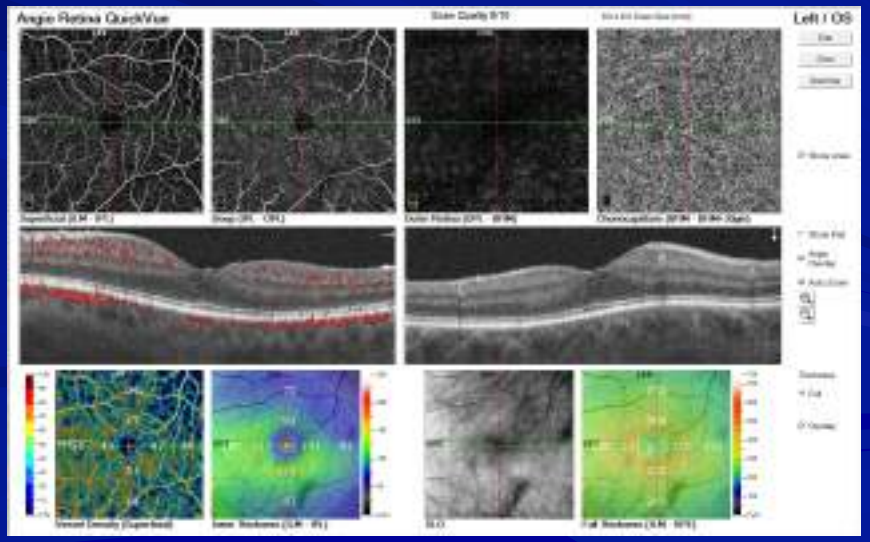


OCT-A 9-25-2018
POAG OS > OD





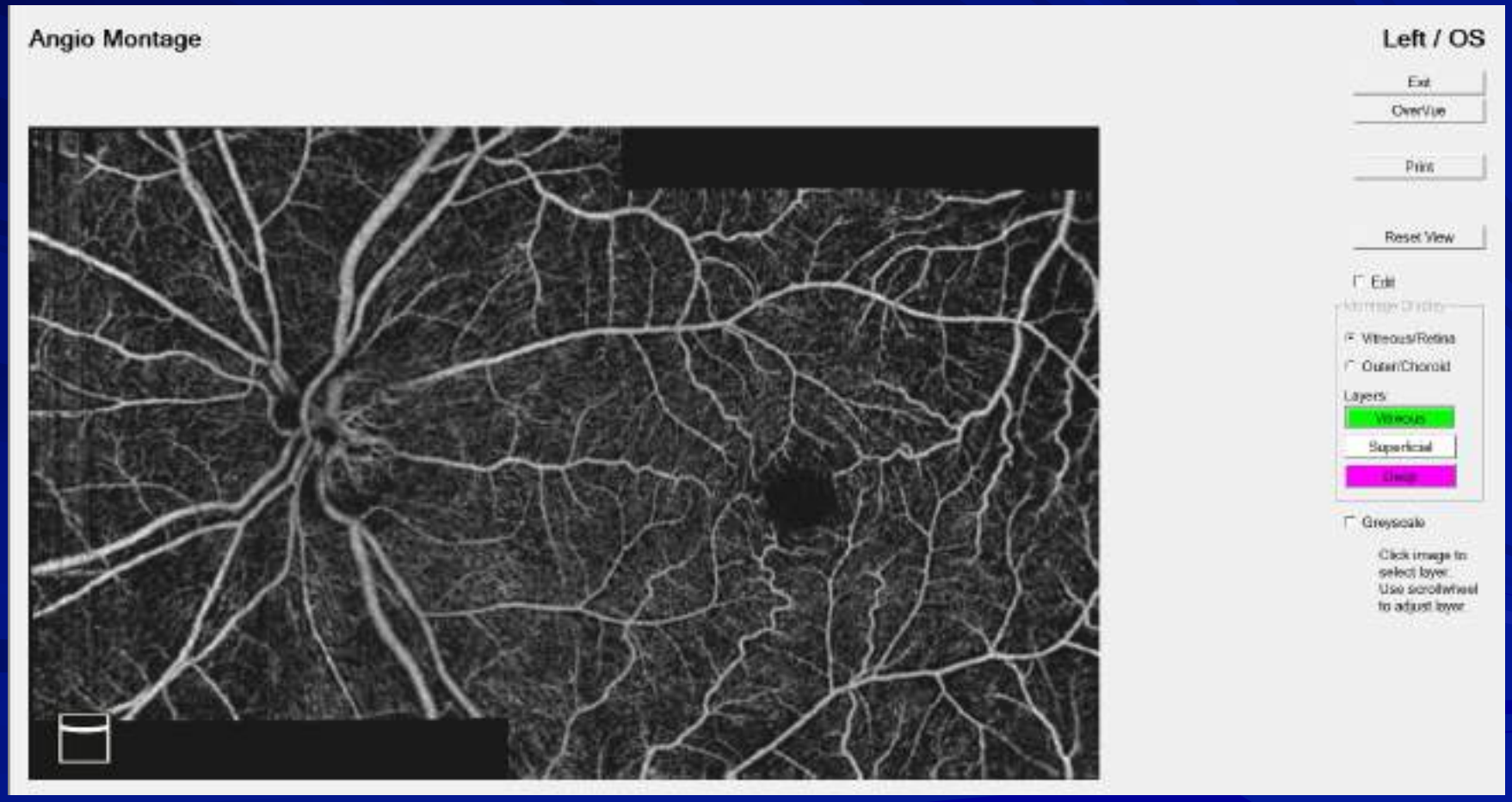




Montage OD


Angio Montage
Right / OD
Exit
Print
Reset View
Edit
Vitreous/Retina
Outer/Choroid
Layers
Superficial
Greyscale
Click image to
select layer.
Use scrollwheel
to adjust layer.

Montage OS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Superficial
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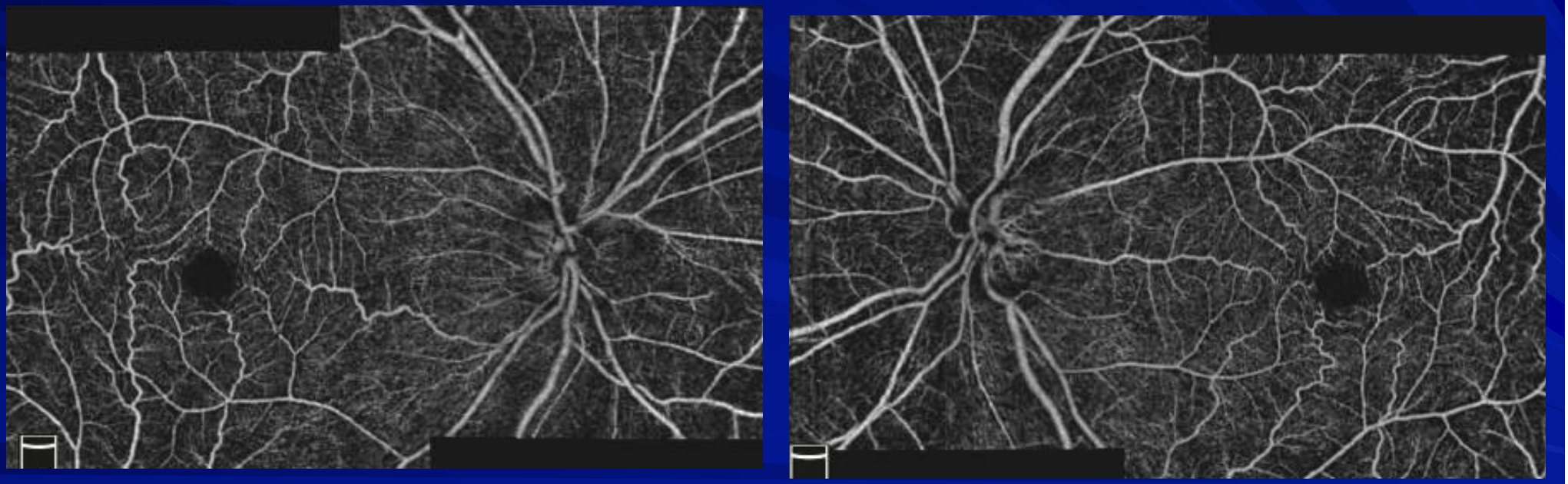
Greyscale
Click image to select layer. Use scrollwheel to adjust layer

Montage OU



They do read their EHR communication

Drs. Centar & Imler

From:
Date: Tuesday, September 25, 2018 1:07 PM
To: <centarimler@atlanticbb.net>
Subject:

To Whom it may concern:

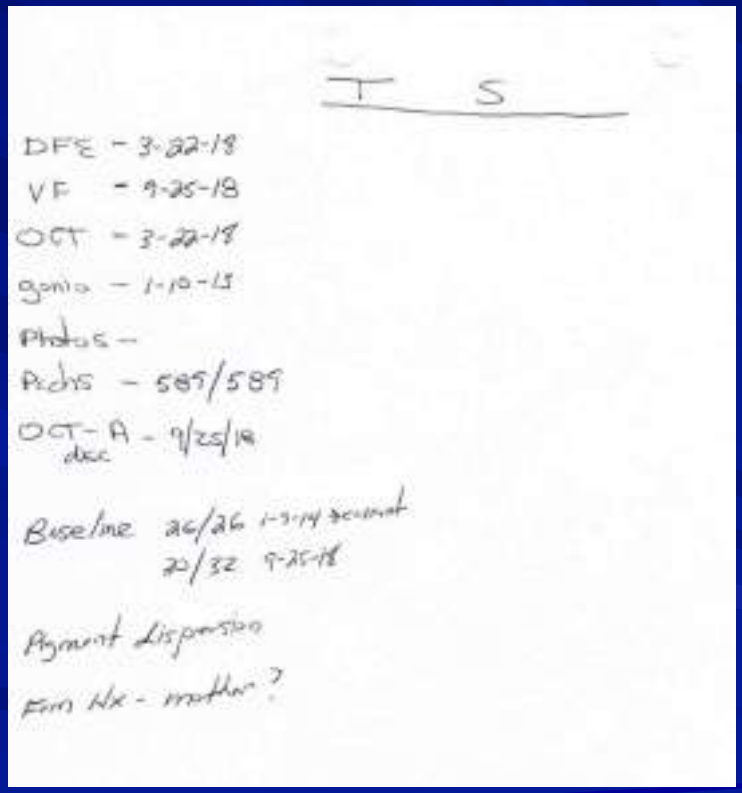
I was reading my patient chart online, which was emailed to me right after my office visit today. I noticed they have my weight recorded as 344 pounds. That weight is incorrect because I'm now at 333, which has been holding steady between 332 and 334 for several months now.

Sincerely,

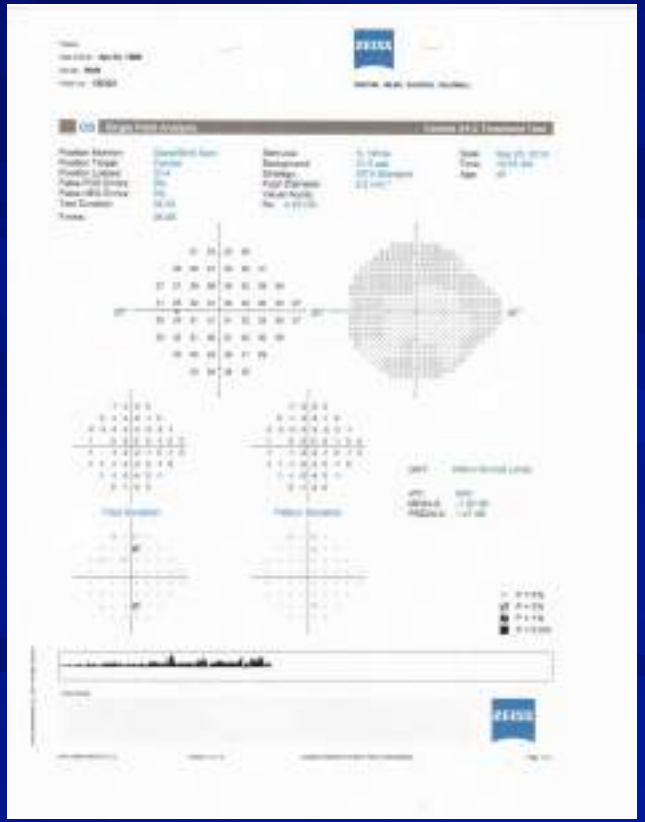
Sent from my iPhone

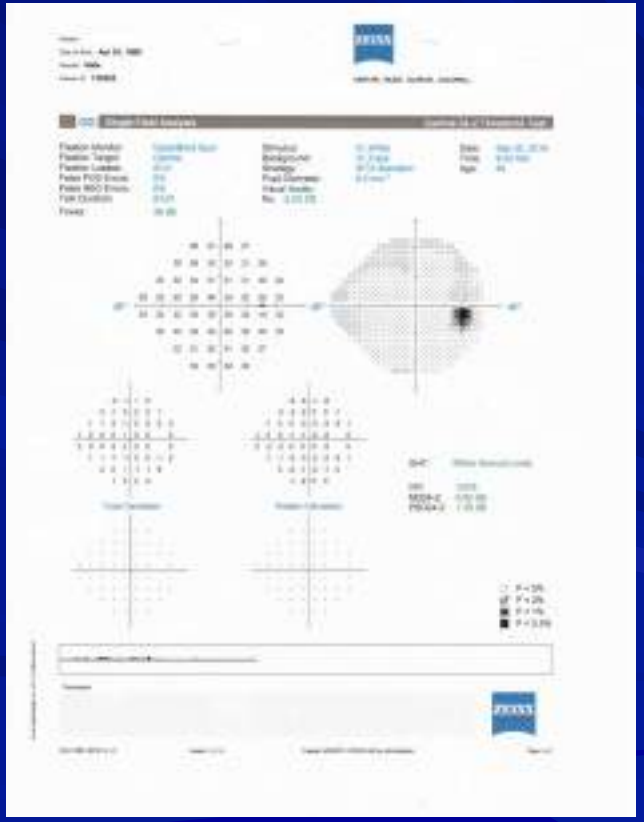
49 year old man

- Ocular Hypertension since 2014
  - ✶ No treatment
- Pigment Dispersion
- Baseline IOP or Tmax 26/26
  - ✶ 2014— March 2018
- Today 30/32, new Tmax 9-25-18

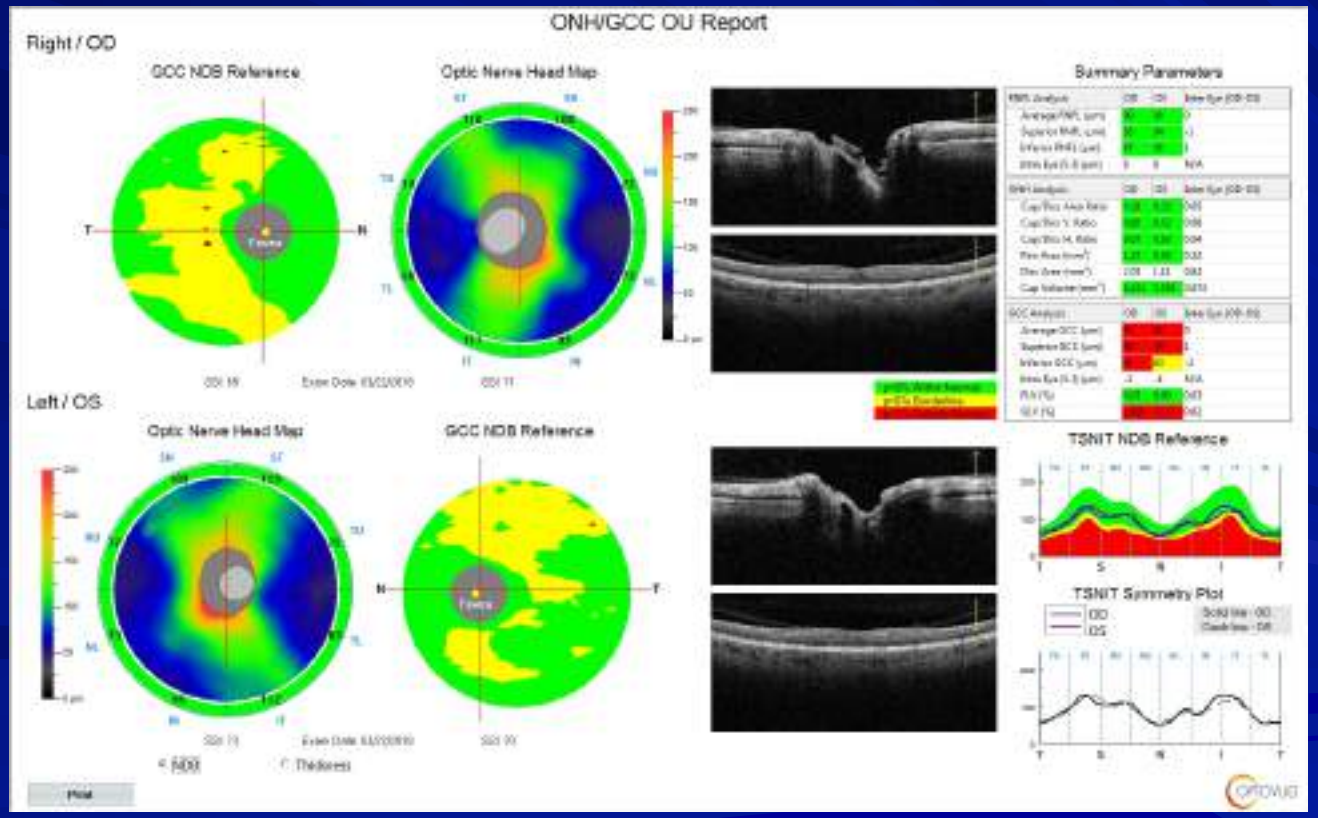


VF 24-2 Sita-Faster
9-25-2018

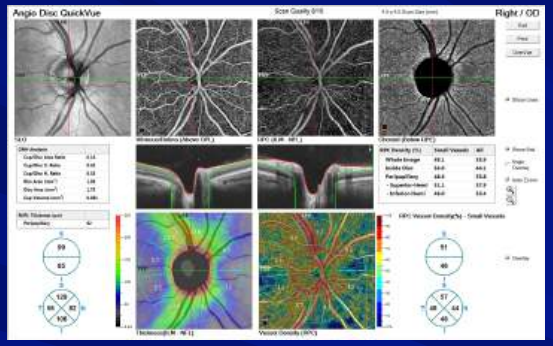


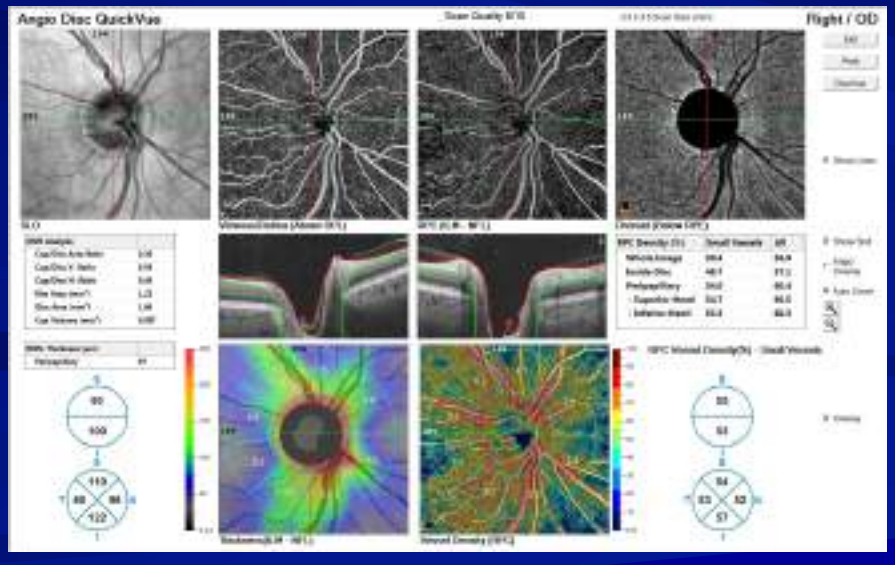


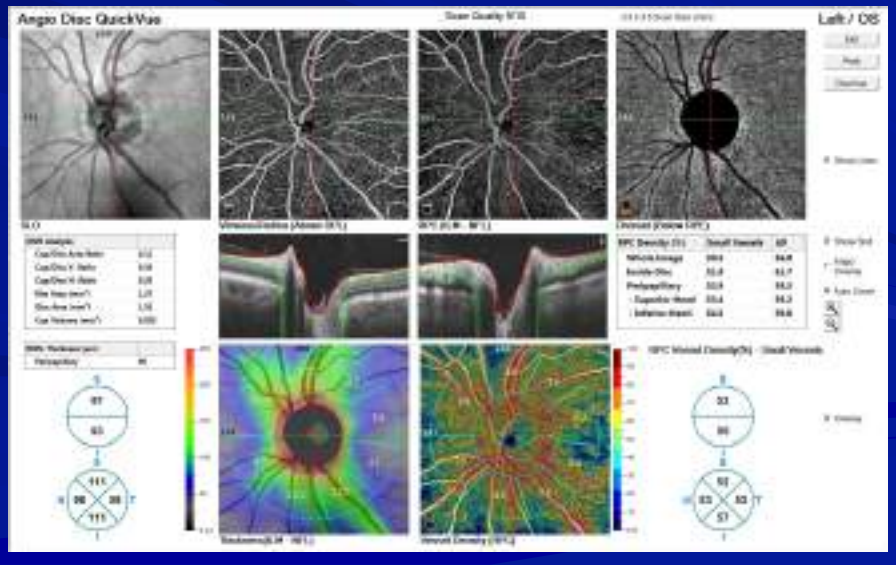
OCT NFL and GCC
3-22-18



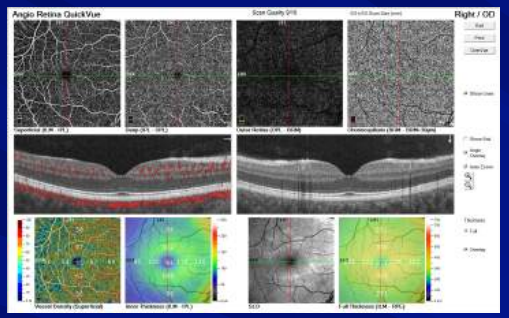
OCT-A 9-25-2018

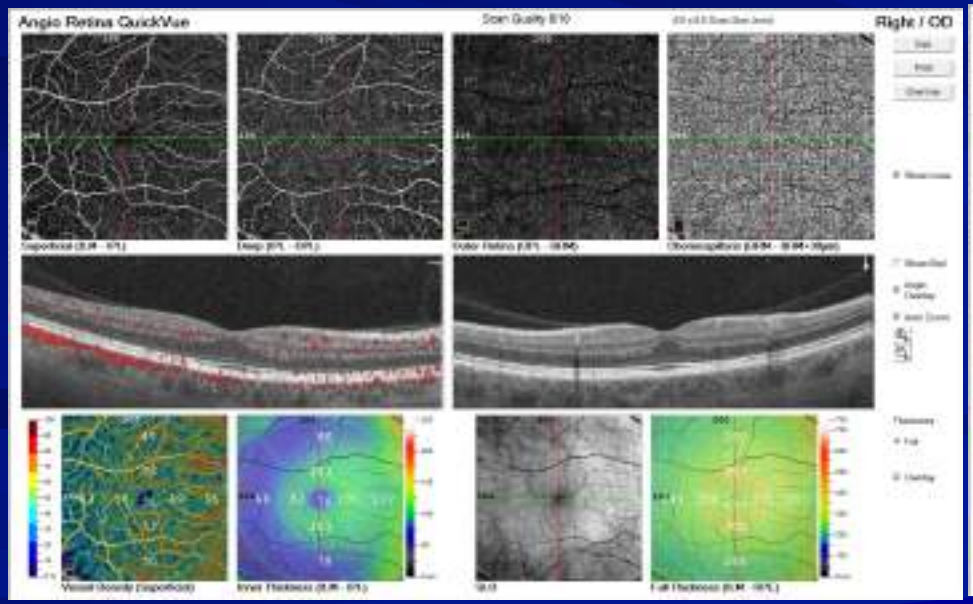


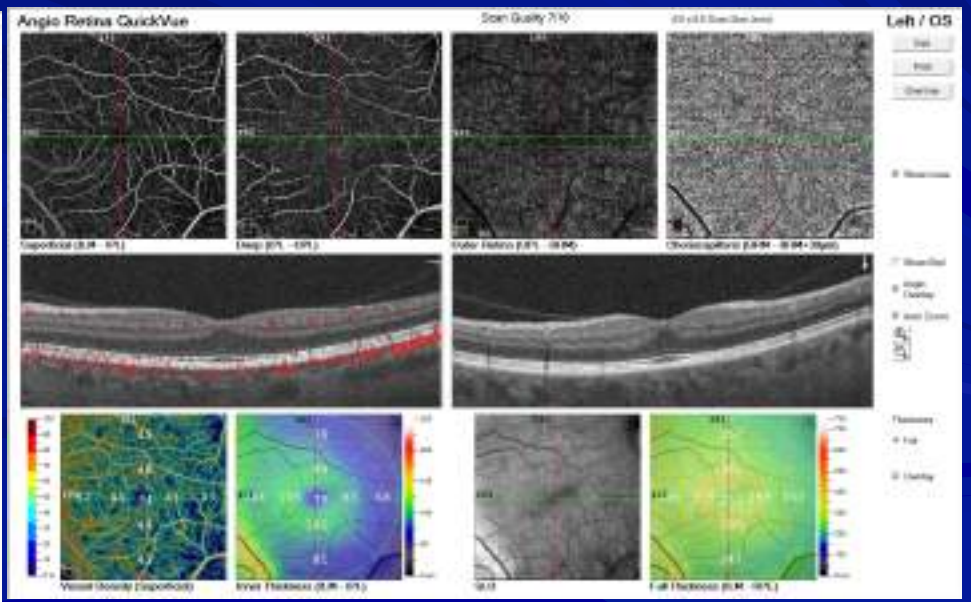




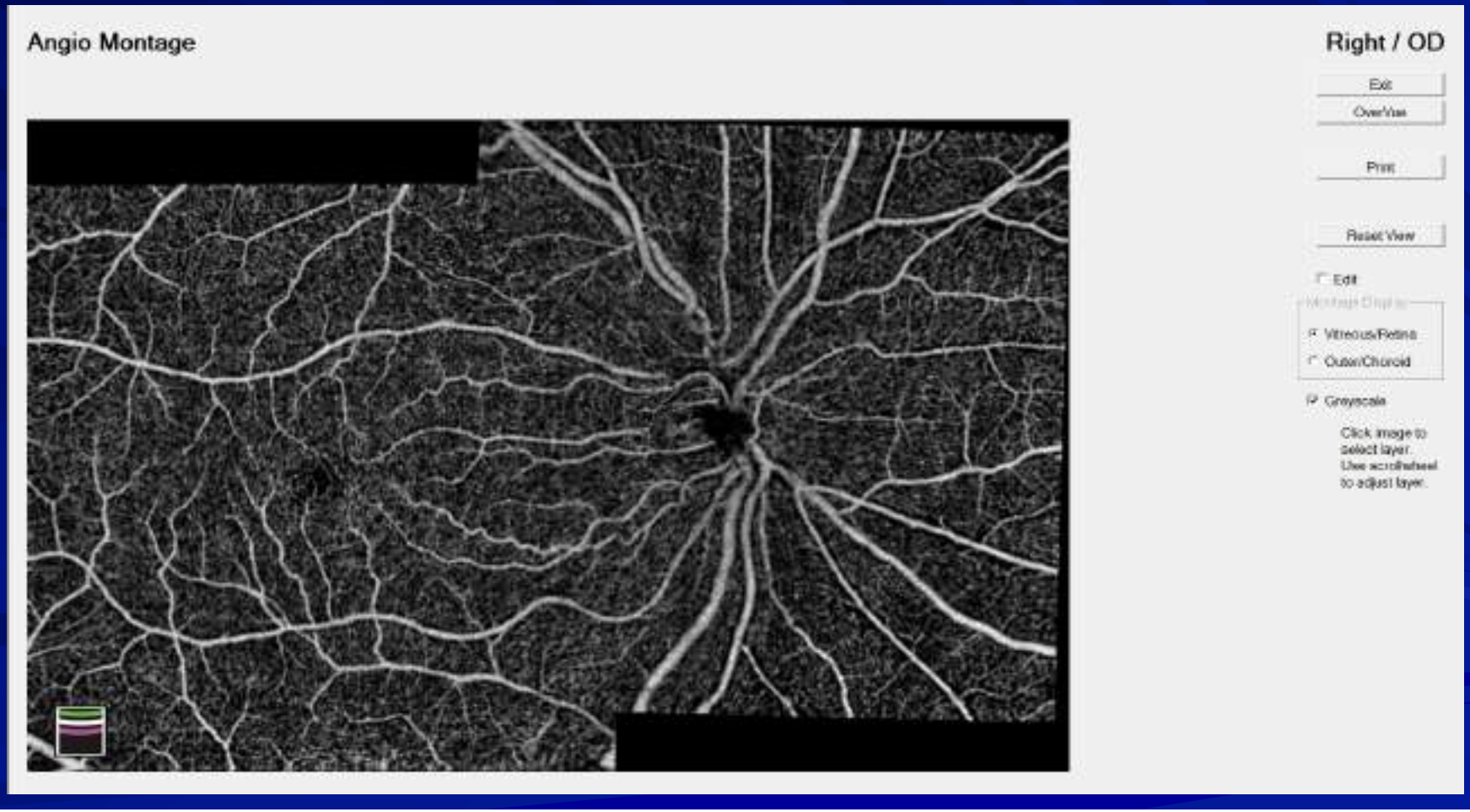
OCT-A 9-25-2018







Montage OD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Right / OD
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Reset View
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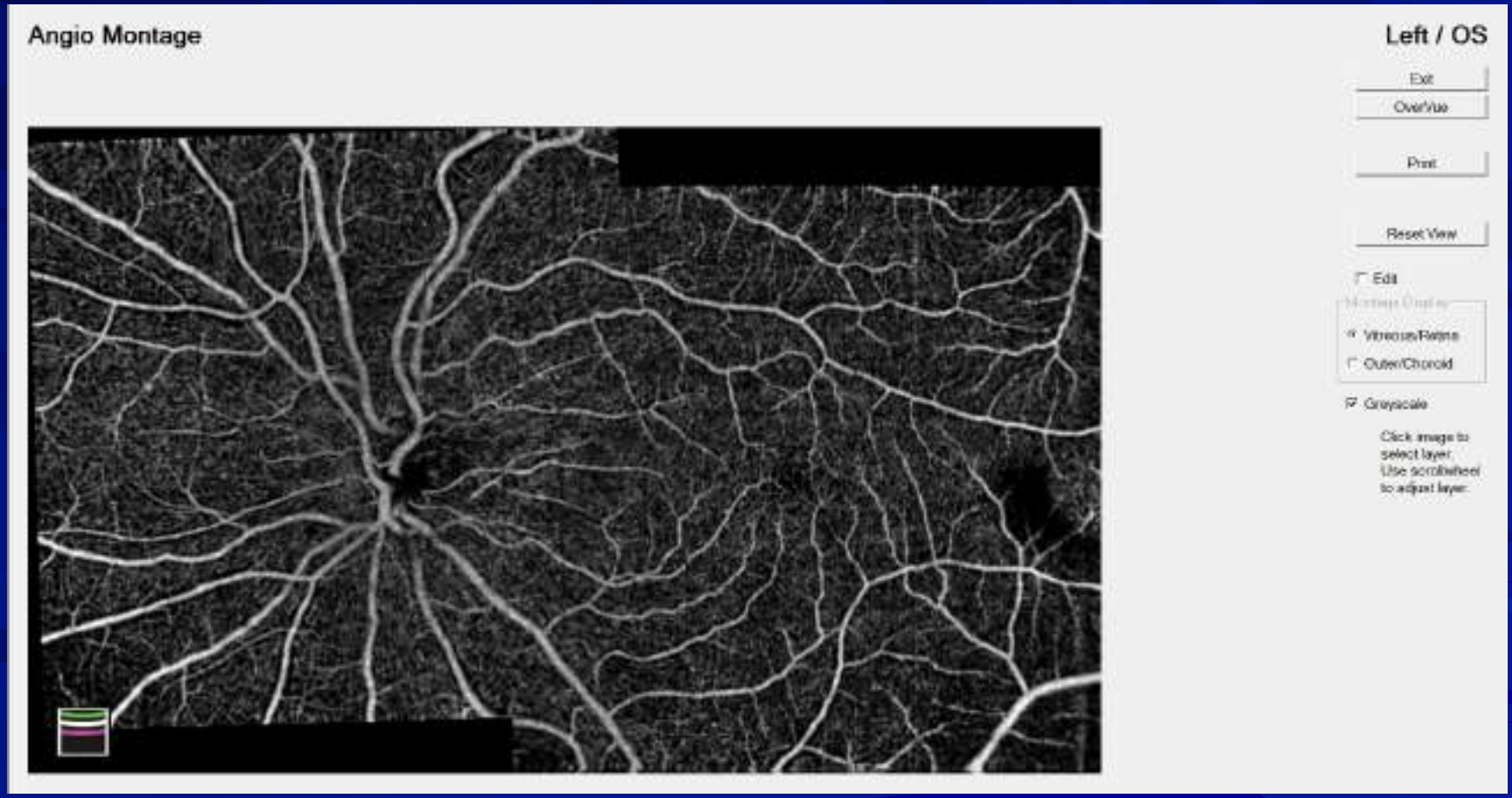
Vitreous/Retina
Outer/Choroid
Greyscale
Click image to
select layer.
to adjust layer.

Montage OS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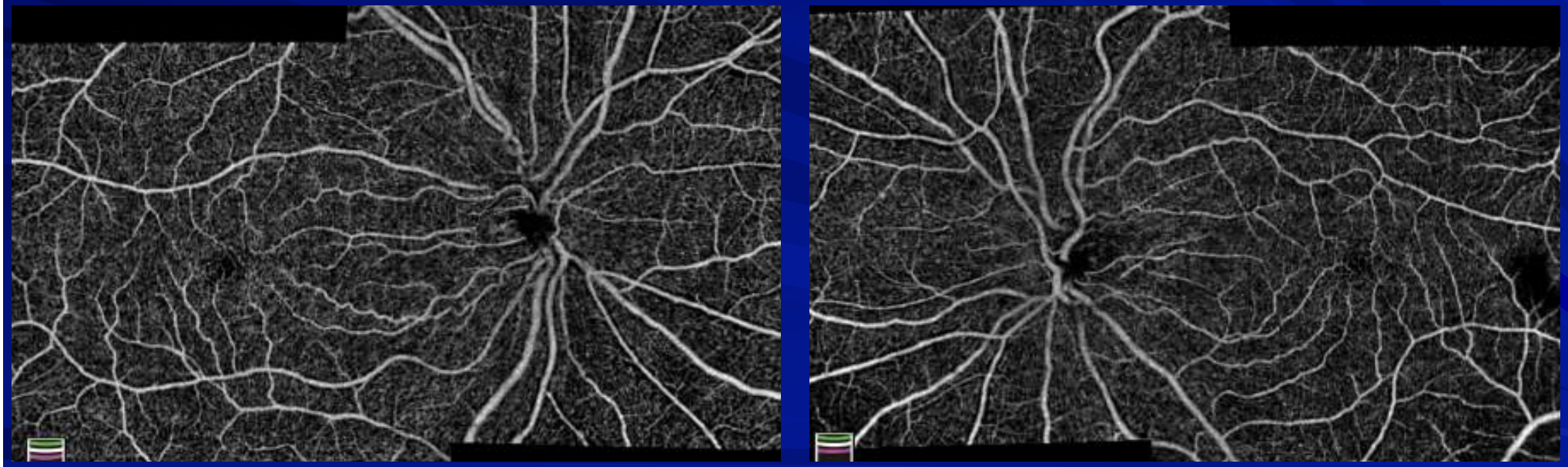
Outer/Choroid
Grayscale
Click image to
select layer.
Use scrollwheel
to adjust layer.

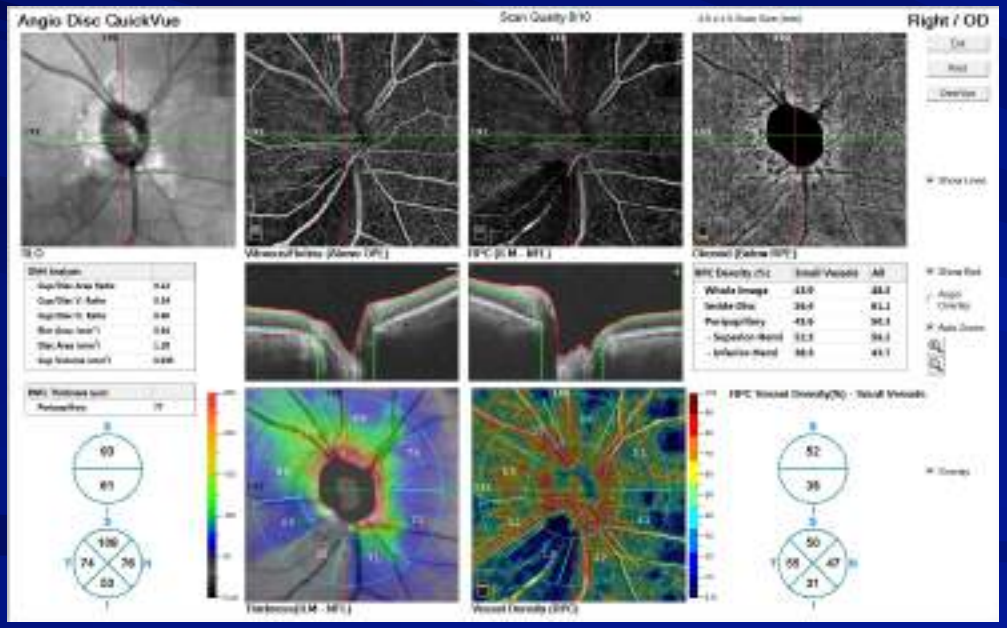
Montage OU

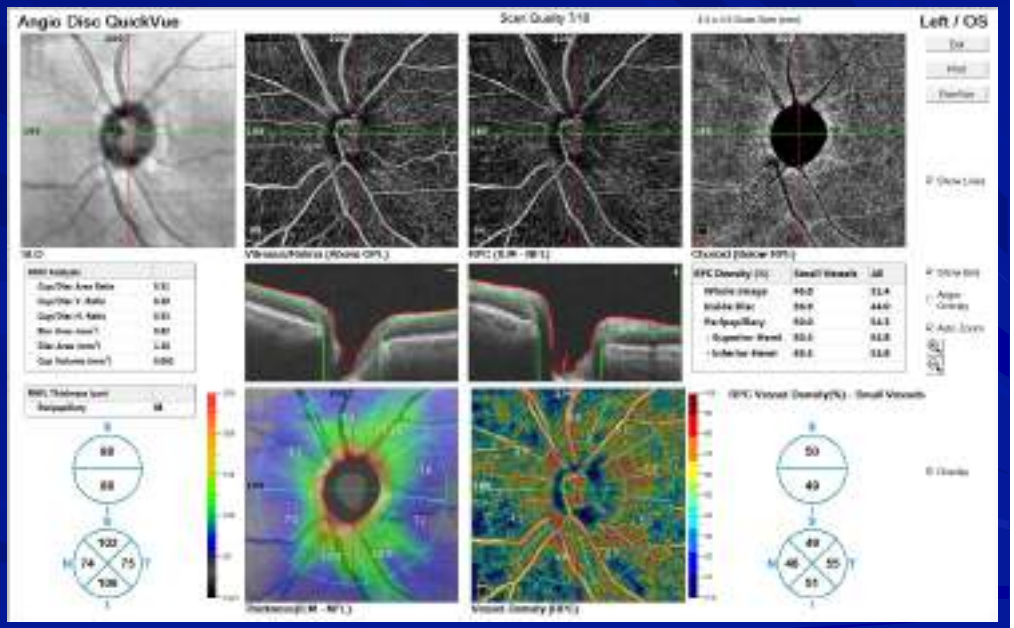


How Does OCTA Change the Way You See Glaucoma?

- Shows early changes in the retina and optic disc
- Adds new information to the diagnosis
- Aids in progression detection

Glaucoma versus Other Optic Neuropathy

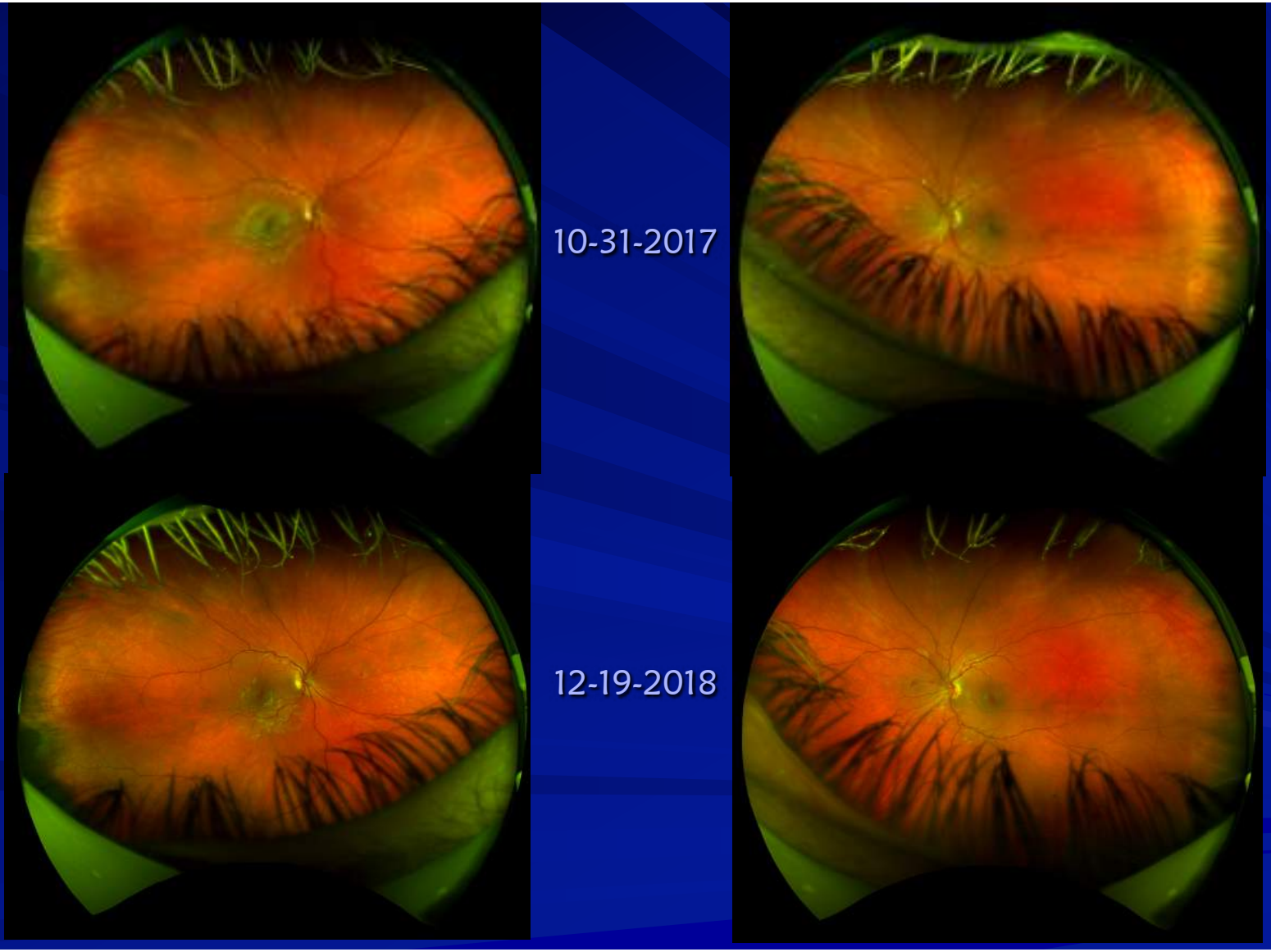




Next Generation Diabetes and Retina Analysis with OCT + OCTA

29 year old man with diabetes

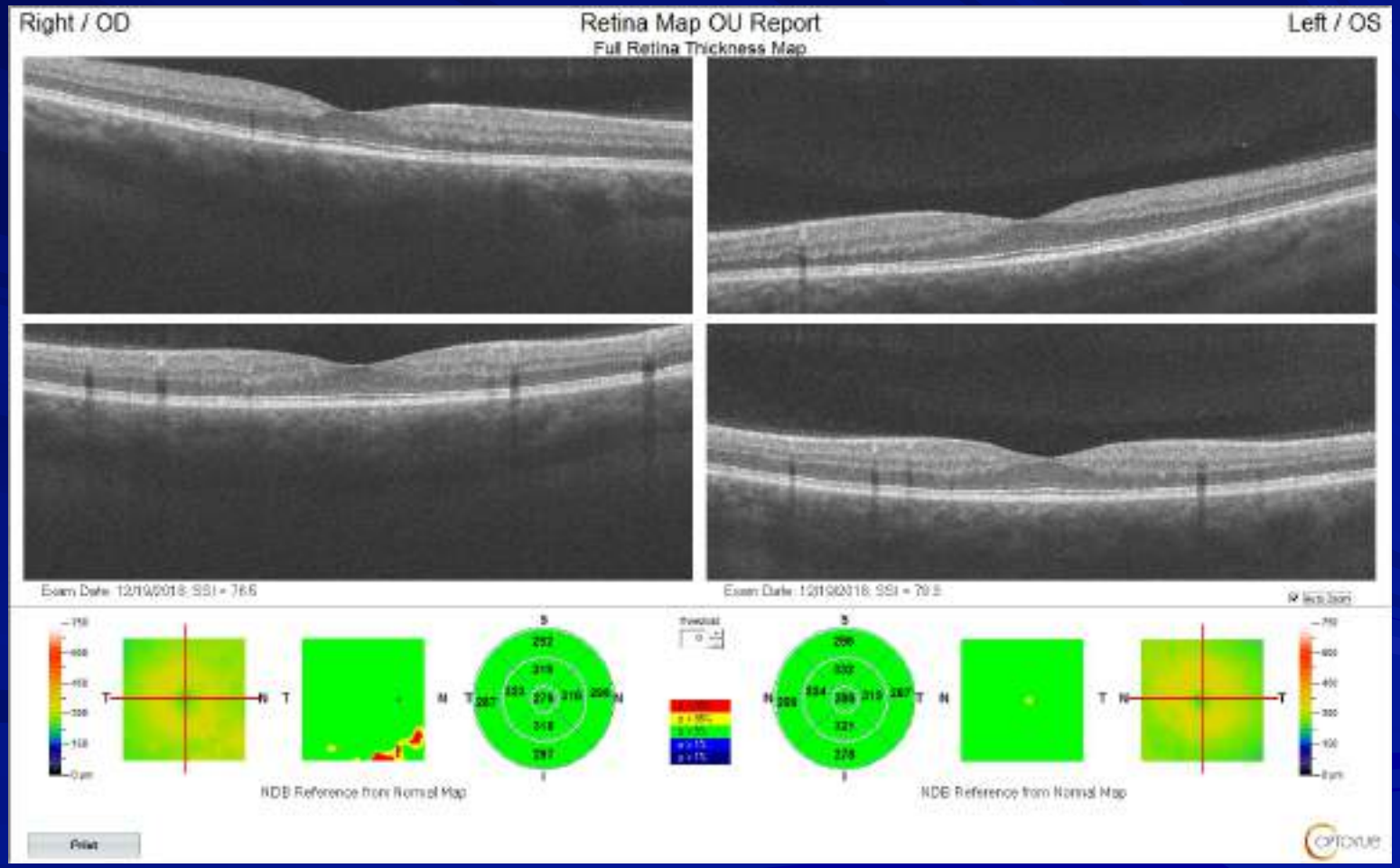
- Yearly diabetic exam, reports no changes to vision
  - Type 1 DM
- BS: 190 this AM, last HbA1c 8.6
- Vision 20/20
- Anterior segment: normal
- Posterior segment:
  - Non-proliferative DR
    - Hemes and exudates
  - No CSME
- Billed for:
  - Exam- 99214
  - Optomap, OCT-Wellness, and OCT-A (Angiography)


10-31-2017
12-19-2018

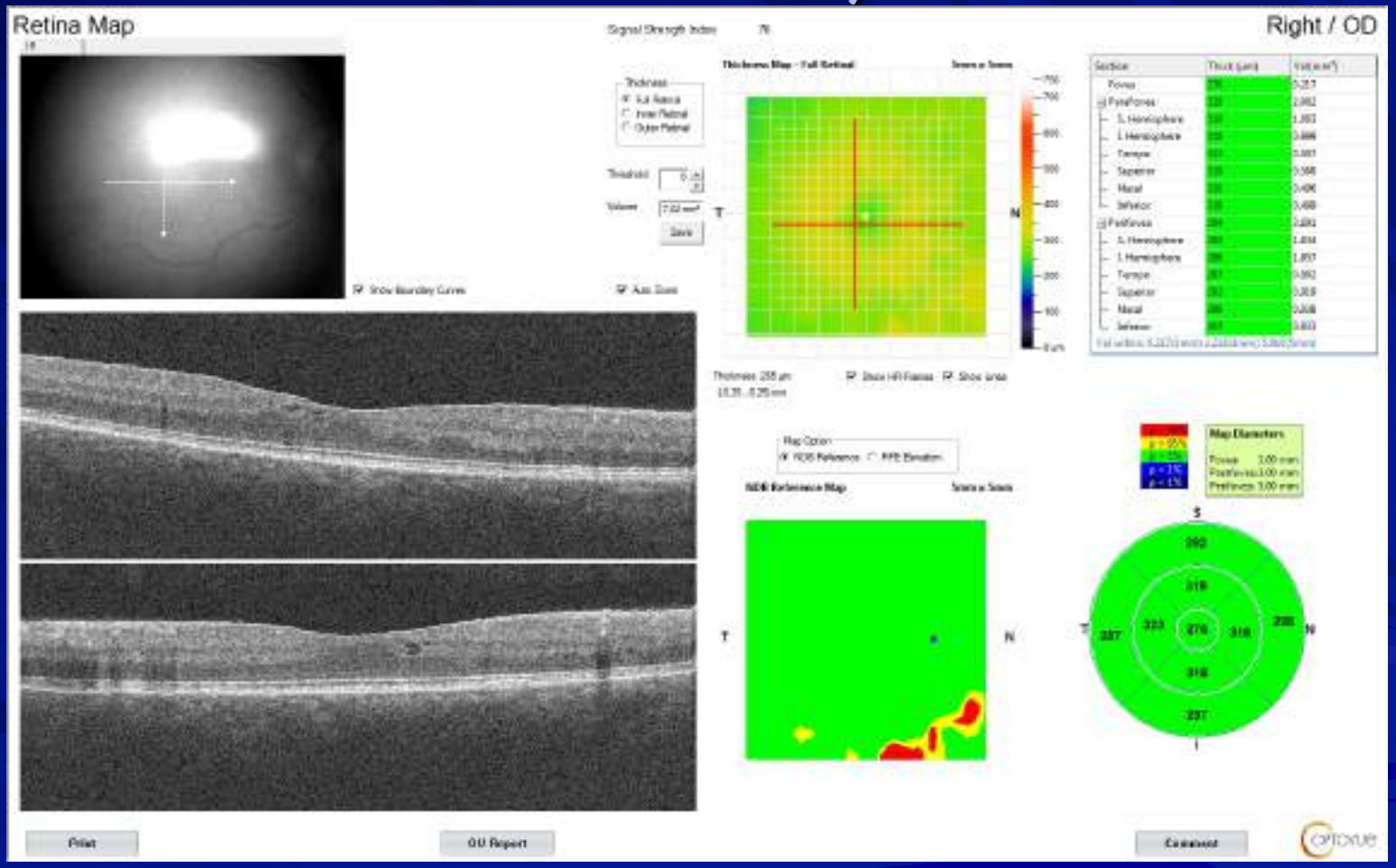

12-19-2018


12-19-2018

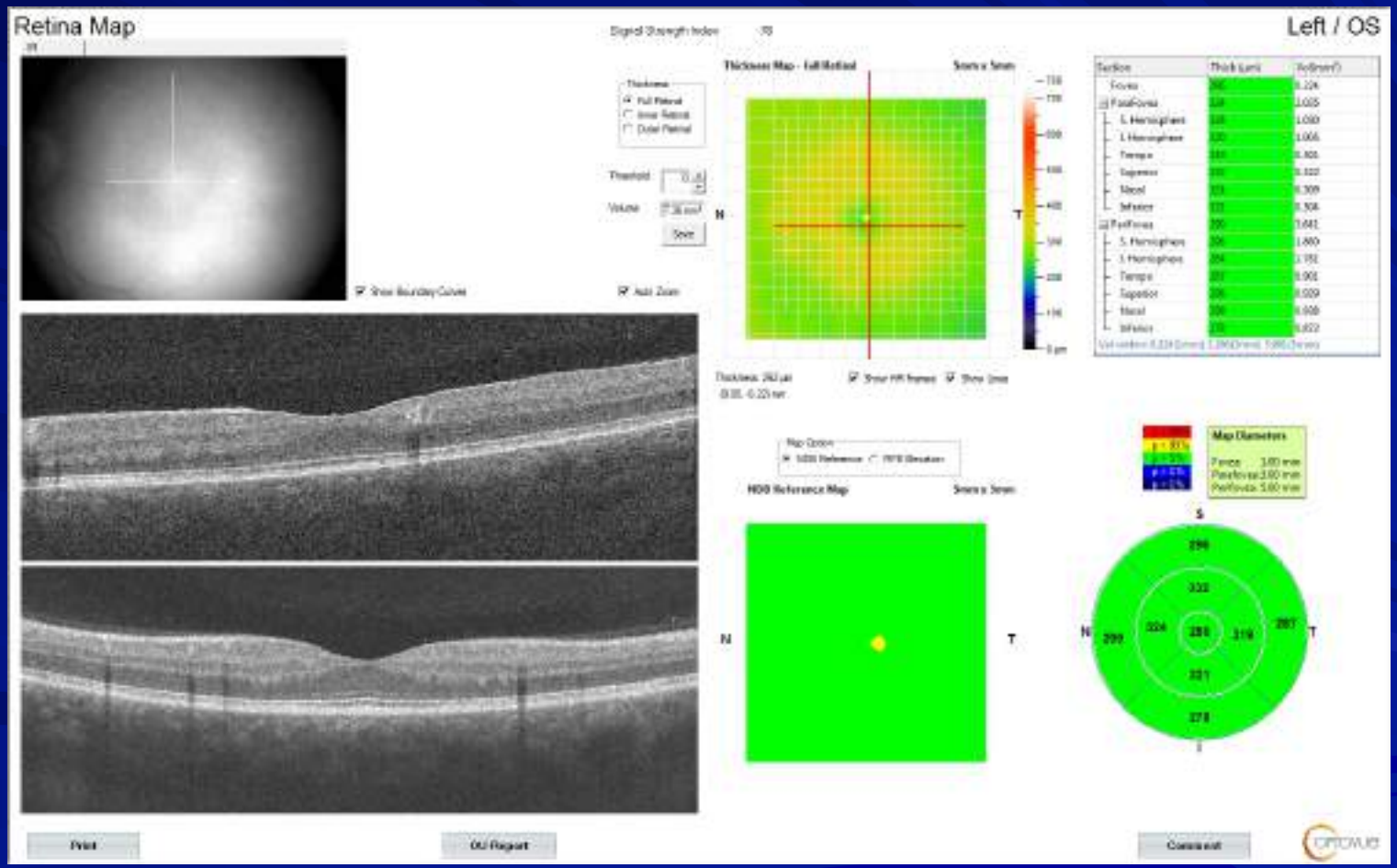
12-19-18


Right / OD
Retina Map OU Report
Full Retina Thickness Map
Left / OS
NDB Reference from Normal Map
NDB Reference from Normal Map
Print

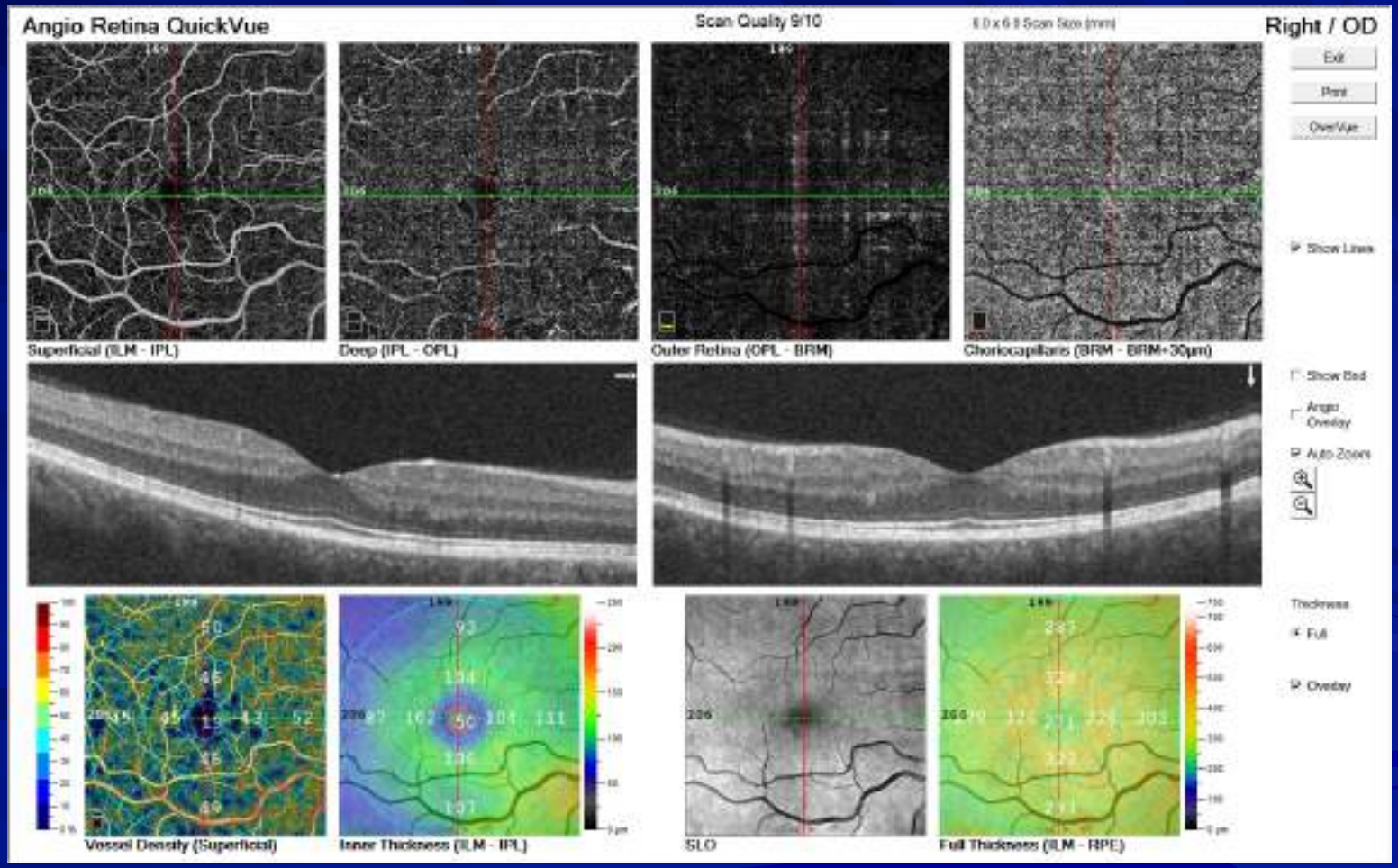
12-19-18 what do you see?



12-19-18 what do you see?



12-19-2018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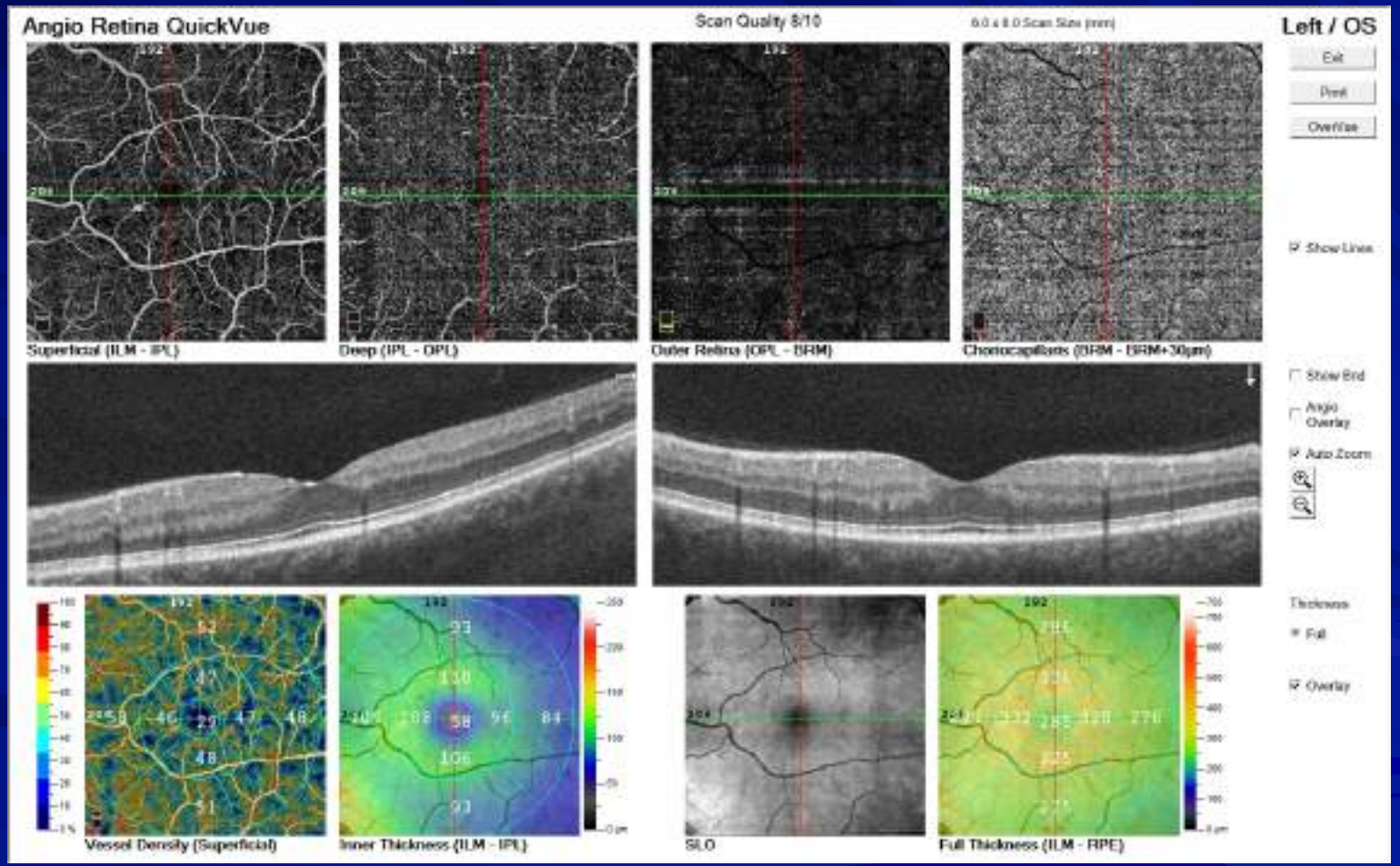
Right / OD
Exit
Print
Show Lines
Superficial (ILM - IPL)
Deep (IPL - OPL)
Outer Retina (OPL - BRM)
Choriocapillaris (BRM - BRM+30µm)
Show Bscan
Angio Overlay
Auto Zoom
Thickness
Full
Overlay
Vessel Density (Superficial)
Inner Thickness (ILM - IPL)
SLO
Full Thickness (ILM - RPE)

12-19-18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Left / OS
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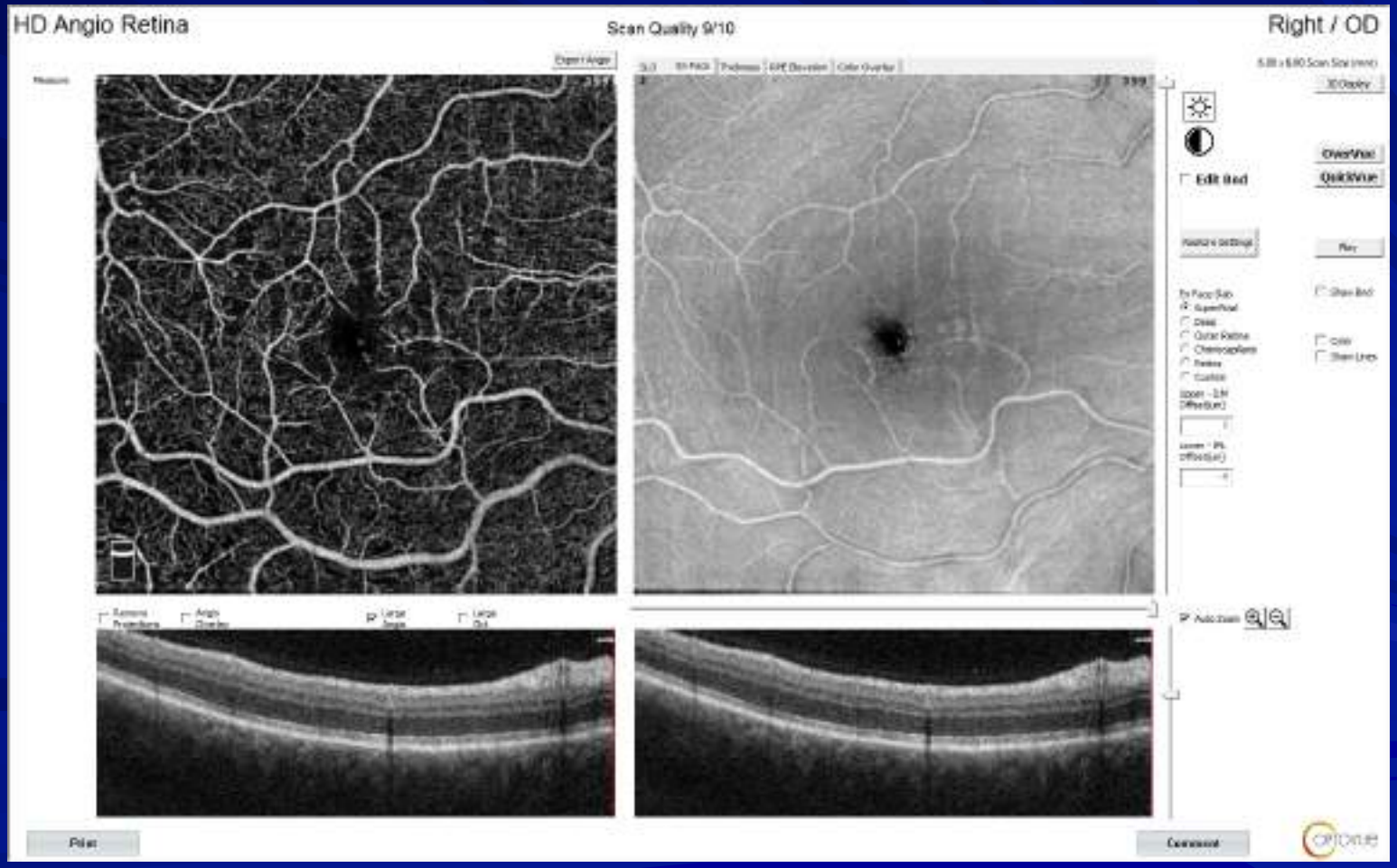
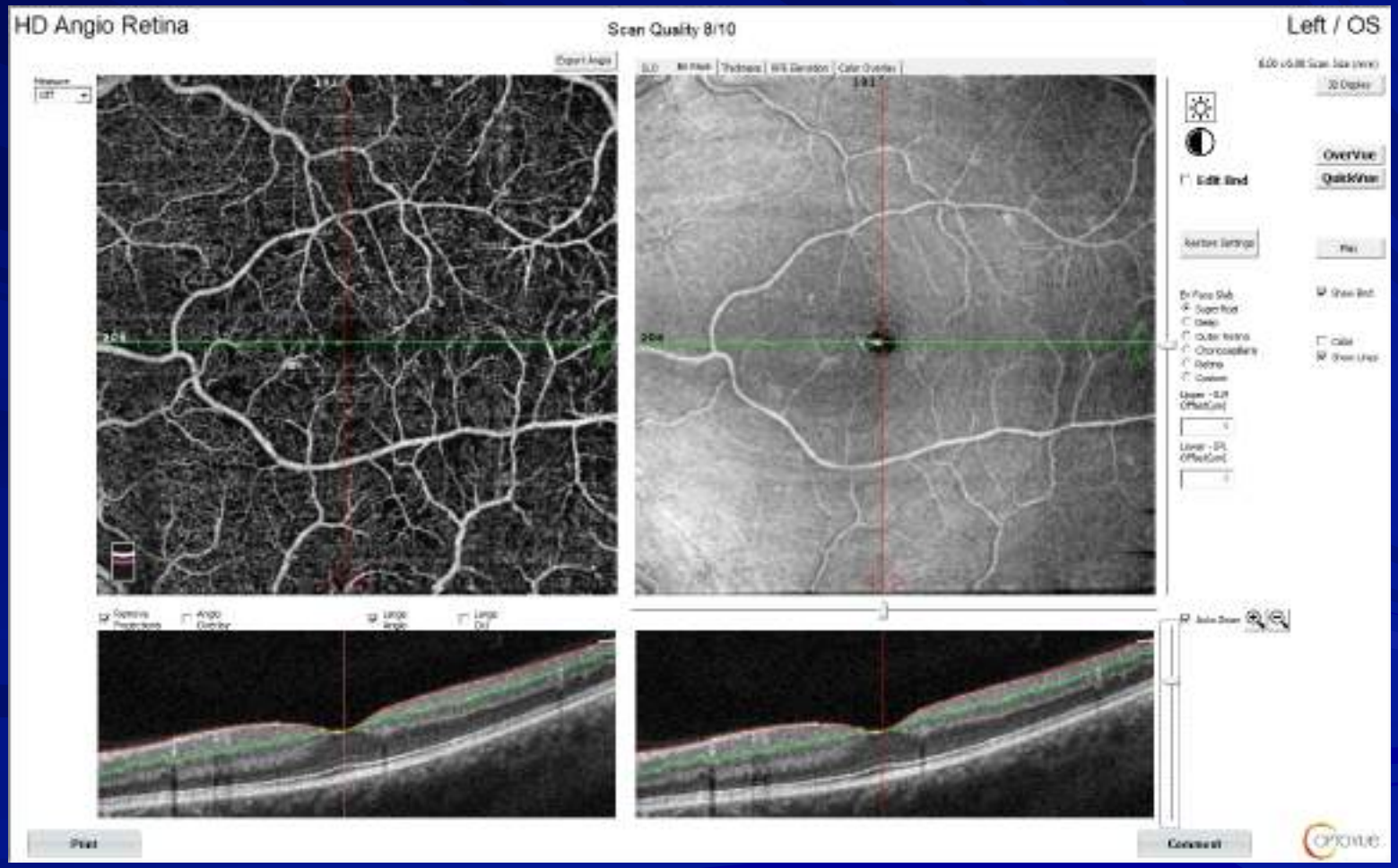
Show Lines
Show Grid
Angio Overlay
Auto Zoom
Thickness
Full
Overlay
Superficial (ILM - IPL)
Deep (IPL - OPL)
Outer Retina (OPL - BRM)
Choriocapillaris (BRM - BRM+30µm)
Vessel Density (Superficial)
Inner Thickness (ILM - IPL)
SLO
Full Thickness (ILM - RPE)

12-19-2018



12-19-2018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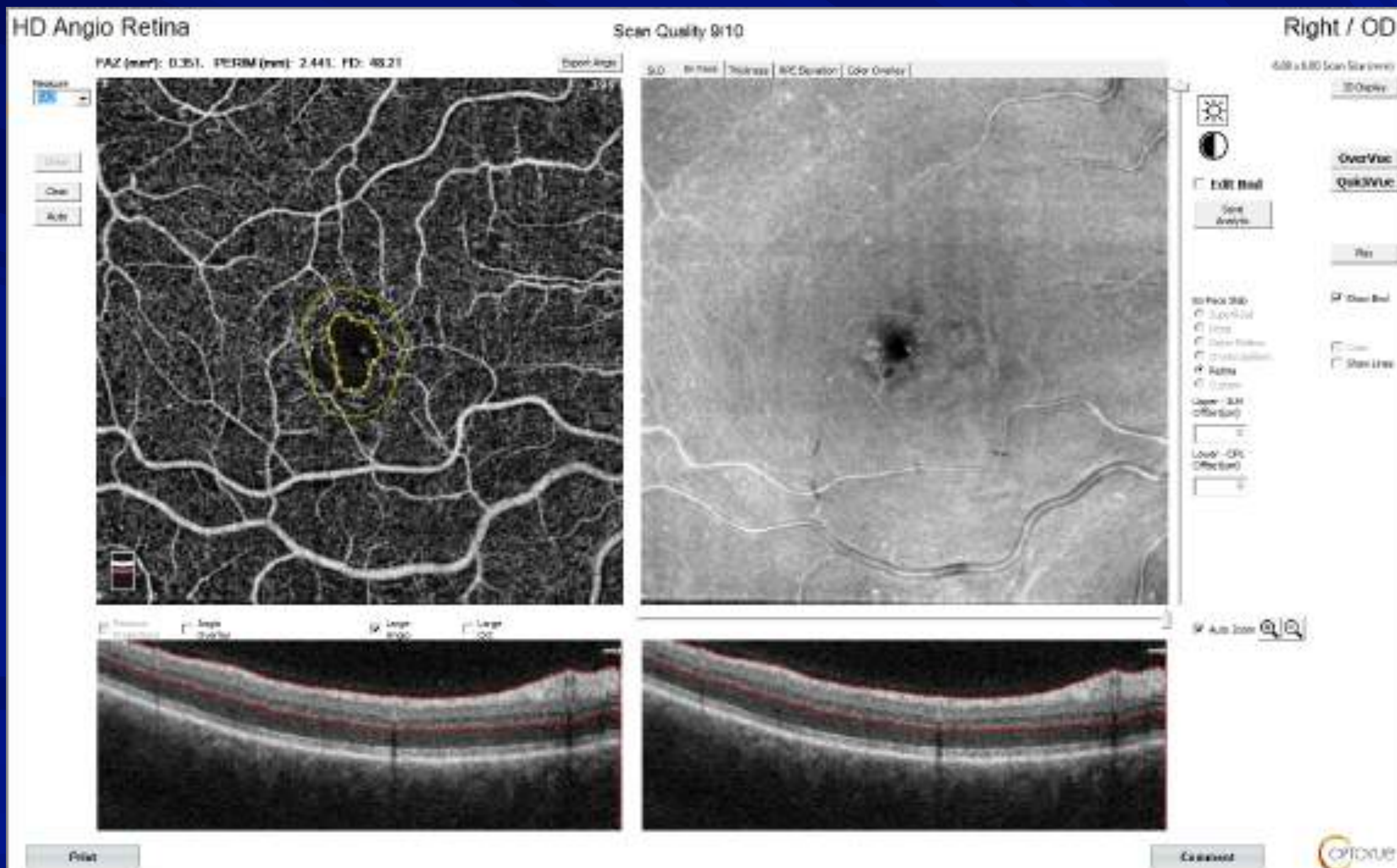
Left / OS
OverVue
QuickView
Edit Bmd
Print
Comment

12-19-2018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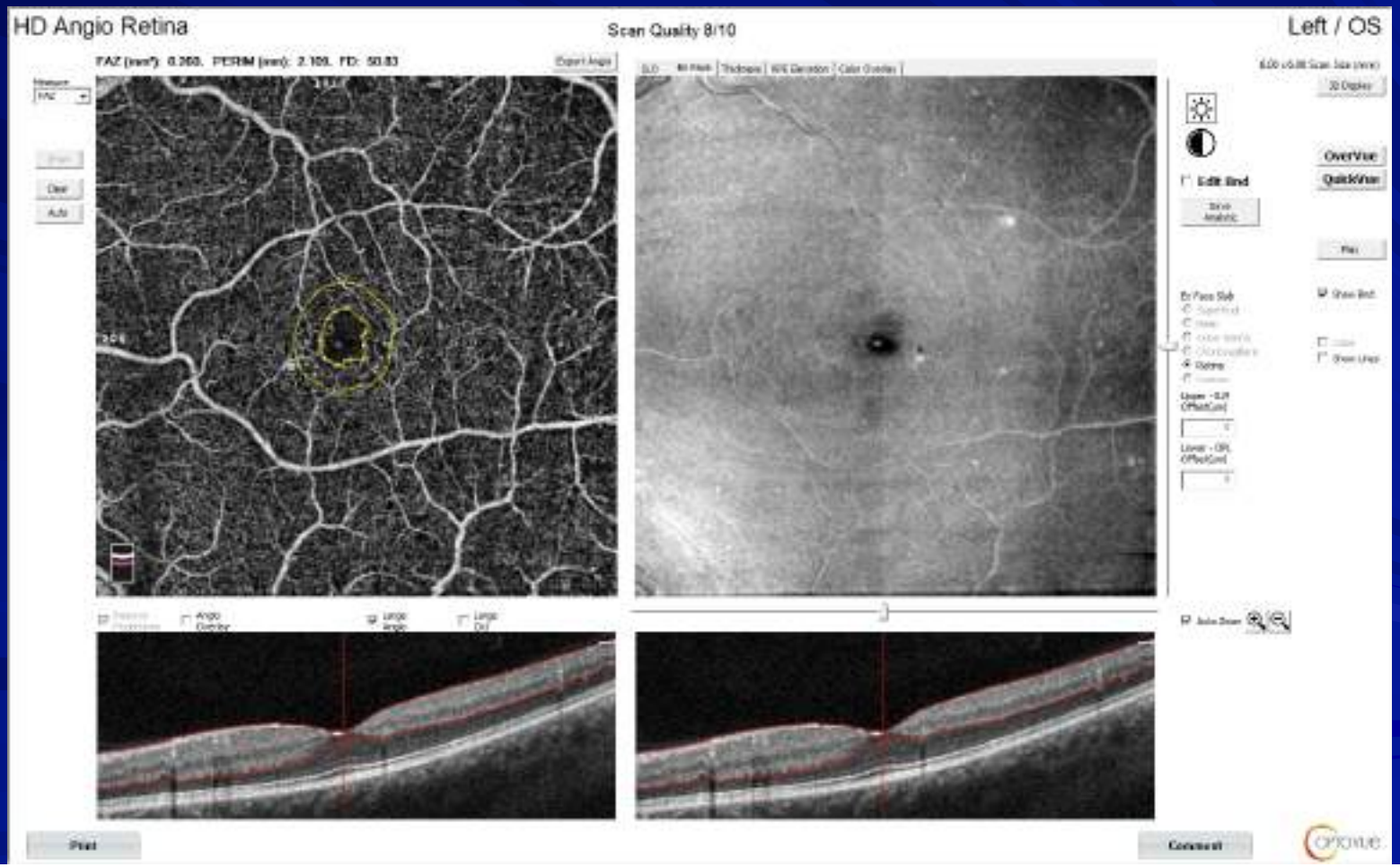
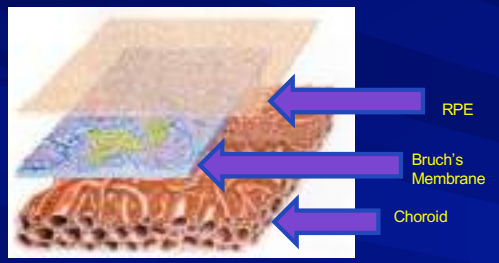
12-19-2018

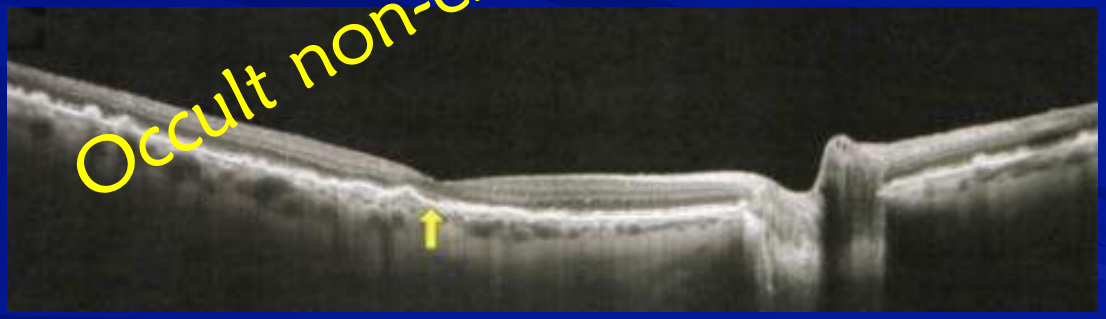


OCT and OCT-A

- Treatment?
- Certainly useful, beneficial, essential, and important in following the patient with diabetes
- Improved HbA1c

Type 1 "Occult" CNV

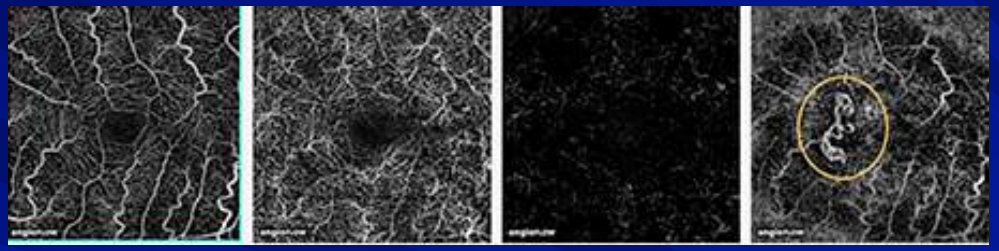


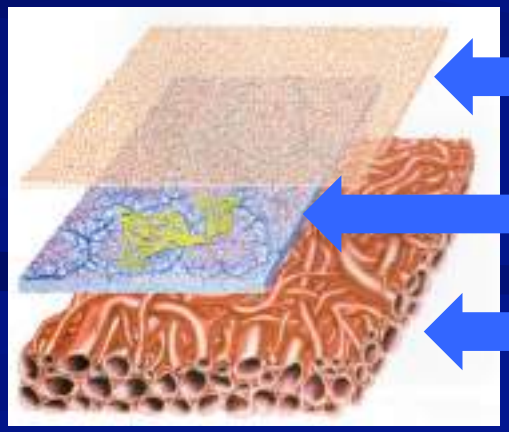


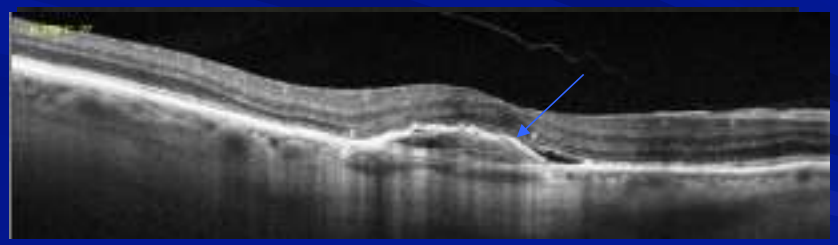
- New vessels develop in the choroid
- New vessels located below RPE and above Bruch's membrane

Type 1 "Occult" CNV

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

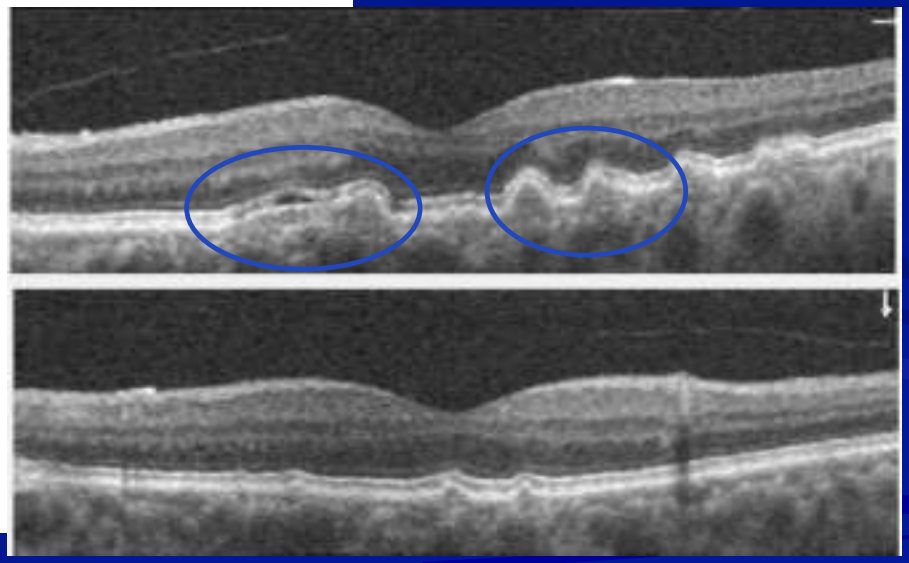




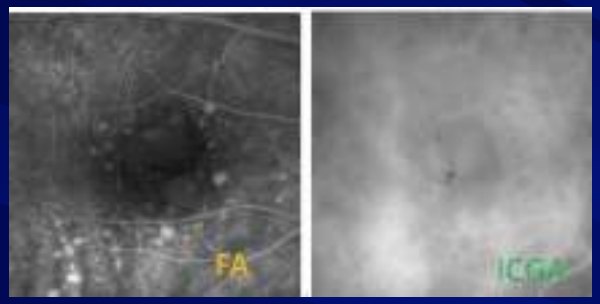


CNV?

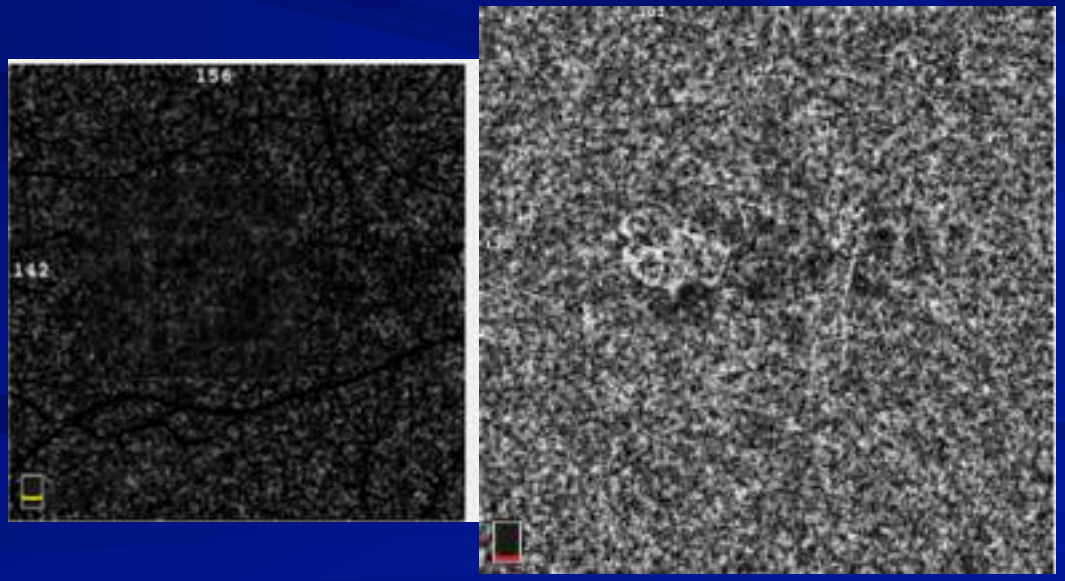
72 y/o Hispanic male
20/30
History of "Dry AMD"

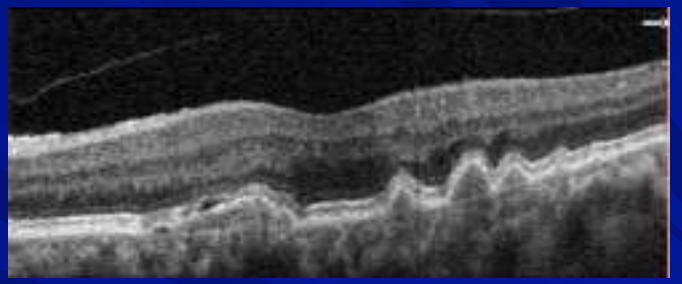


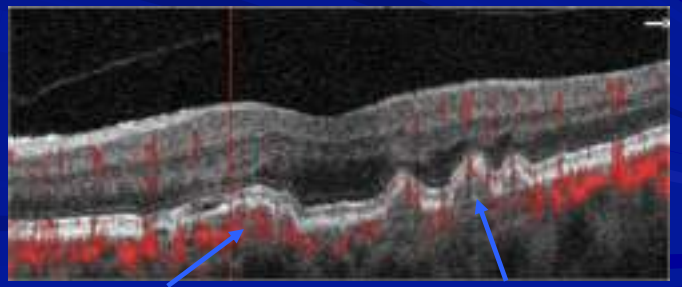
Multimodal imaging and OCTA



VAGUE???

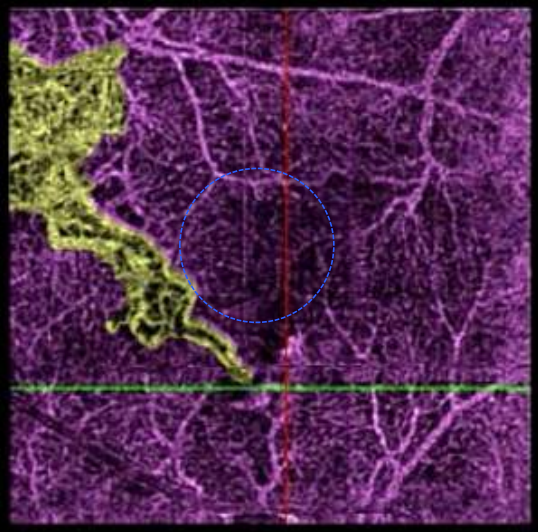


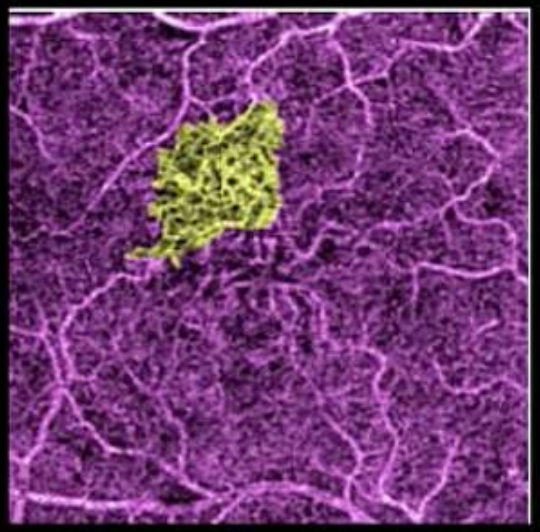


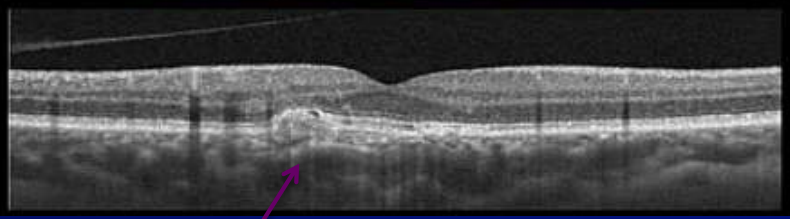


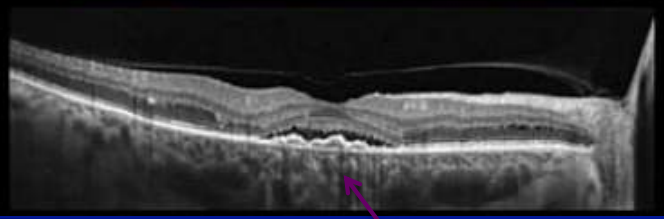
Vascularized Non-vascularized

Type 1 CNV: Below RPE, Wider than Type 2, Avascular Zone Usually Not Involved

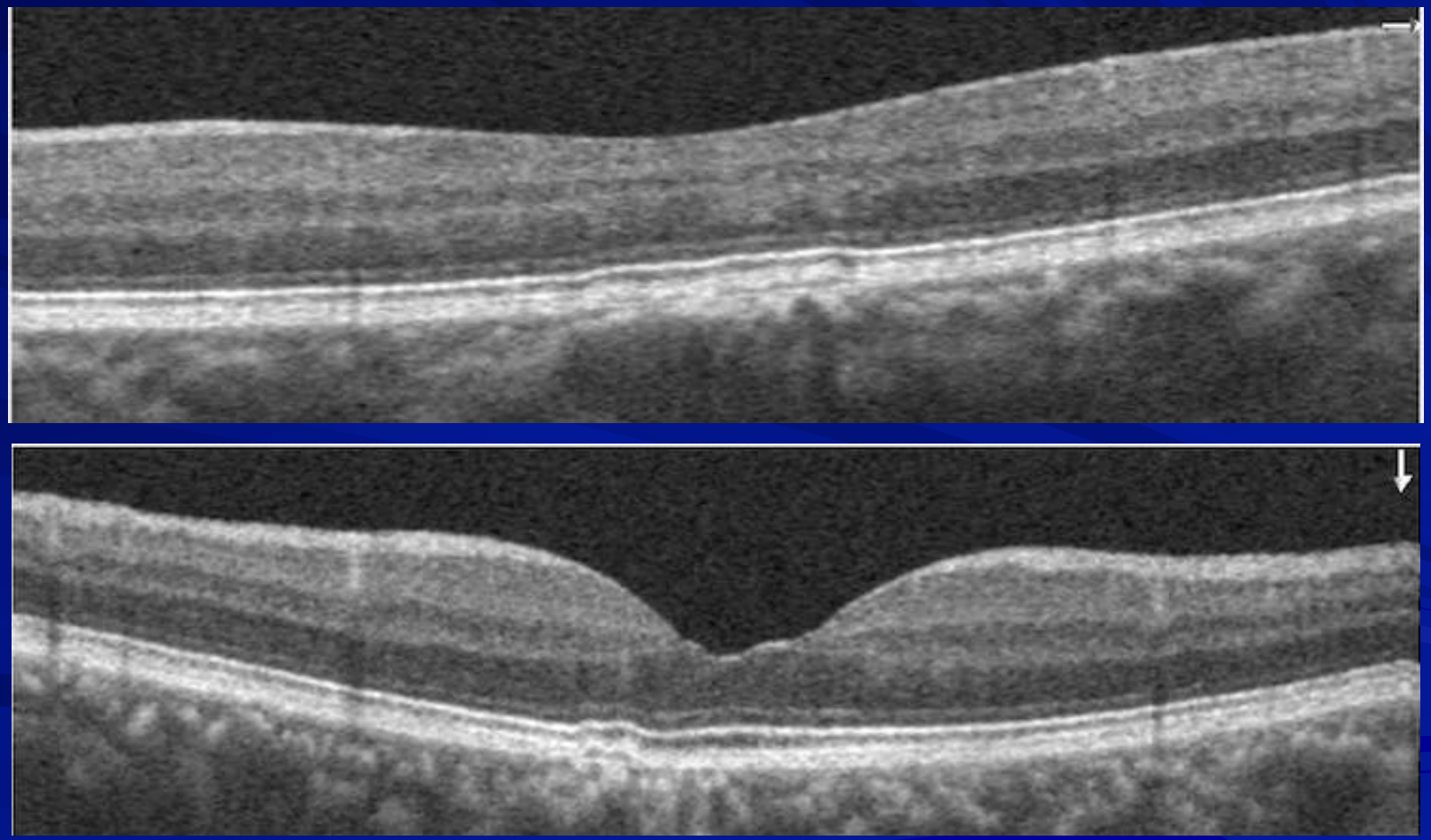


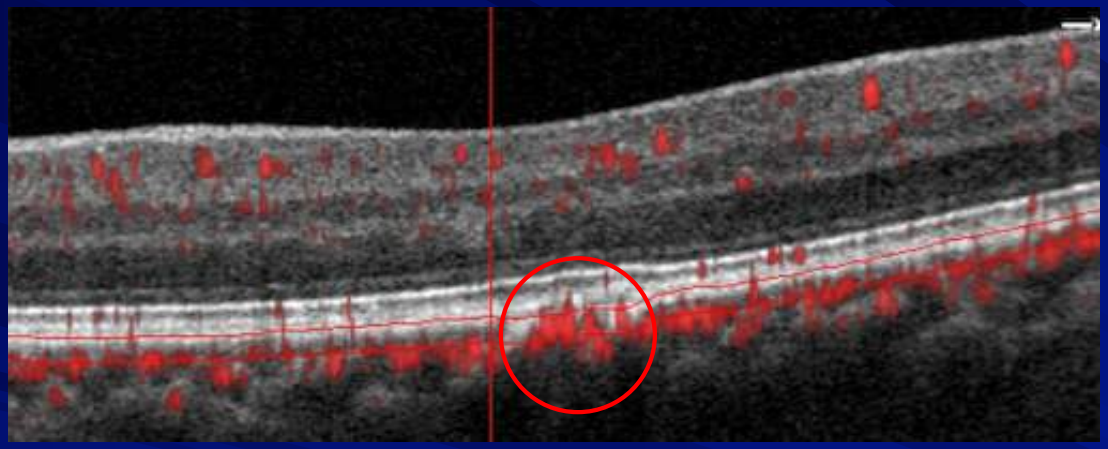


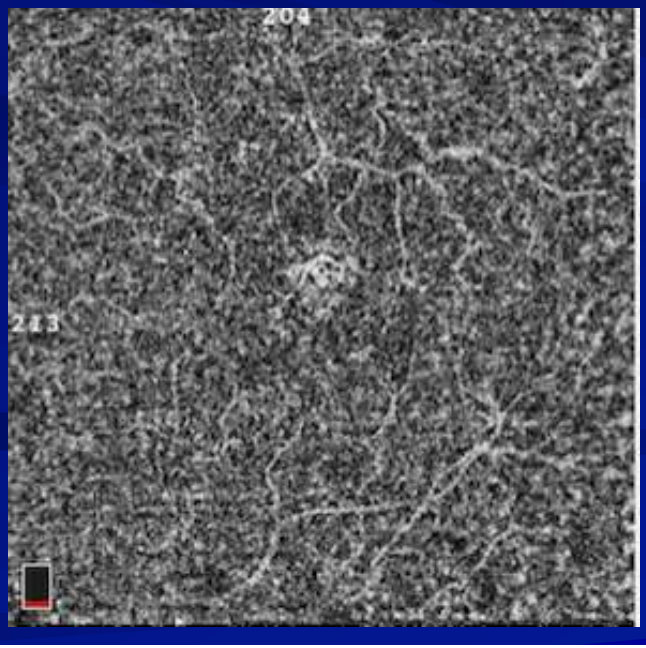




And the not so obvious ones…

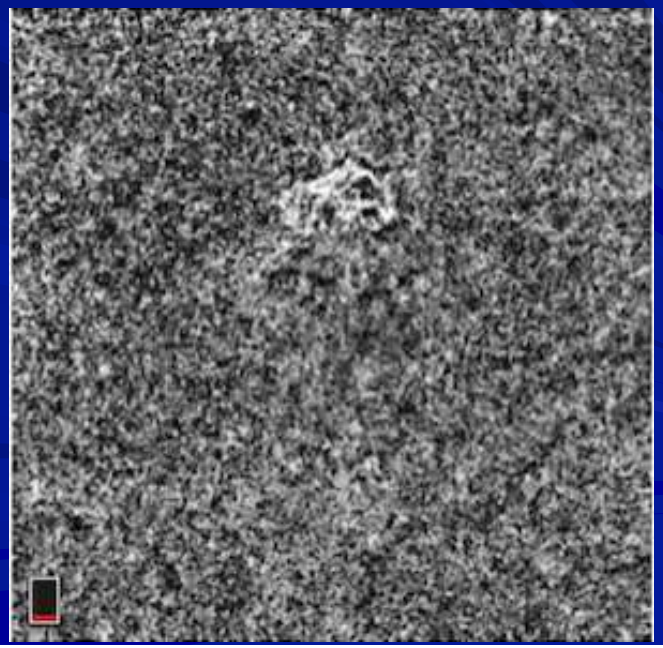




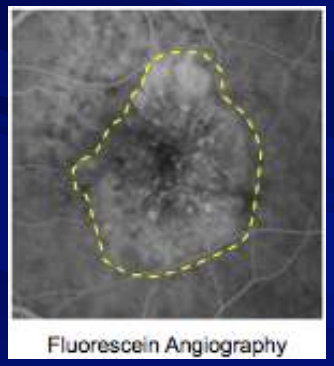


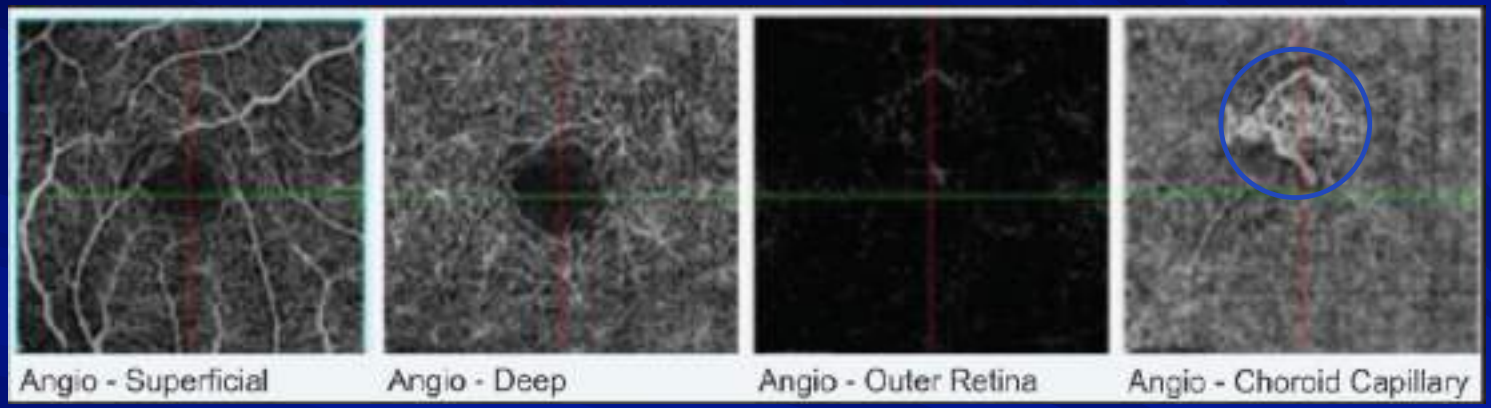
6x6

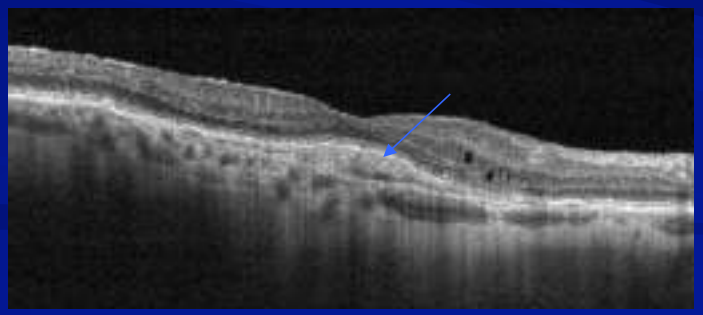
3x3



Case example: 70 y/o WM, AMD

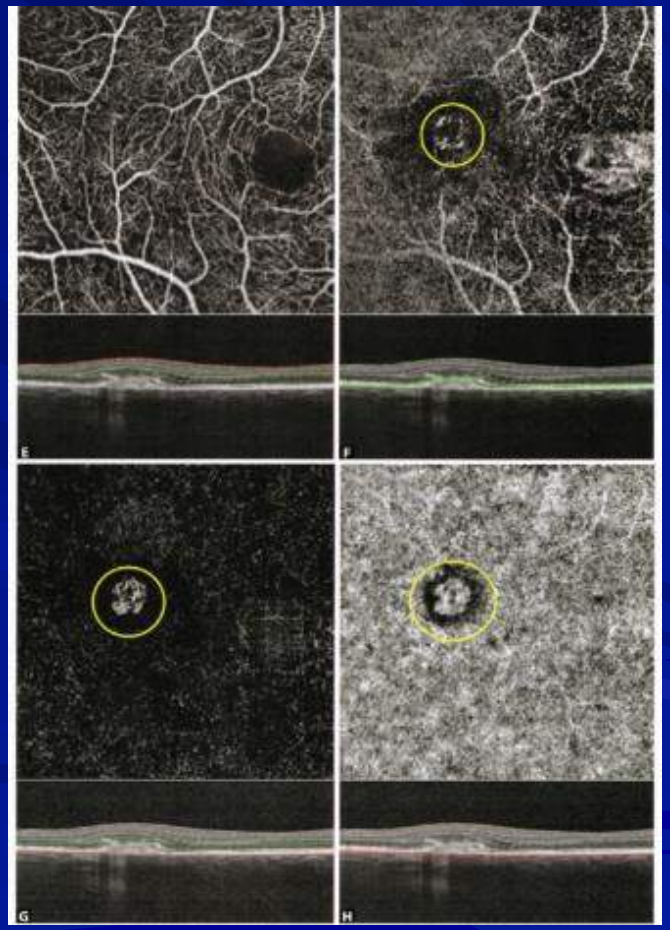

Fluorescein Angiography





Below the RPE

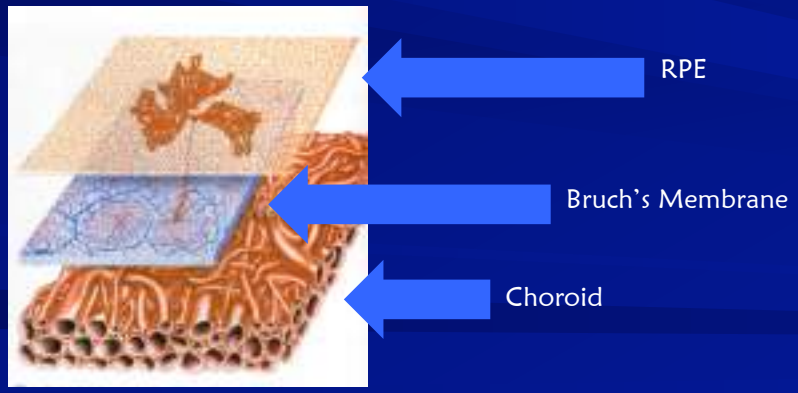
Type 2 "Classic" CNV

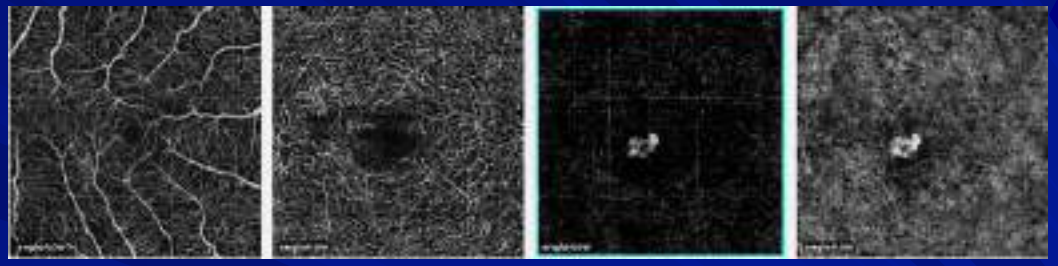


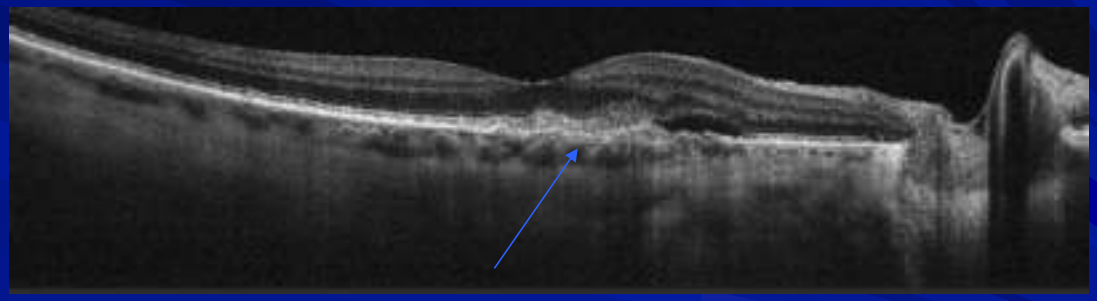
- New vessels develop in choroid
- New vessels located above the RPE and above Bruch's membrane

Type 2 "Classic" CNV

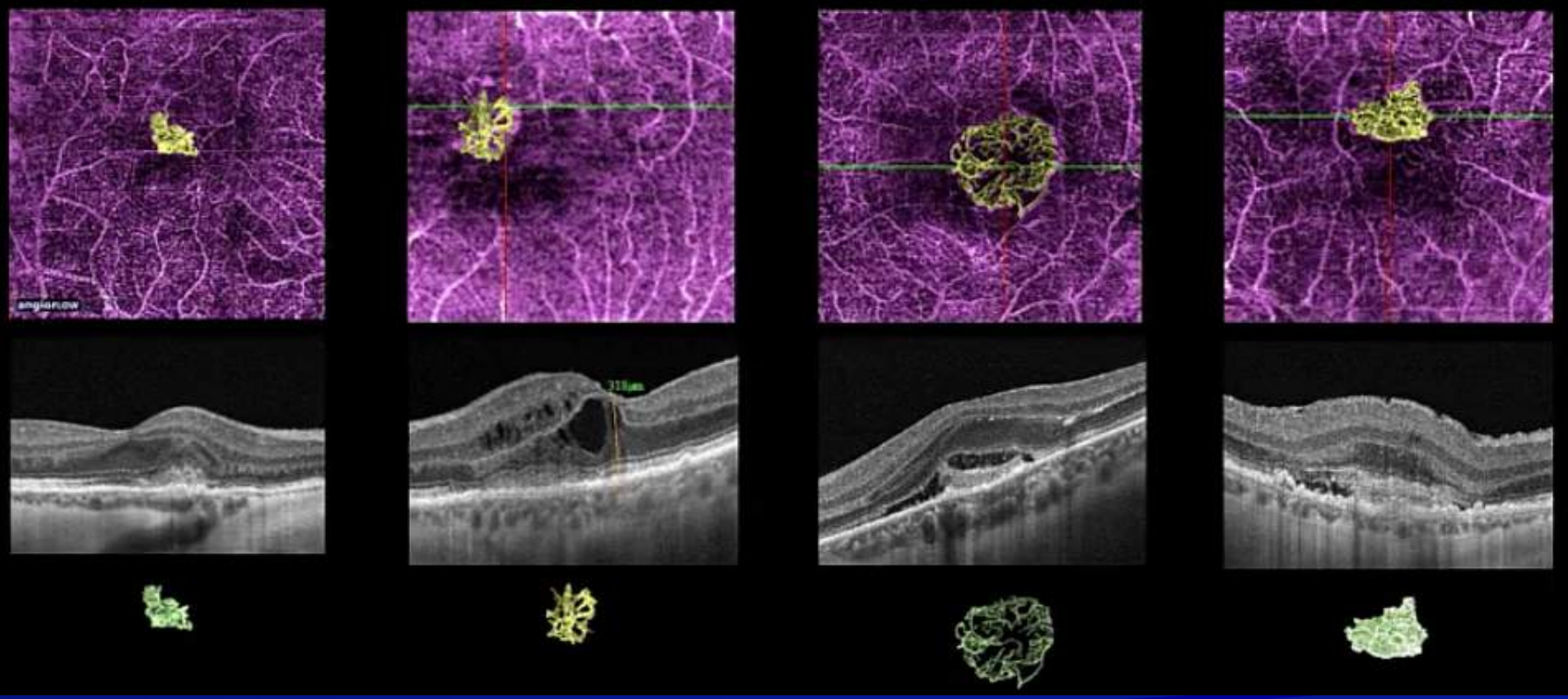
- New vessels develop in choroid
- New vessels located **ABOVE the RPE** and ABOVE Bruch's membrane



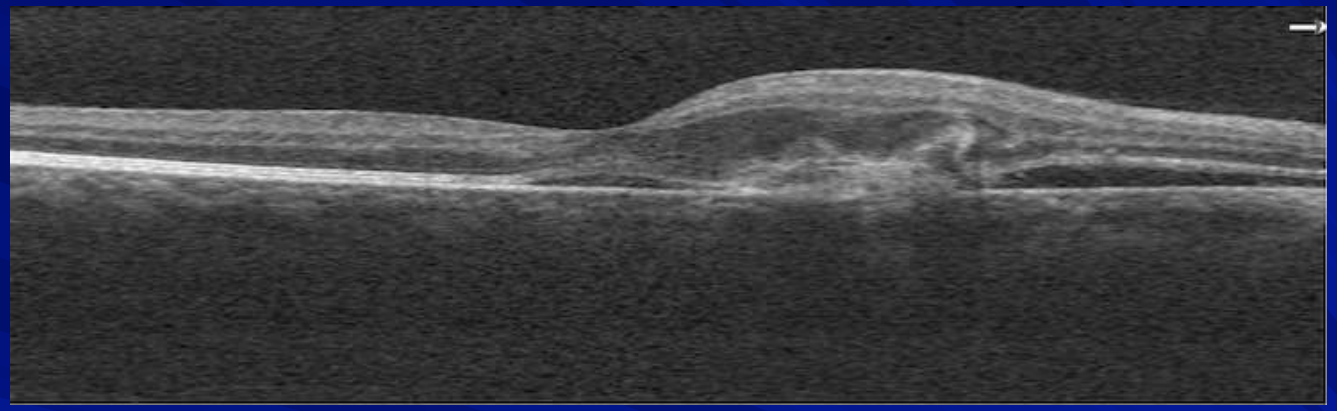


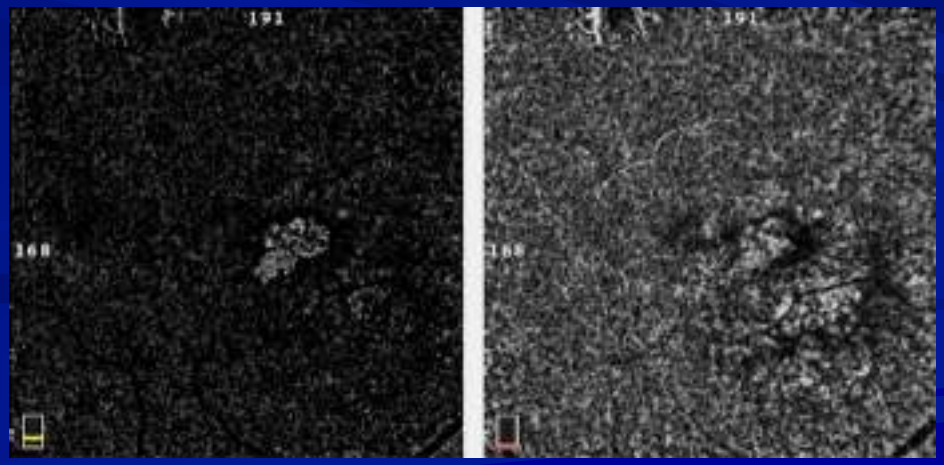


Type 2 CNV: Above RPE, Smaller than Type 1, Avascular Zone Always Involved.
Very Heterogeneous Shapes



48 y/o WM 2 week history of "dark spot" OD



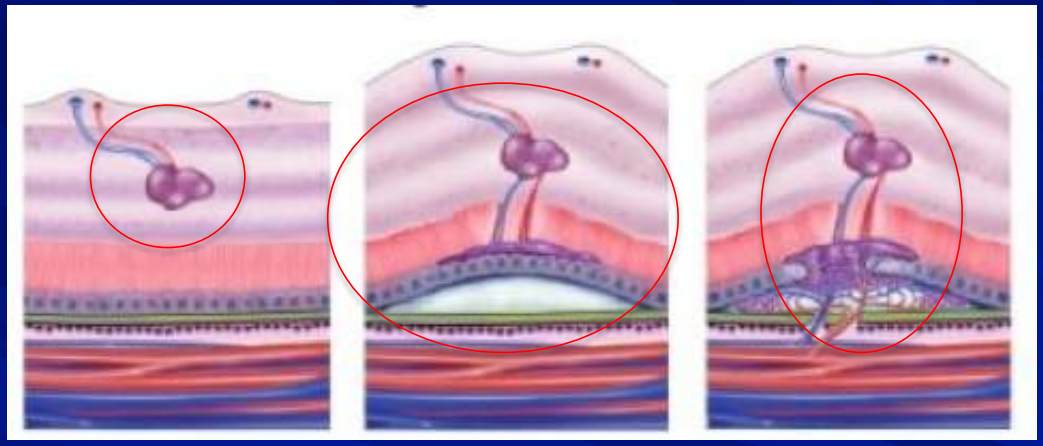


Retinal Angiomatous Proliferation

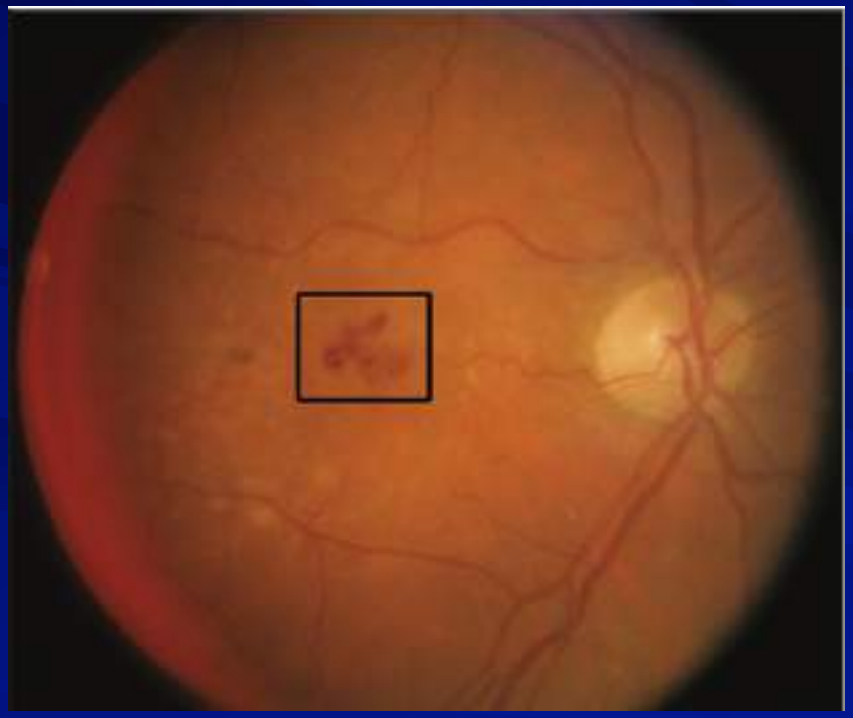
RETINA

RPE

CHOROID



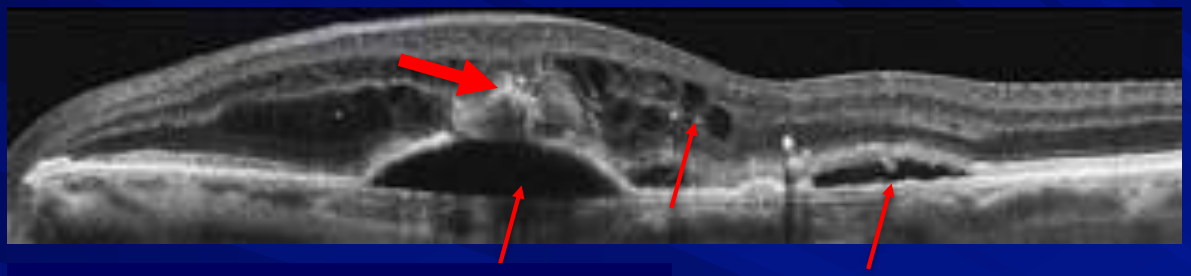
Stage 1	Stage 2	Stage 3
Intra-retinal proliferation	Neovascularization penetrates the sub-retinal space	Neovascularization penetrates the RPE space
*Hemes *Edema *Exudate	*Neurosensory detachment *Serous PED	*Vascularized PED; CNVM



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

https://jamanetwork.com/journals/jamaophthalmology/fullarticle/420891

Inspect the SD-OCT carefully!!



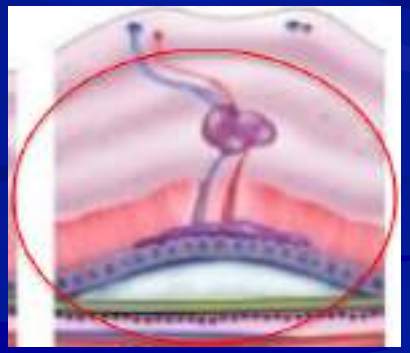
VA 20/40

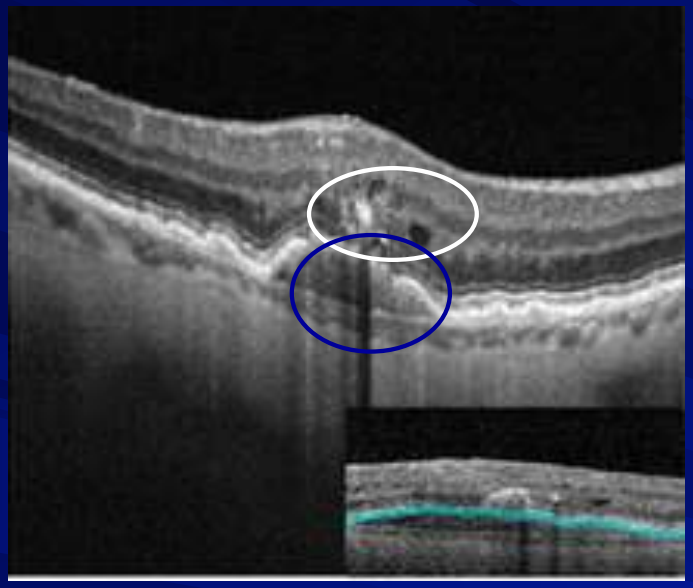
HYPER-REFLECTIVE lesion above pigment epithelial detachment

Intraretinal cysts

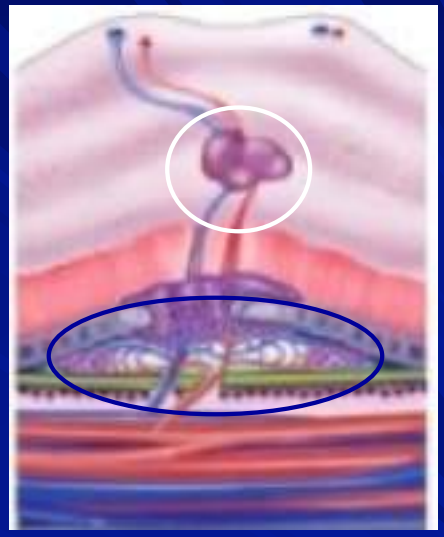
Serous pigment epithelial detachment/ neurosensory detachment

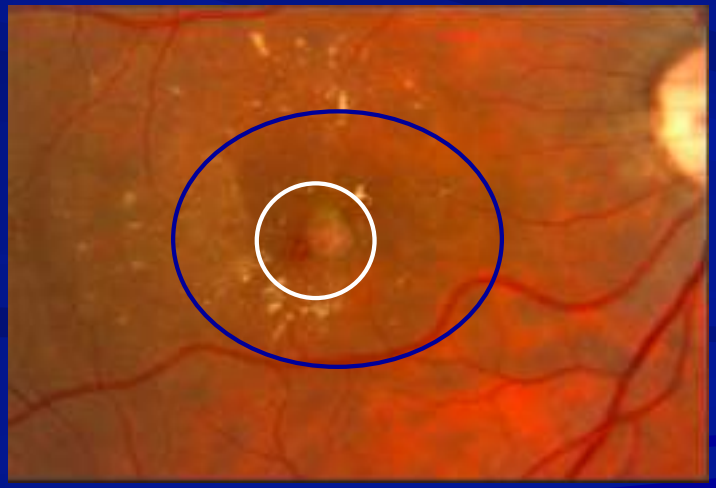
Stage 2





Stage 3





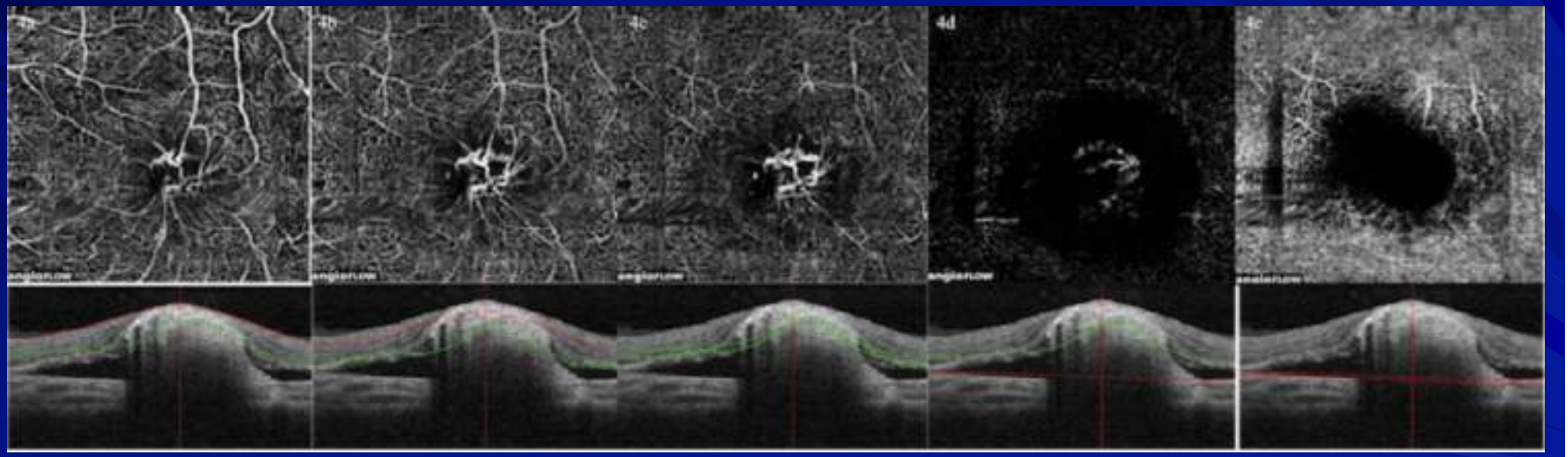
http://imagebank.asrs.org/file/26943/retinal-angiomatous-proliferation

https://www-ncbi-nlm-nih-gov.ezproxylocal.library.nova.edu/pubmed/29019795

What about the OCTA?

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

Type 3 CNV: Intraretinal Anastomosis: THROUGH RPE

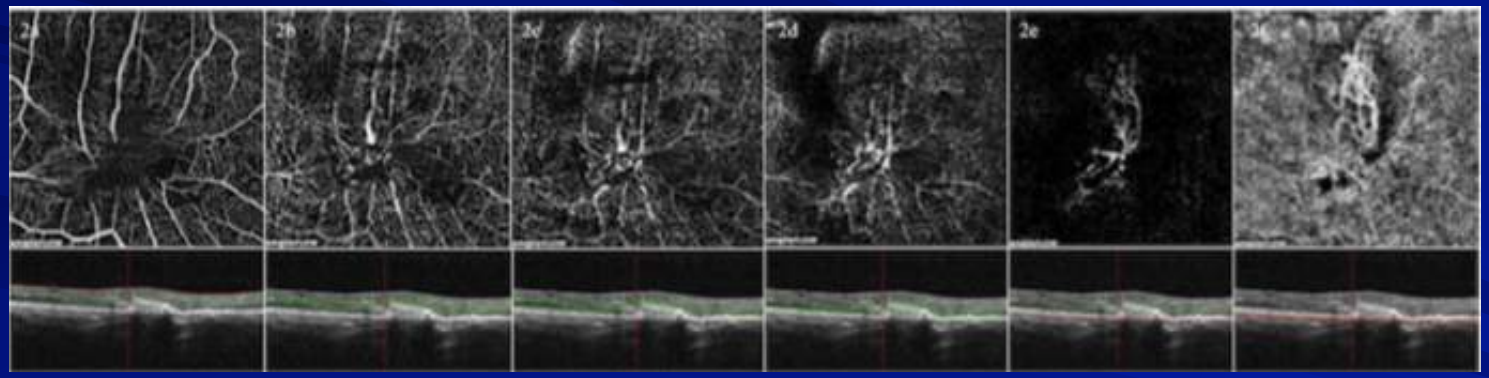


Inner retina (SCP+DCP) to Outer retina (Avascular/choriocapillaris)

What about the OCTA?

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

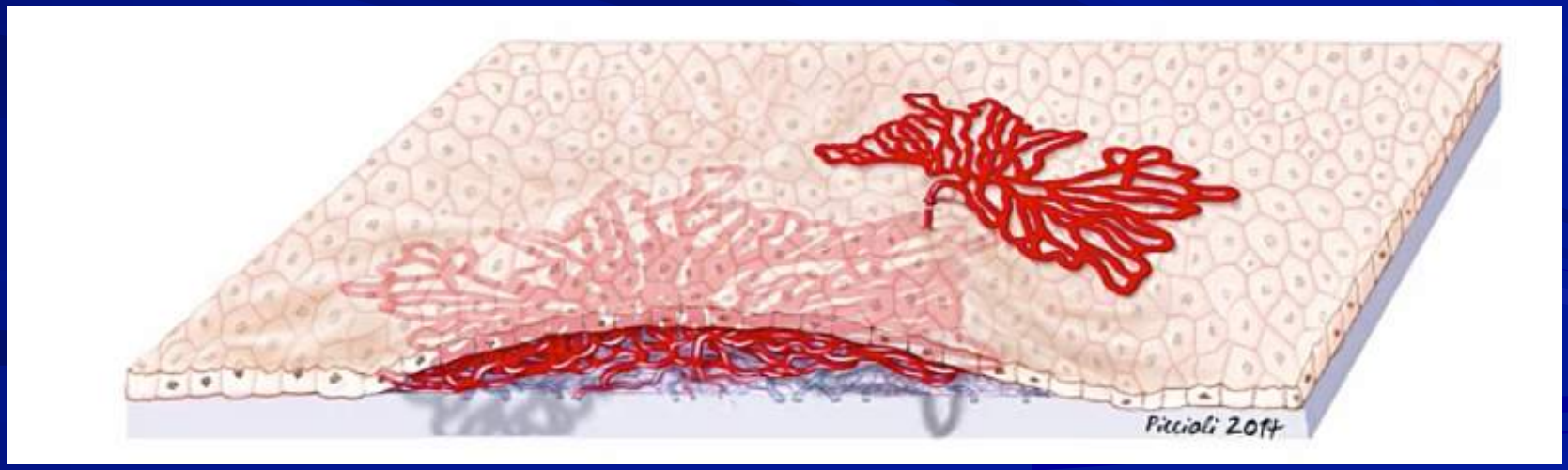
Type 3 CNV: Retinal/Choroidal Anastomosis: INTO CHOROID



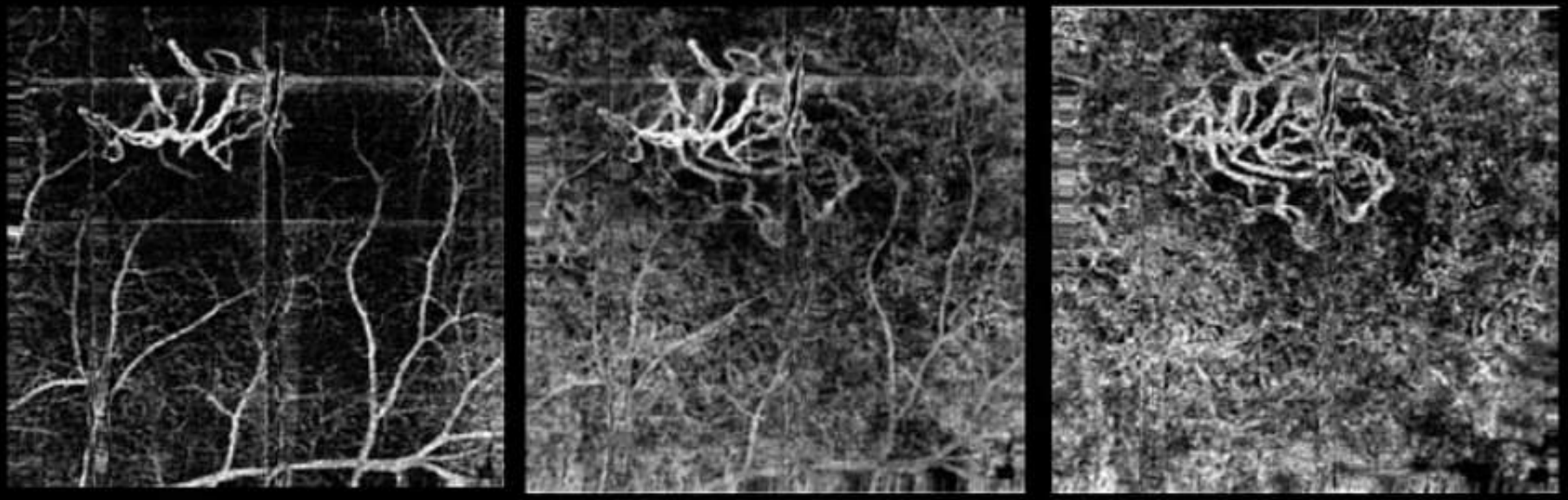
Inner retina (SCP+DCP)to Outer retina (Avascular/choriocapillaris)

Type 4 "Mixed"- Subretinal and Sub-RPE

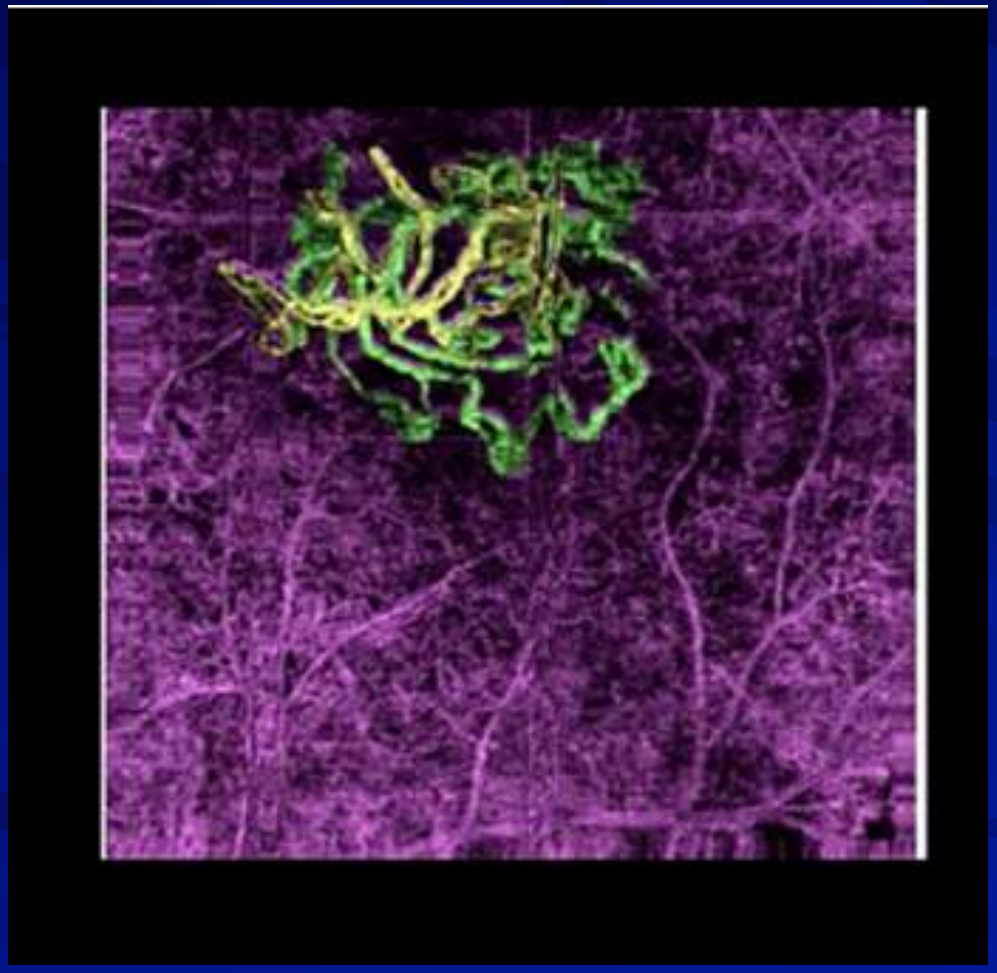
- Two or more CNV layers
  - One above the RPE, one below the RPE
- High flow lesions



Type 4 CNV : Initially Located Below the RPE, NV Spreads into the Outer Retina



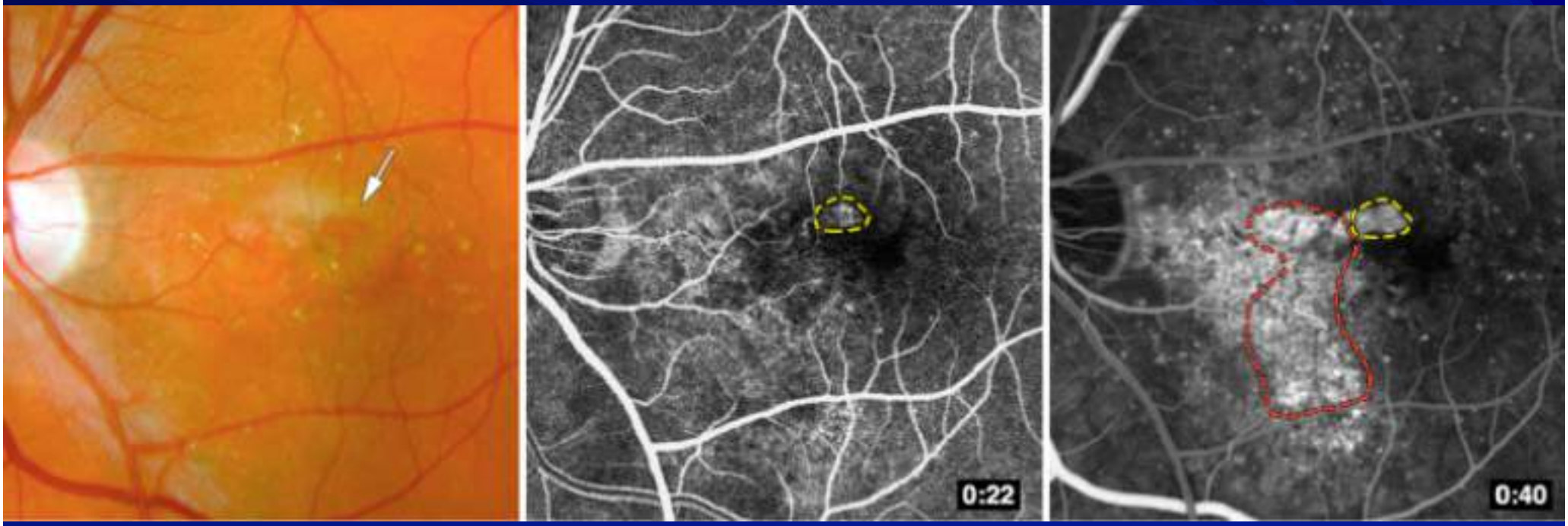
Angio - Deep | Angio - Outer Retina | Angio - Choroid Capillary



Green: Type 1 (Sub RPE)

Yellow: Type 2 (Subretinal)

Case Example: Multimodal imaging of 66 y/o Caucasian male

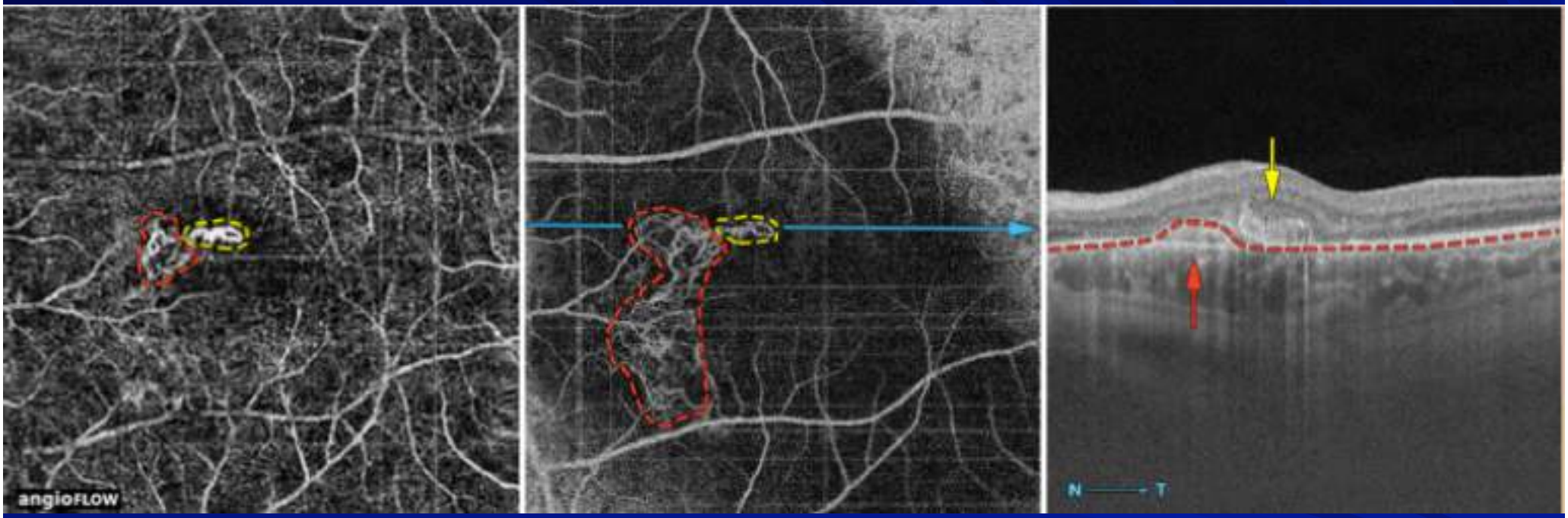


Fundus image and Occult

FFA: Early; Classic component

FFA: Late; Classic

Courtesy of Novais et al.



Choriocapillaris

Red: Occult; Yellow: Classic

Courtesy of Novais et al.

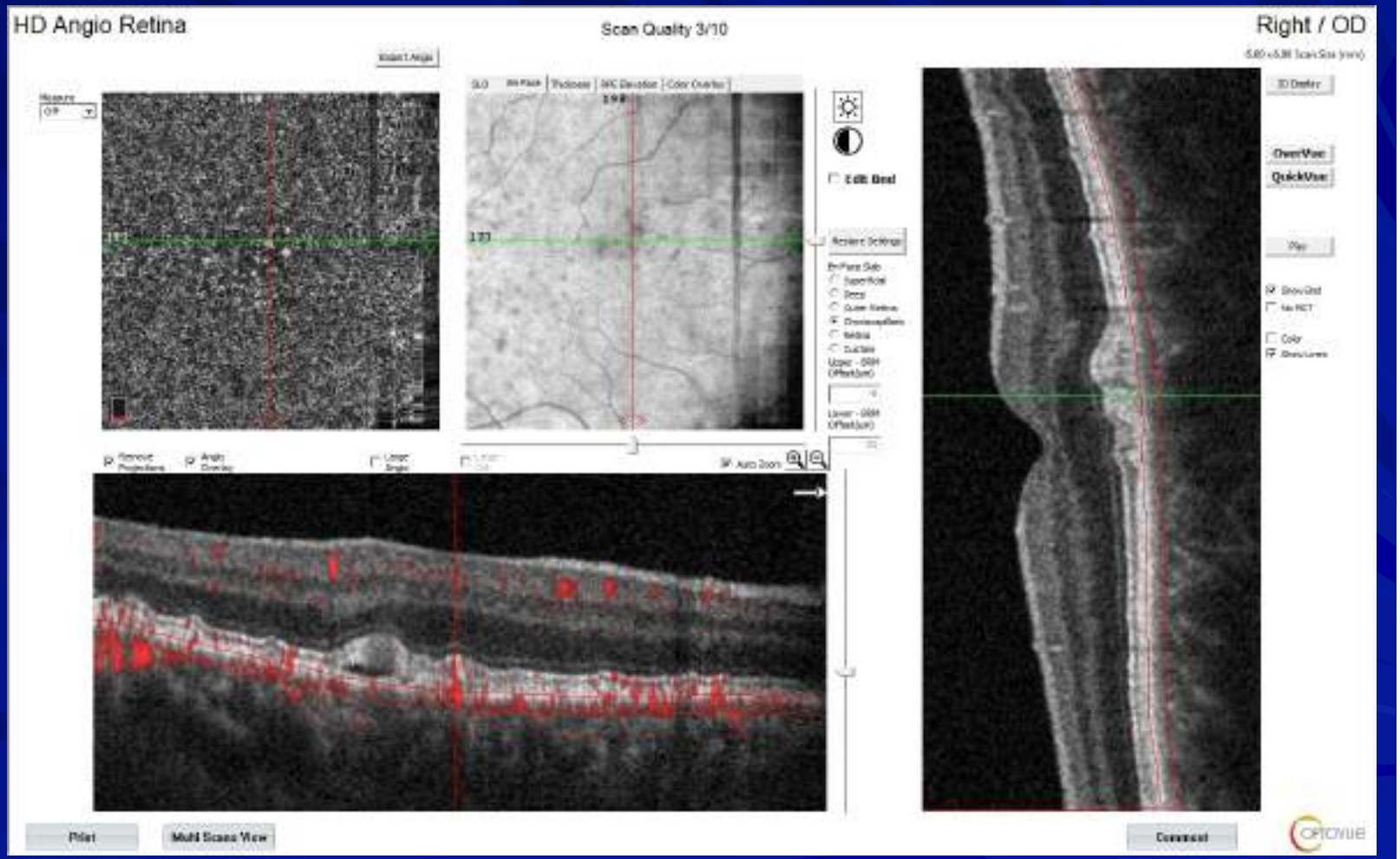
OCT Angiography

Subclinical CNV or “Occult non-exudative CNV”

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

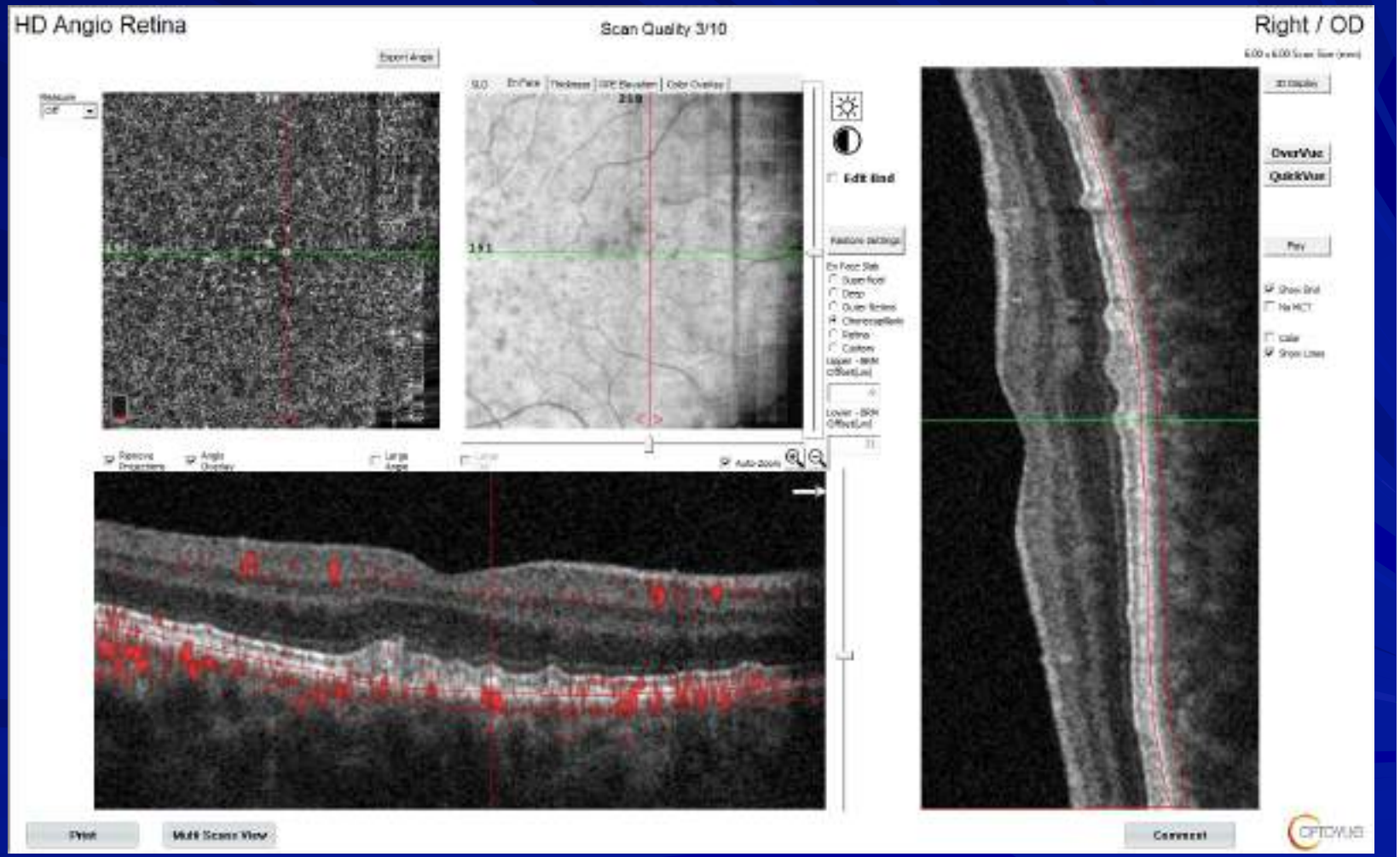
Occult Non-Exudative CNV

Patient A



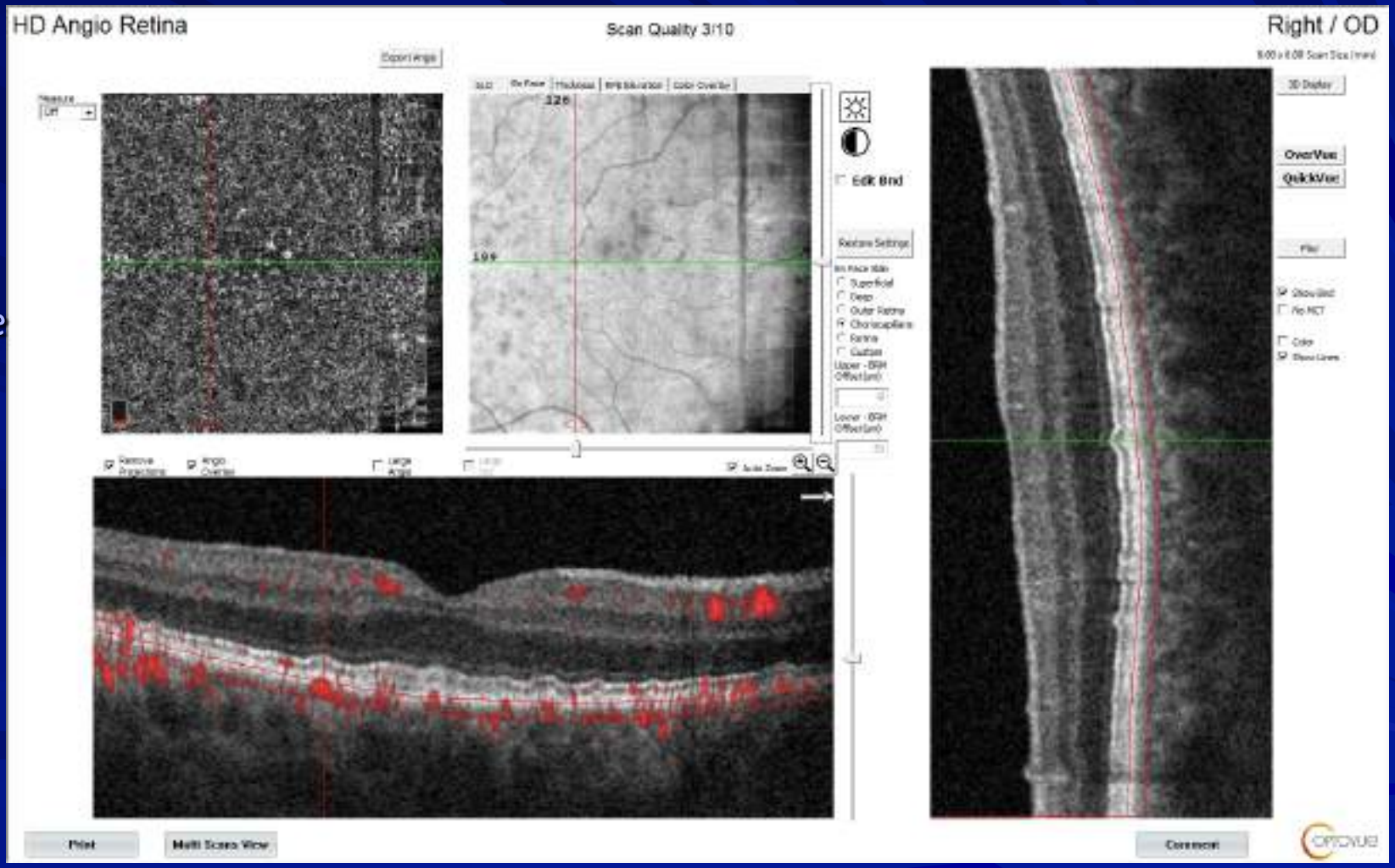
Occult Non-Exudative CNV

Patient A

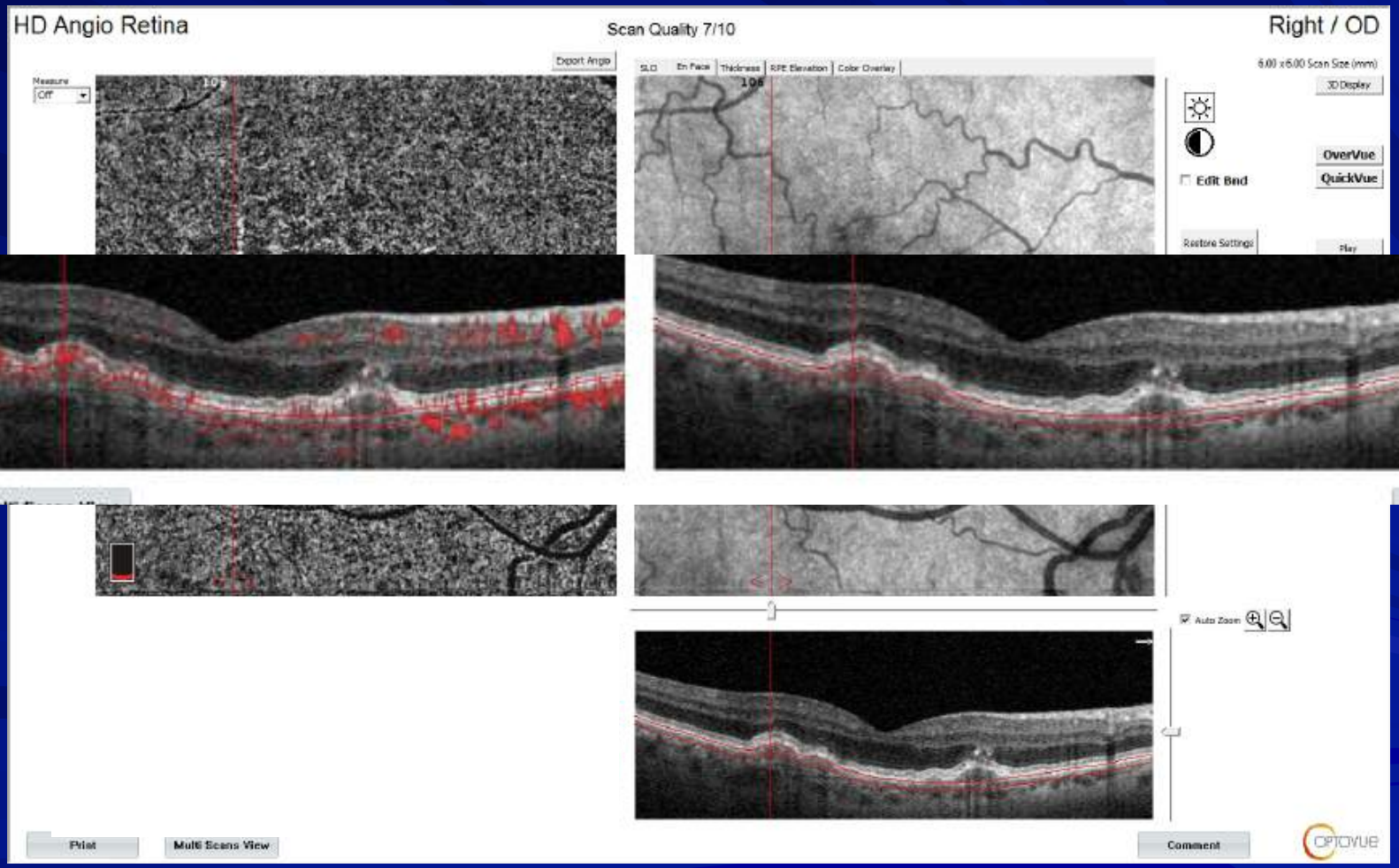


Occult Non-Exudative CNV

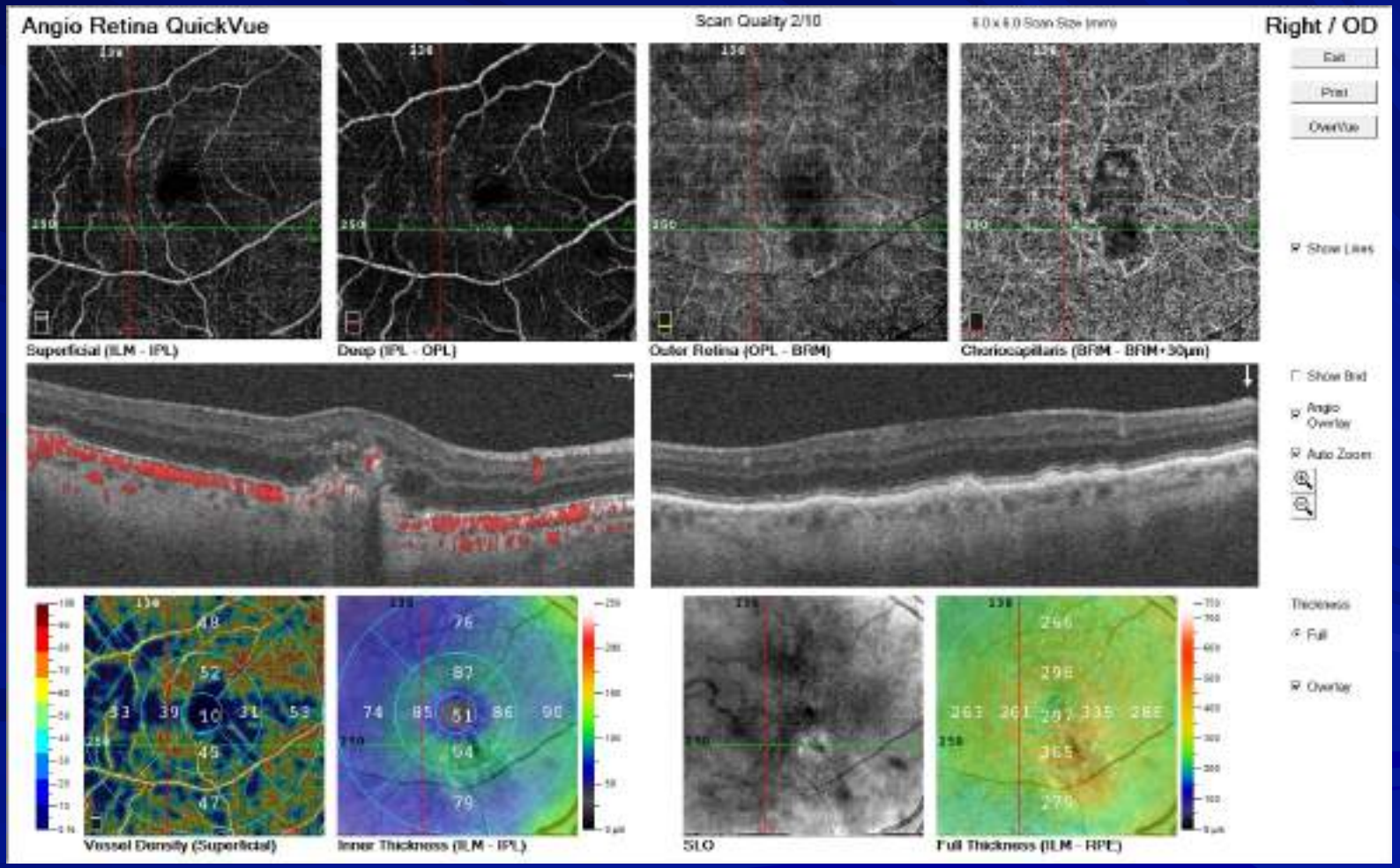
Patient A



Which is More Suspicious?

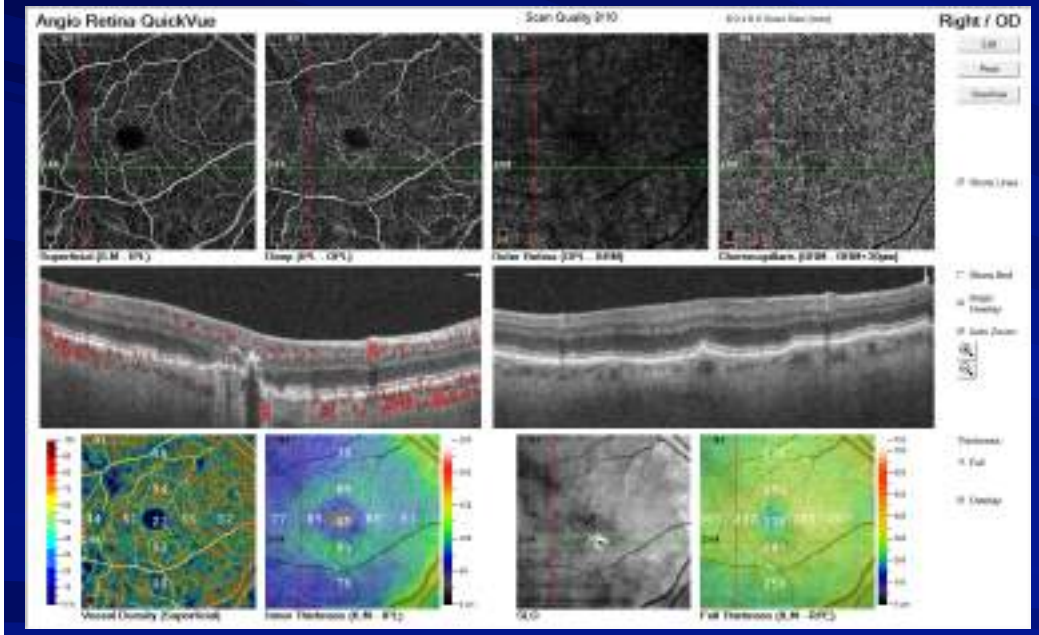


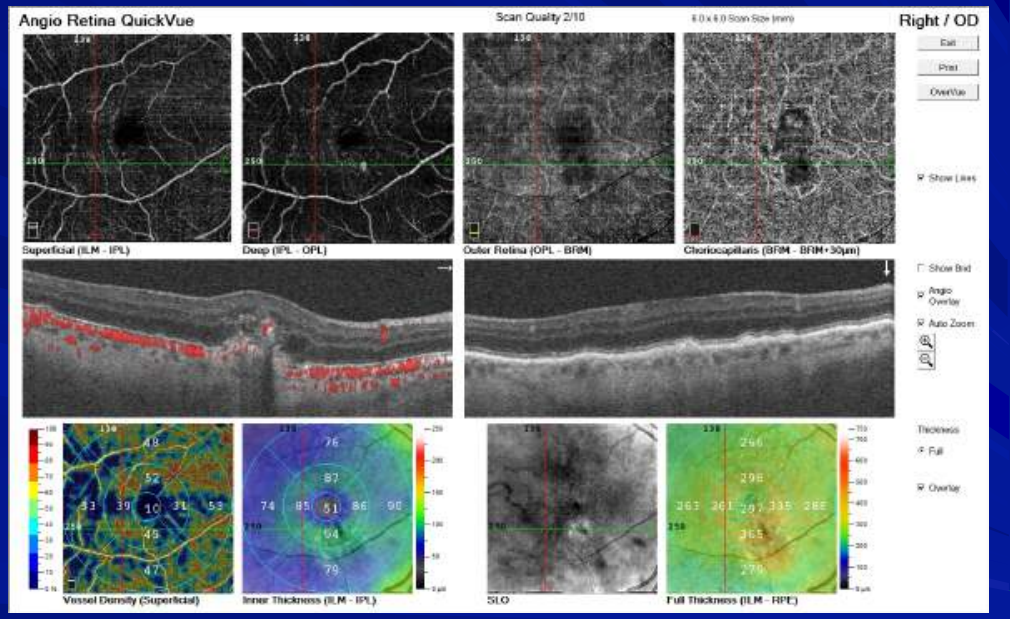
OCT Angiography Evaluation AMD



OCT Angiography Evaluation AMD

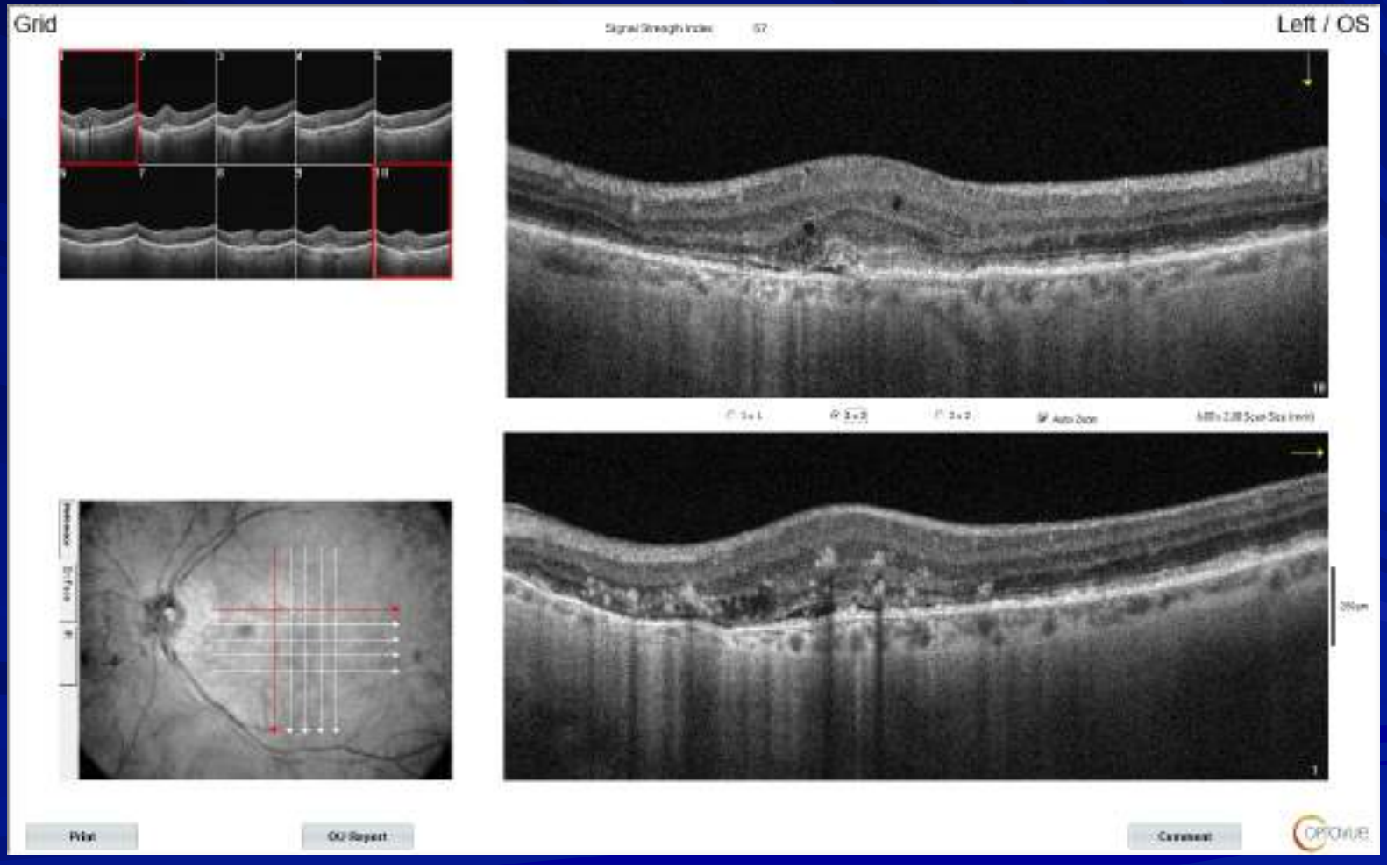
After and Before Bevacizumab (Avastin)





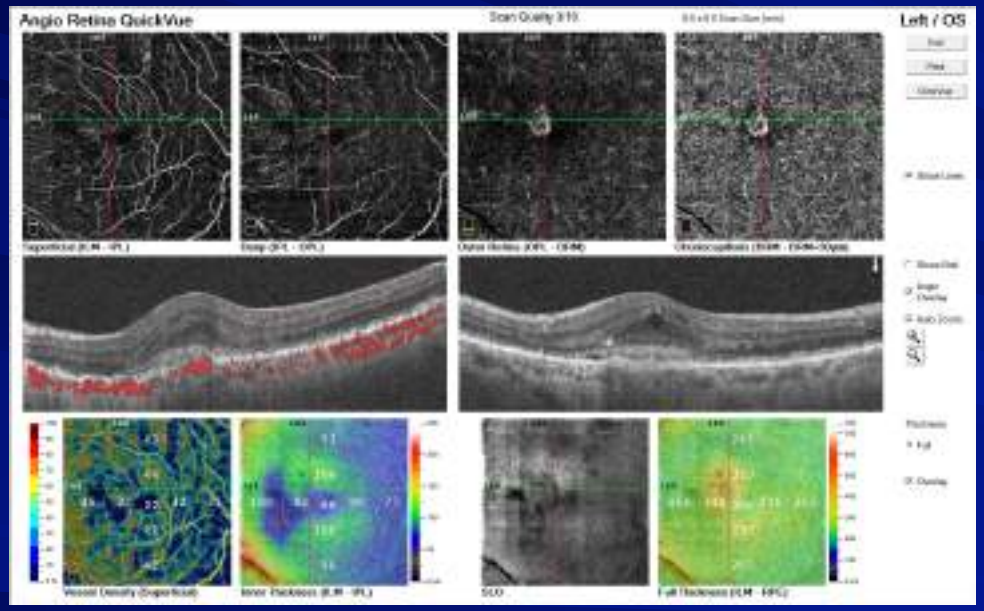
Evaluation AMD Patients for Neovascularization

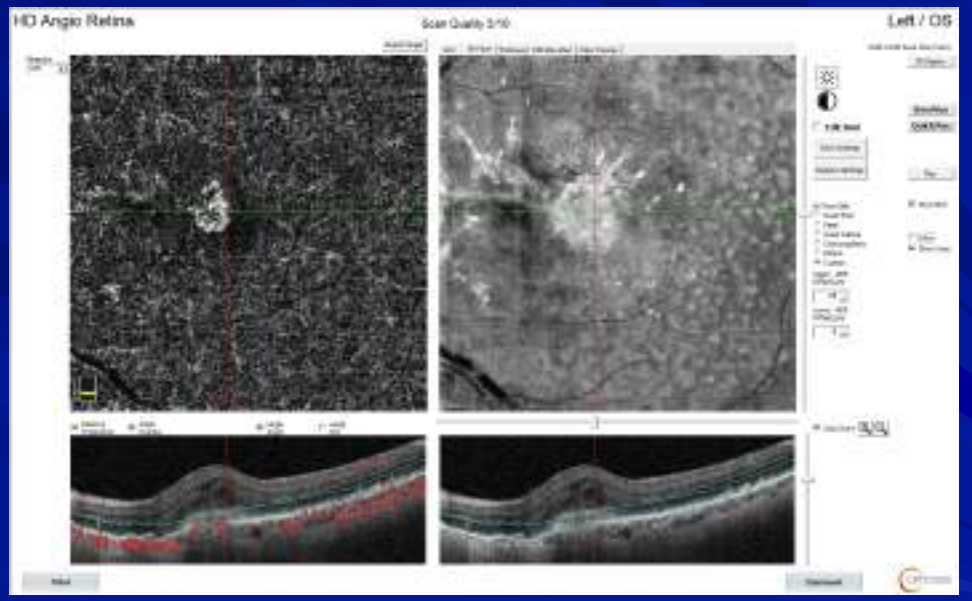
OCT Grid



Evaluation AMD Patients for Neovascularization

Using OCT Angiography





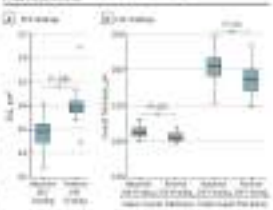
Other Uses
Endothelial Disease

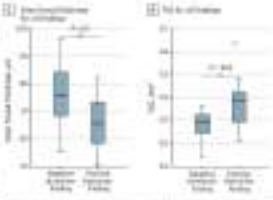
Alzheimer

Dementia

Association of Preclinical Alzheimer Disease With Optical Coherence Tomographic Angiography Findings

Methods





likely these discrepancies are merely associated with the specificity of the individual test and are in line with a low rate of discordance.[45-47] As such, any individual with a positive marker was considered to have biomarker-positive findings in the collective analysis.

A major limitation of our study is the small sample size, including a limited number of nonwhite individuals. An additional limitation is exclusion of individuals with known vascular disease from our study; we are therefore unable to determine whether these results are translatable to individuals who may have retinal microvascular changes due to other causes. Also, inclusion only of those with preclinical, biomarker-positive disease limits comparison to those with cognitive changes or advanced AD. Recruitment is under way to evalu-

changes in retinal vasculature.

Conclusions

At present, preclinical AD is diagnosable only by invasive, expensive, and time-consuming PET or CSF testing. Our data suggest that OCTA may enable quick, inexpensive, and noninvasive screening for individuals with preclinical AD based on FAZ enlargement. However, these findings could be owing to confounding factors unrelated to the FAZ enlargement. Longitudinal studies in larger cohorts would be needed to determine whether this finding has value in identifying preclinical AD, so that these individuals may receive appropriate care.

ARTICLE INFORMATION

REFERENCES

Alzheimer disease. Nat Rev Neurol. 2010;6(3):

Optometric Education Consultants

Thank you!

OCT-Angiography
What You Need to Know with this New Technology