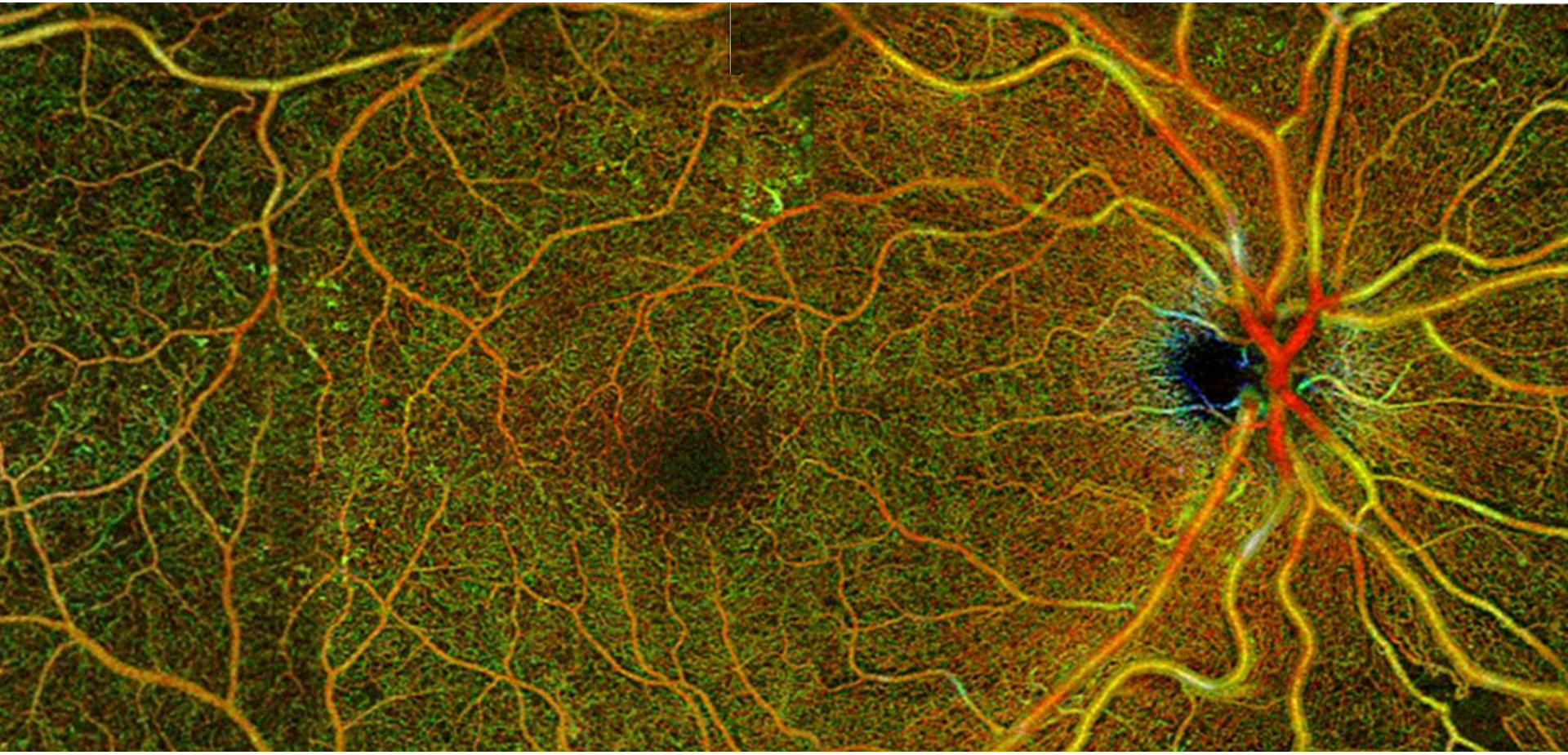
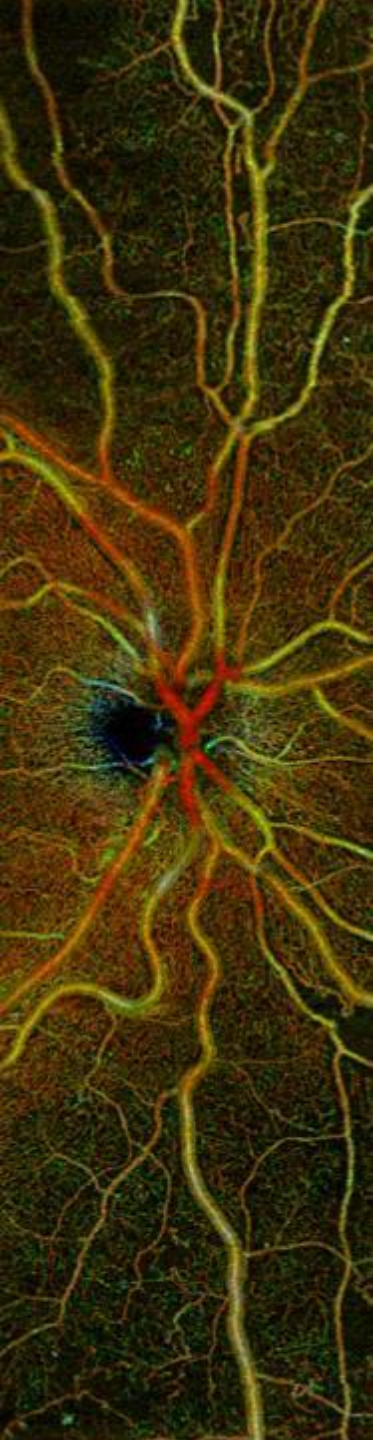


OCT ANGIOGRAPHY: IMAGING MOTION

Rick Trevino, OD, FAAO

Rosenberg School of Optometry



ONLINE NOTES

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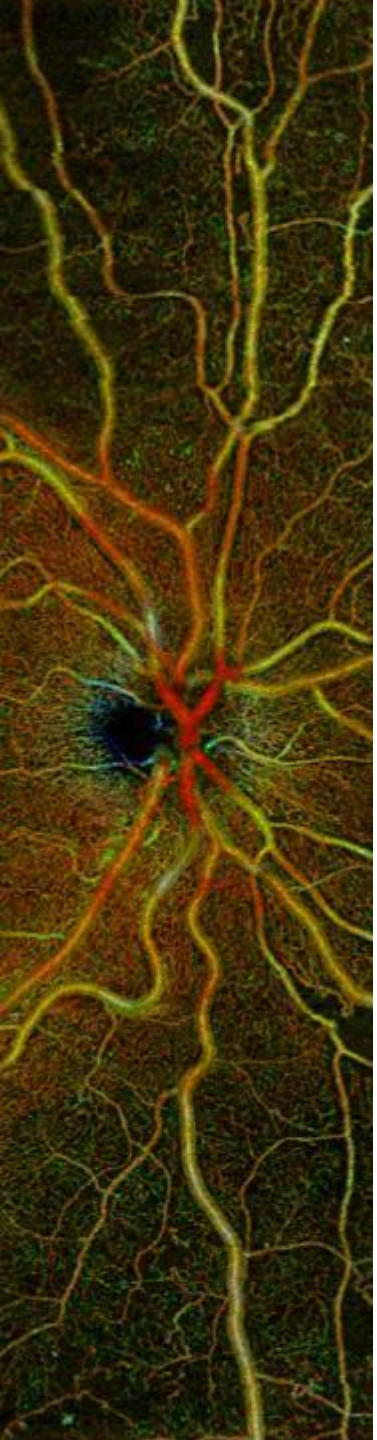
DISCLOSURES

- No conflicts of interest to disclose.



RESOURCES

PMID: 33292740

Google:
OCT Angiography

International Journal of Retina and Vitreous

REVIEW Open Access

A practical guide to optical coherence tomography angiography interpretation

Eugenia Custo Greig[1,2], Jay S. Duker[1] and Nadia K. Waheed[1*]

Abstract

Background: Optical coherence tomography angiography (OCTA) can image the retinal vasculature in vivo, without the need for contrast dye. This technology has been commercially available... been limited to the research setting. Over the... publications detail OCTAs use for the... vasculature...

Body: This review provides an overview of OCTA imaging and details... begins with a summary of OCTA technology and artifacts that arise from... practices for... are discussed. OCTA has the unique... ties... with... retinal plexus. Slabs offered in standard... for... Lastly, the use of OCTA for the clinical interpretation of... retinopathy and age-related macular degeneration, is discussed.

Conclusion: OCTA is evolving from a scientific tool to a clinical imaging... cessful image interpretation in a clinical setting.

Keywords: Optical coherence tomography angiography, Interpretation

FREE FULL TEXT

Background

Optical coherence tomography angiography (OCTA) first became commercially available in 2014 [1]. This technology allowed for the visualization of retinal microvasculature in vivo. Prior to OCTA, fluorescein angiography (FA) and indocyanine green angiography (ICGA) were the mainstay modalities for retinovascular visualization. These imaging modalities generated a 2-dimensional en face view of the retinal vasculature and did not allow for the individual visualization of retinal capillary plexuses. OCTA offered in vivo visualization of the retinal microvasculature in a depth-resolved fashion, without the need for time-consuming dye administration.

Prior to... a research... of OCTA... age related... opathy (D... emerged... scientific... ocular p... language... ophthalm... OCTA in... utility in...

Function... In 1991... described... ity allowe... retina in...

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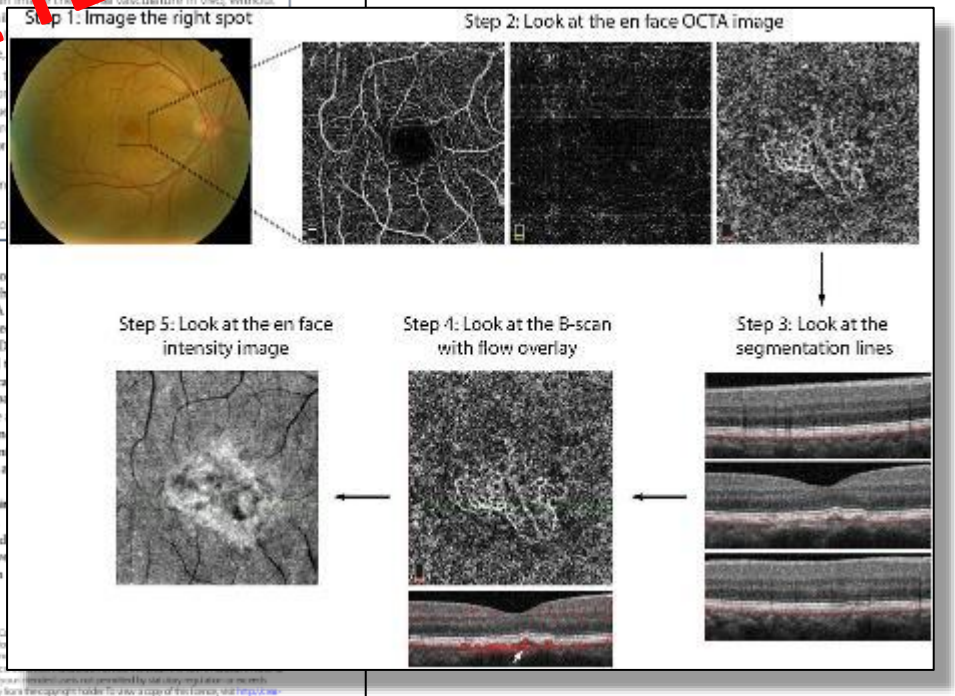
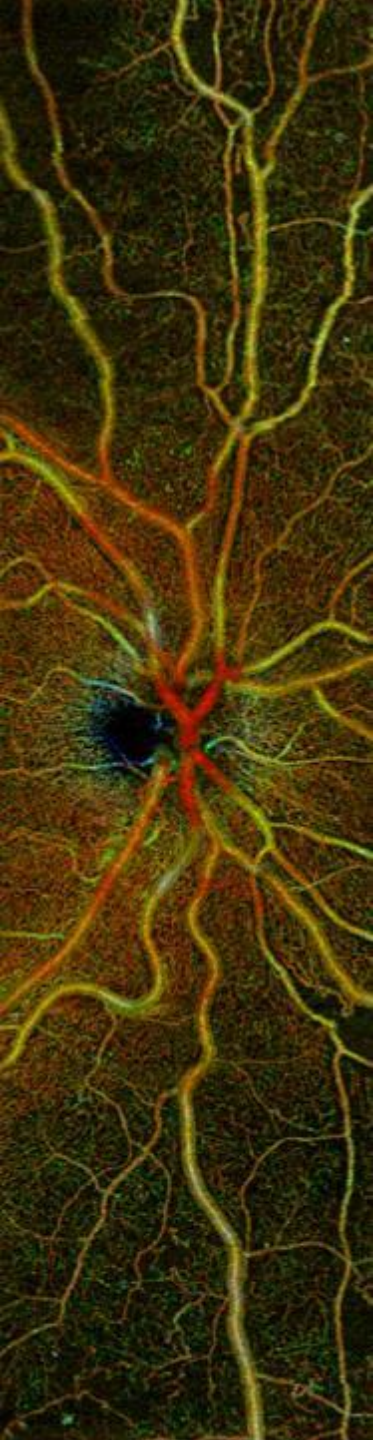
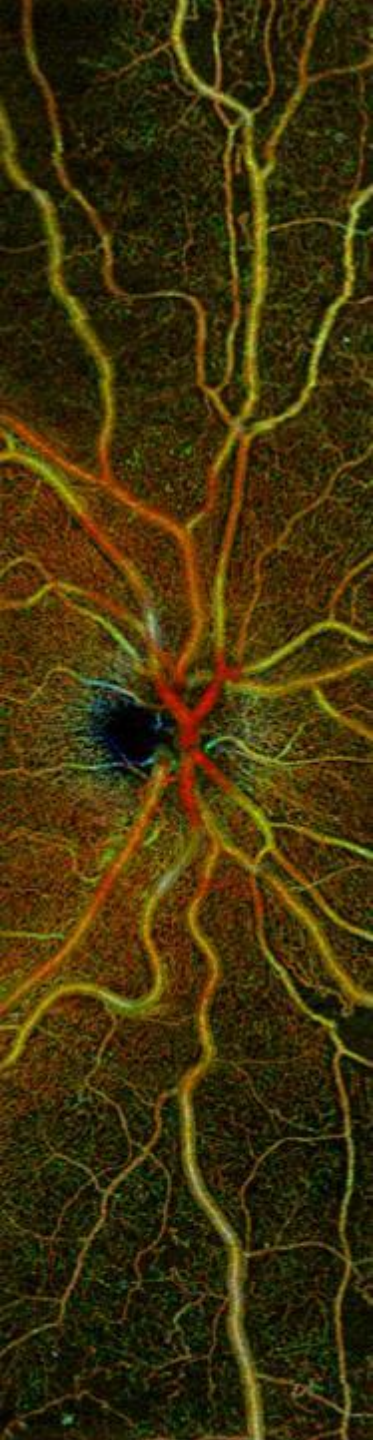


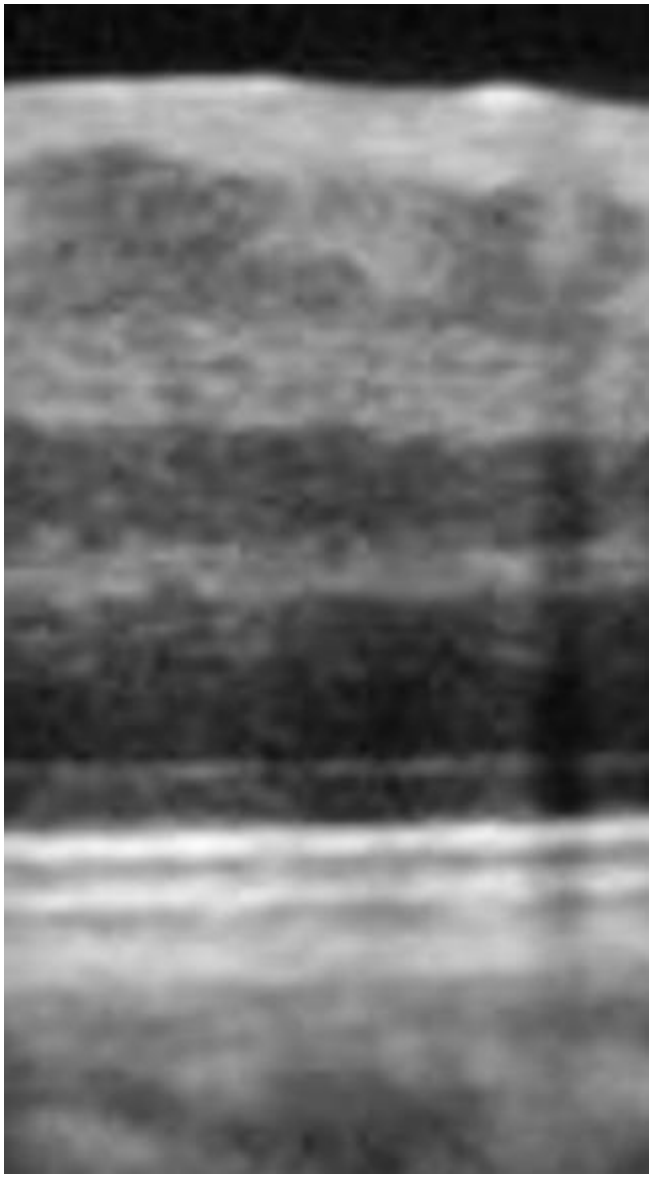


OVERVIEW

- Retinal blood supply
- Technology (Motion contrast)
- Displays & Interpretation
- OCTA in disease
  - Diabetic retinopathy
  - Venous occlusion
  - CNV (AMD, others)
  - Glaucoma

RETINAL BLOOD SUPPLY





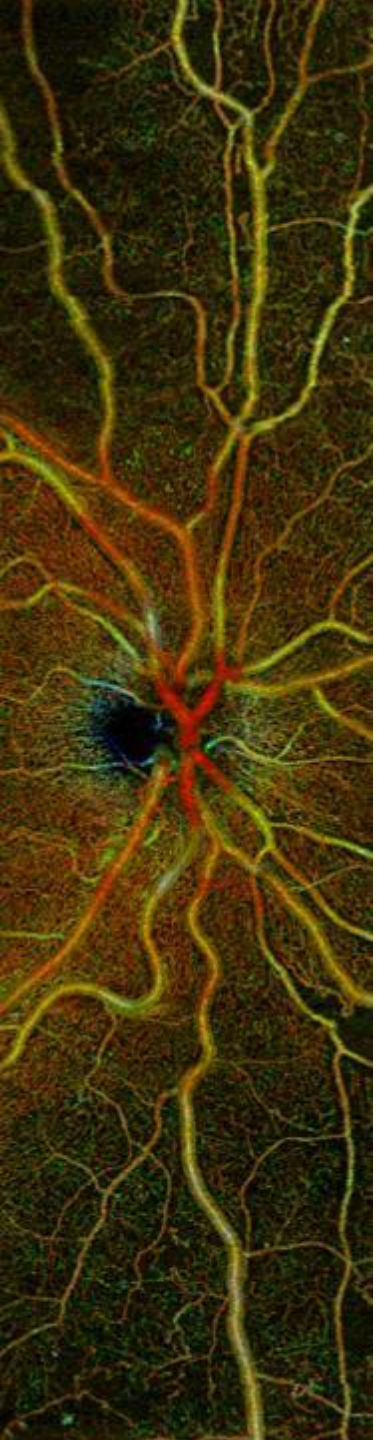
NFL
GCL
IPL
INL
OPL
ONL
PR

Vascularized inner retina

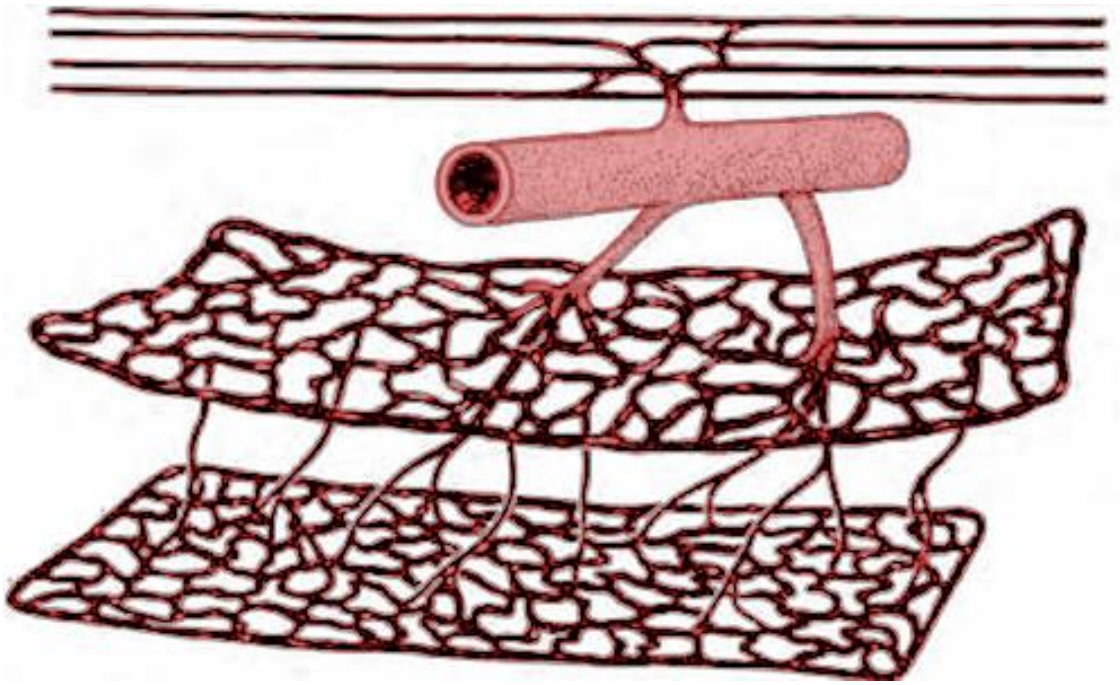
CRA

Choroid

Avascular outer retina



CENTRAL RETINAL ARTERY

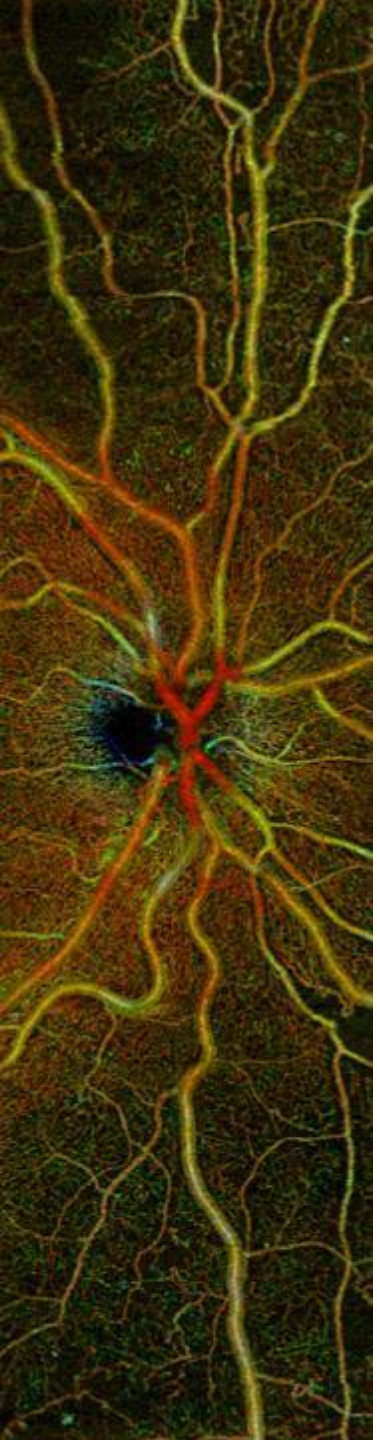


Radial Peripapillary Capillaries

Superficial Capillary Plexus

Deep Capillary Plexus

Superficial capillary plexus: Ganglion cells
Deep capillary plexus: Bipolar cells (INL)

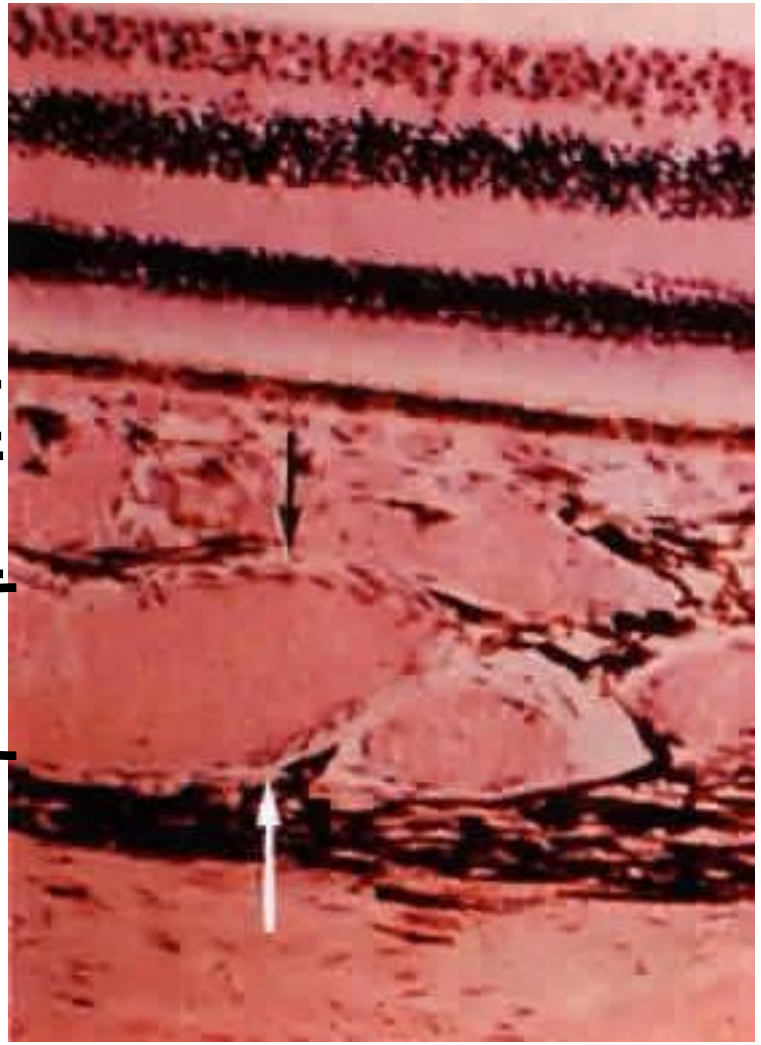


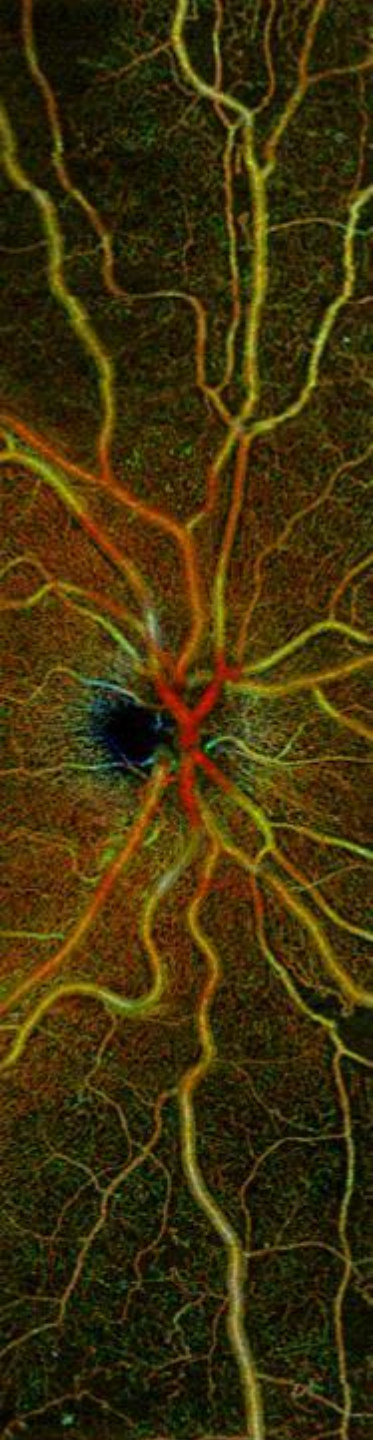
CHOROID

Choriocapillaris

Sattler's

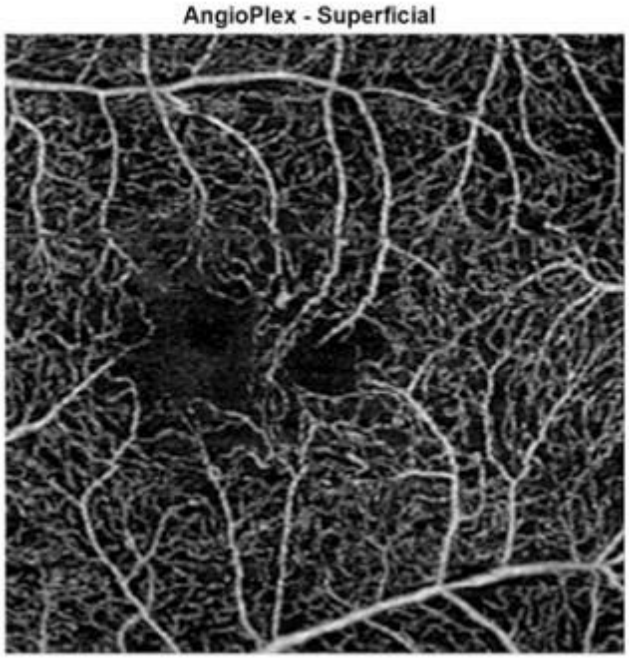
Haller's

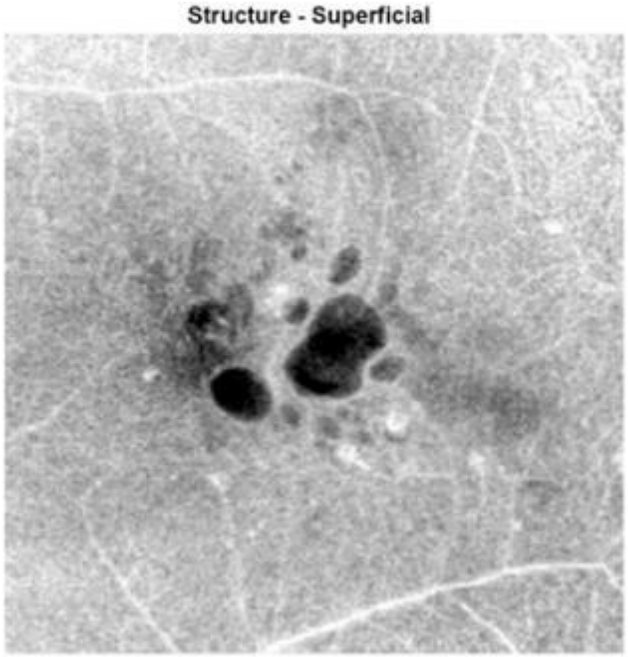


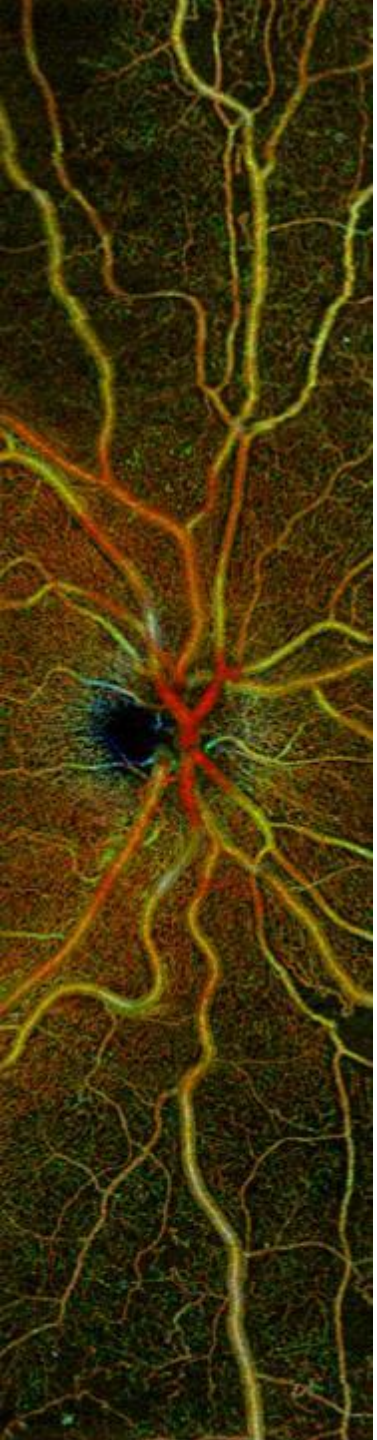


INTRODUCTION

- Non-invasive “flow” imaging
- 3D volumetric data
- Simultaneous retinal and choroidal imaging
- Structure/ vasculature in tandem

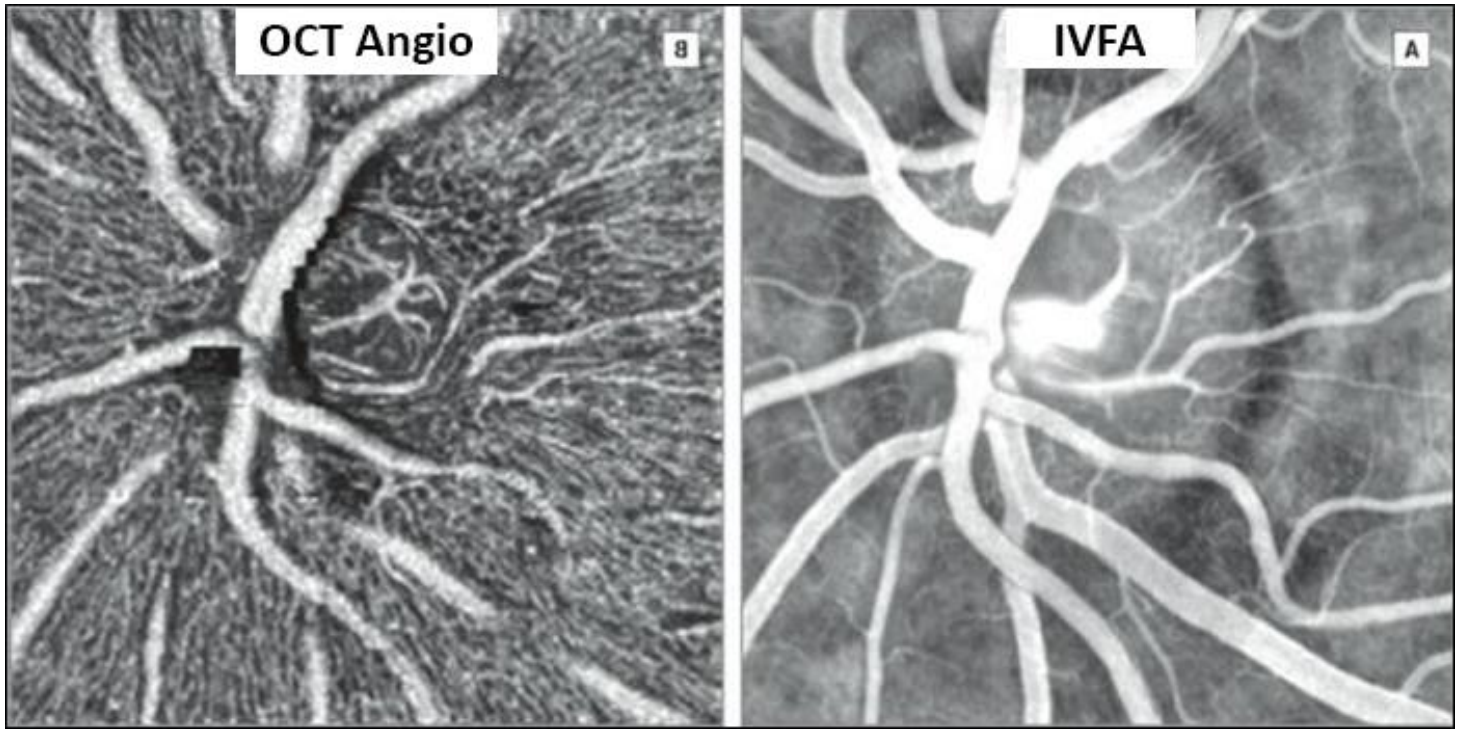


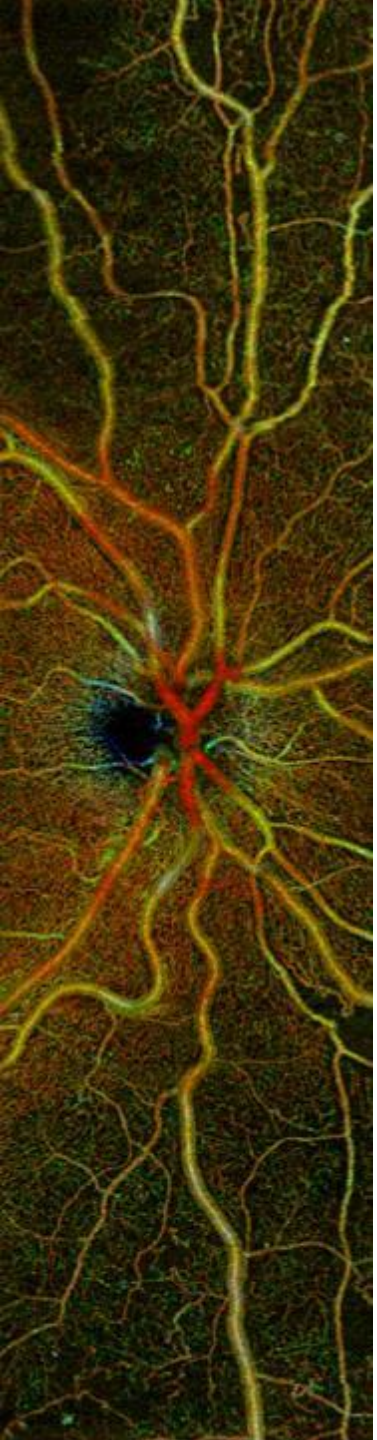




INTRODUCTION

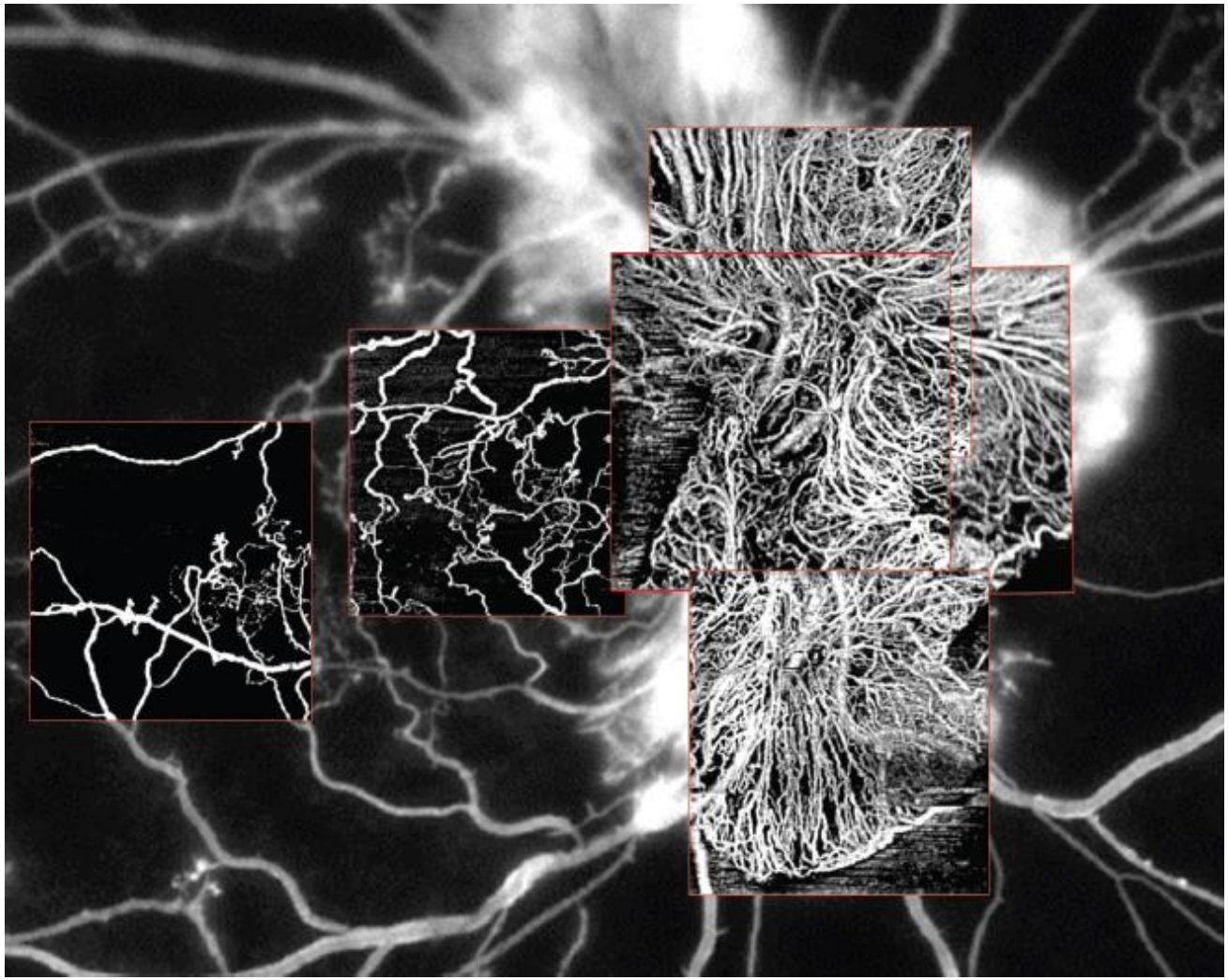
- Rapid acquisition
- Short term repeatability
- High microvascular resolution

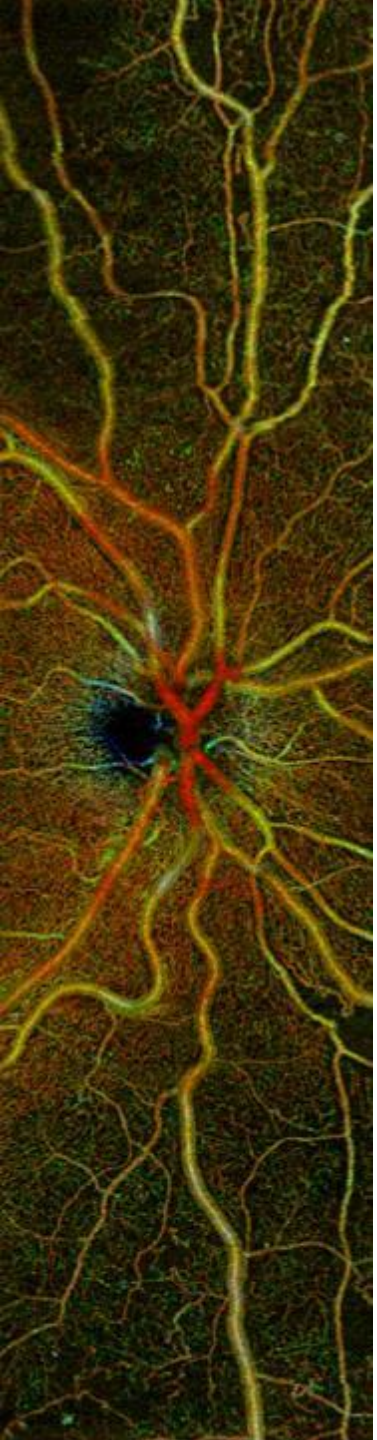




INTRODUCTION

- Precise delineation/measurement of neo



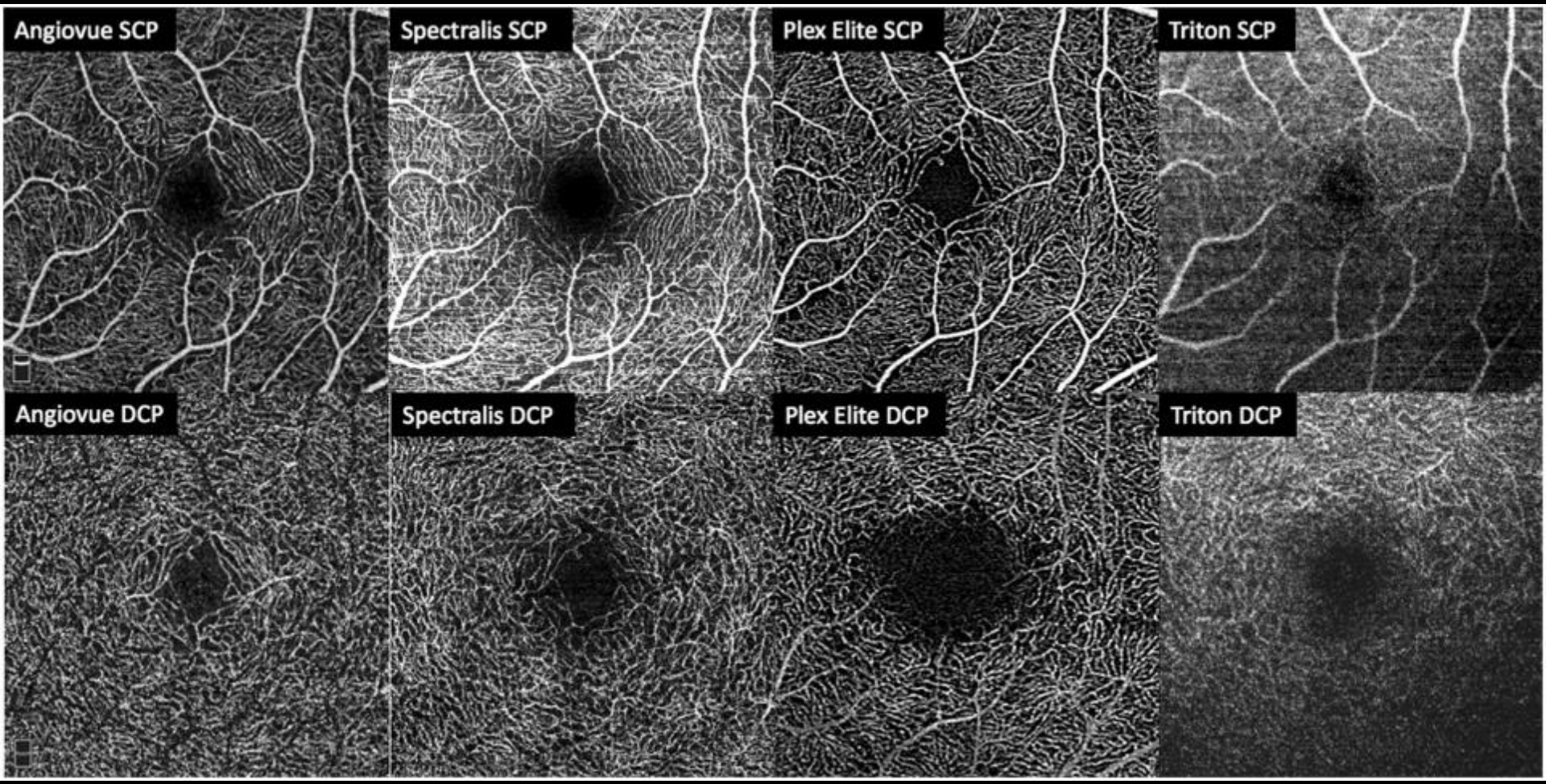


TECHNOLOGY

FDA Cleared

- **Zeiss AngioPlex™**
  - Cirrus & Plex Elite 9000
  - Optical micro-angiography
- **Optovue AngioVue™**
  - RTVue XR Avanti Angiovue
  - Split-spectrum amplitude decorrelation angiography
- **Heidelberg Spectralis OCTA Module**
  - Full spectrum amplitude decorrelation angiography
- **Topcon DRI-OCT Triton SS-OCT**
  - OCT angiography ratio analysis

Statistically significant differences exist across devices when measuring the same parameter



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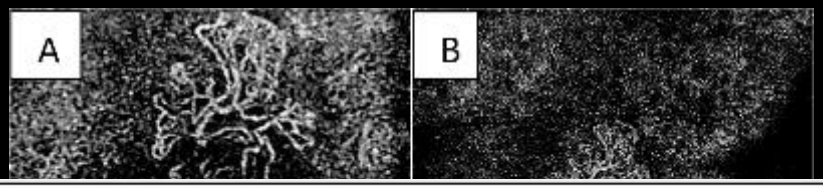
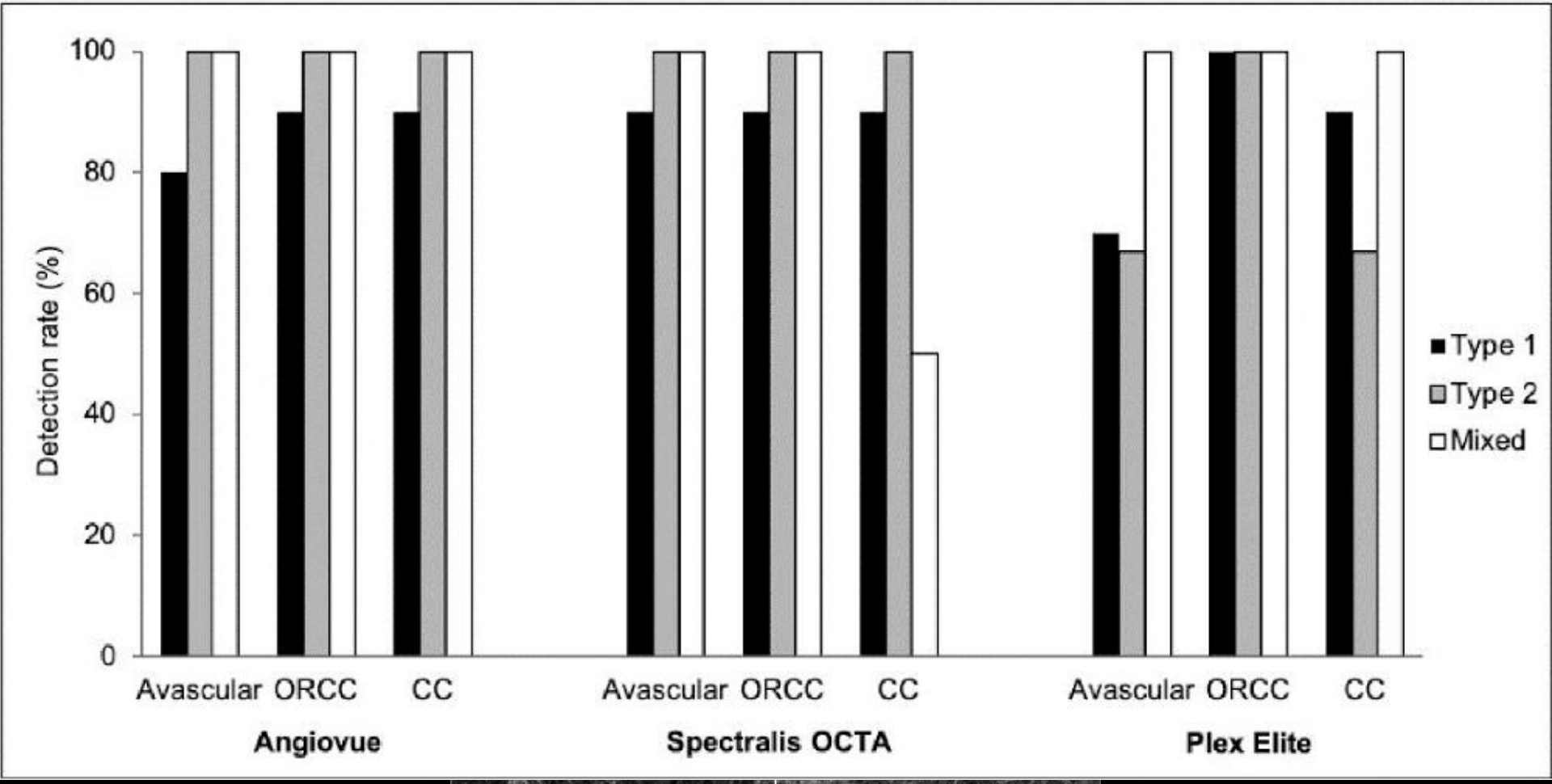
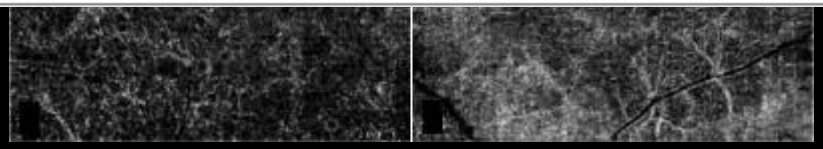
6 x 6



Plex





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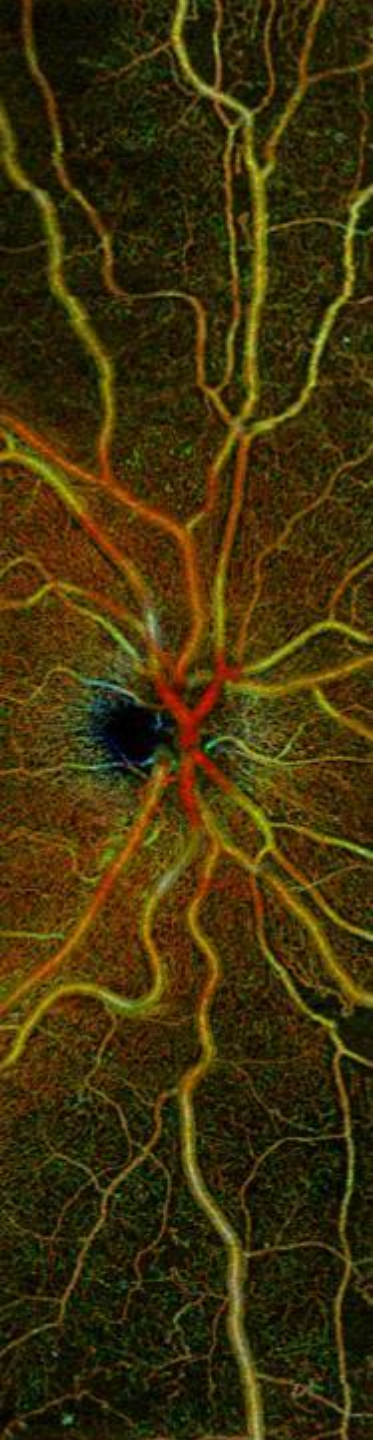
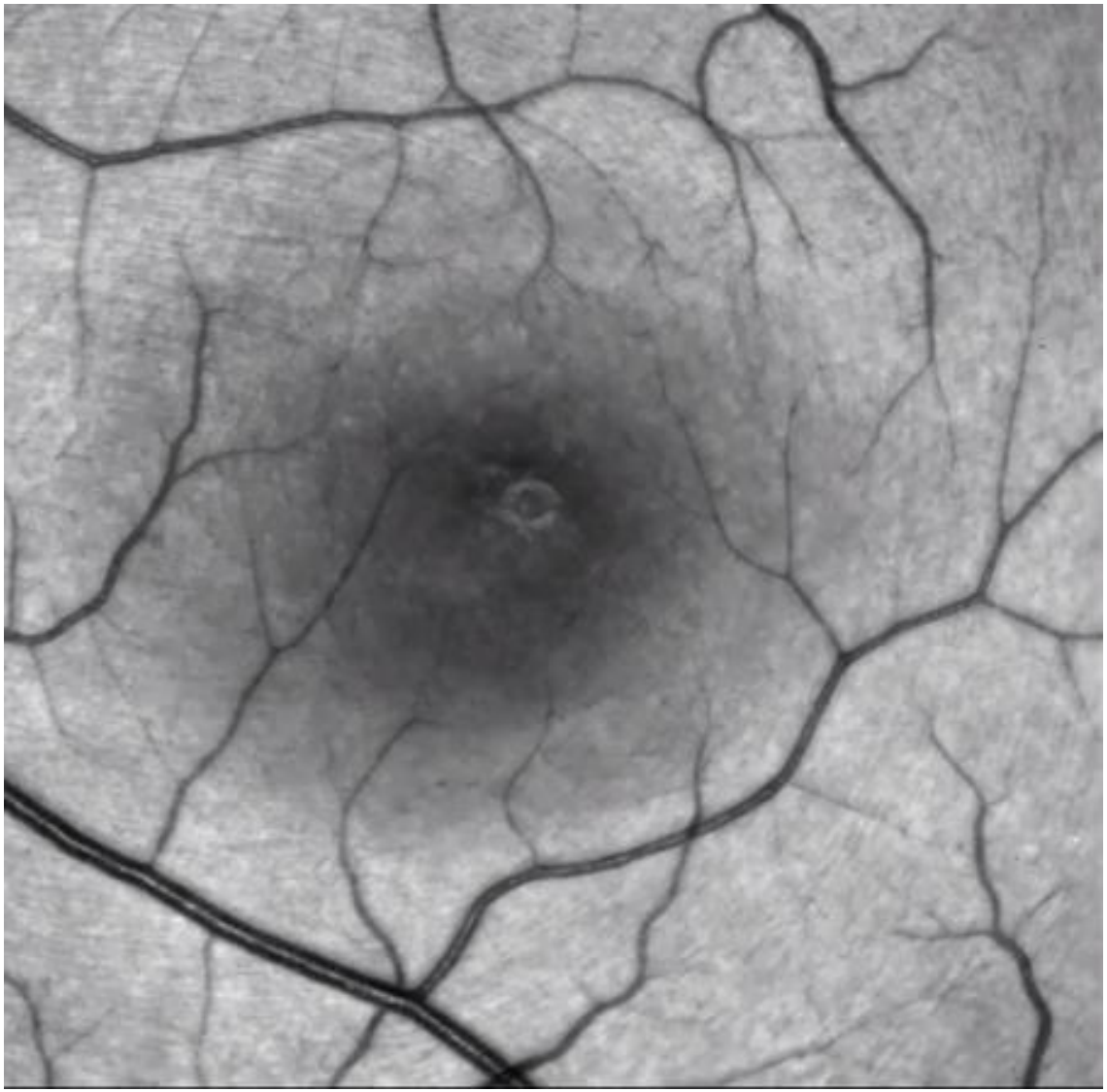
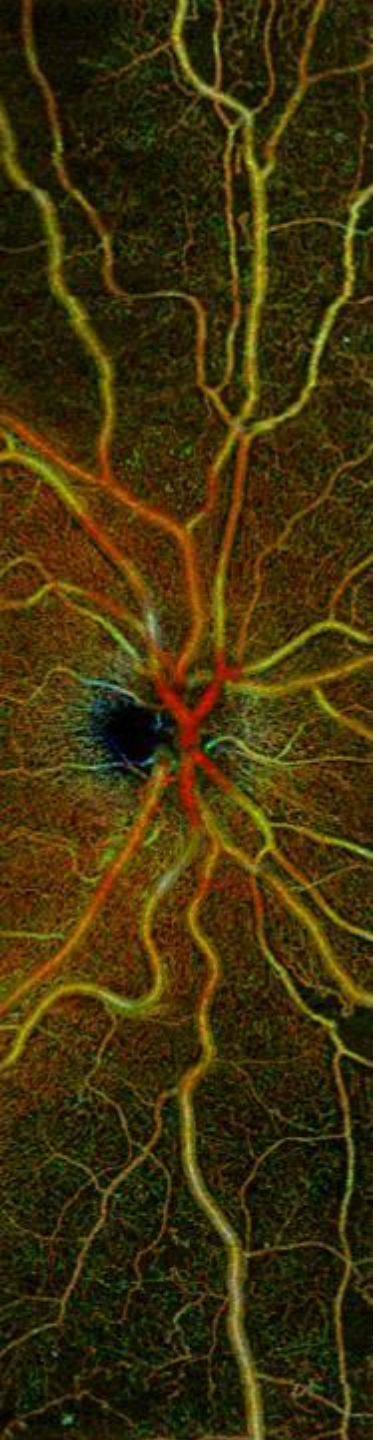


MOTION CONTRAST





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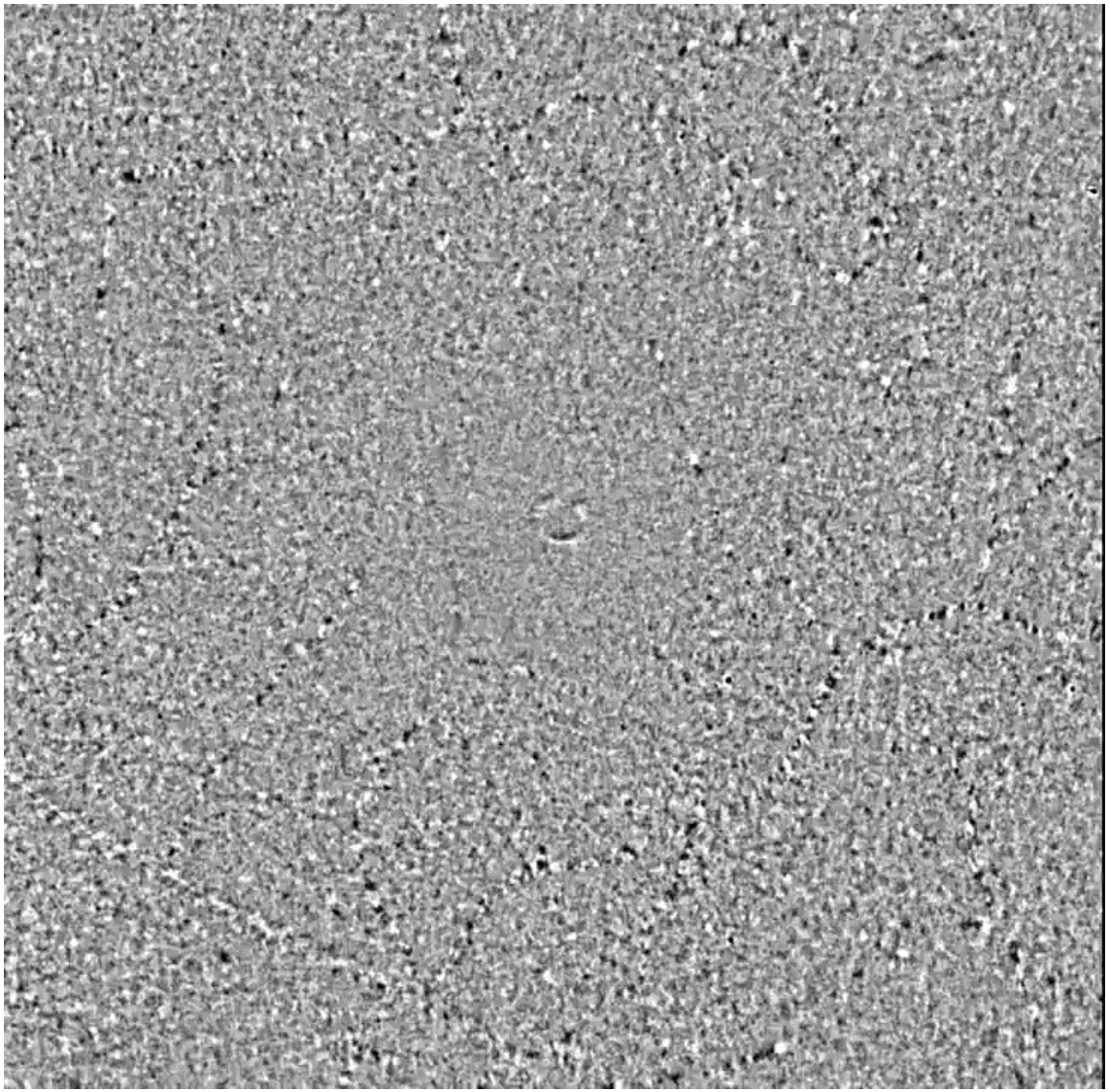
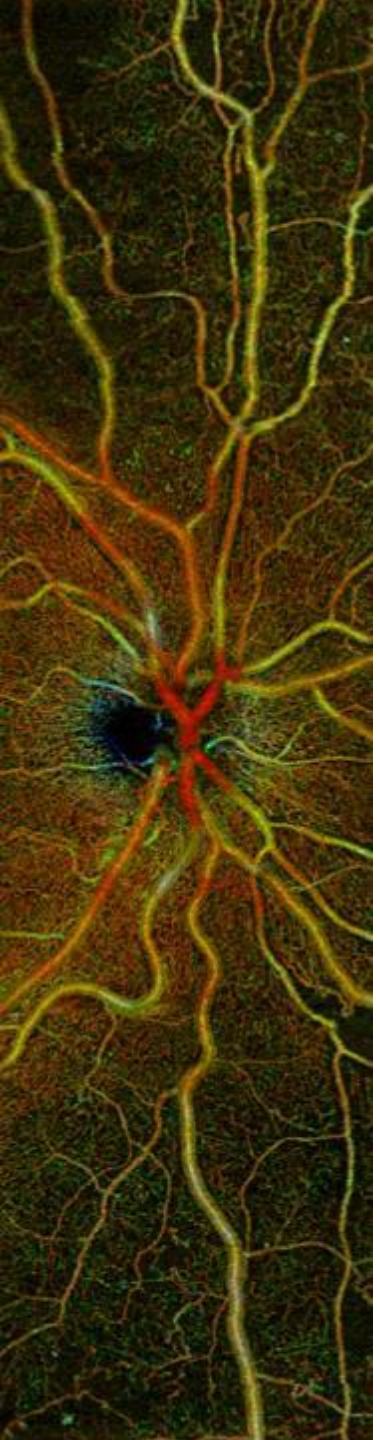
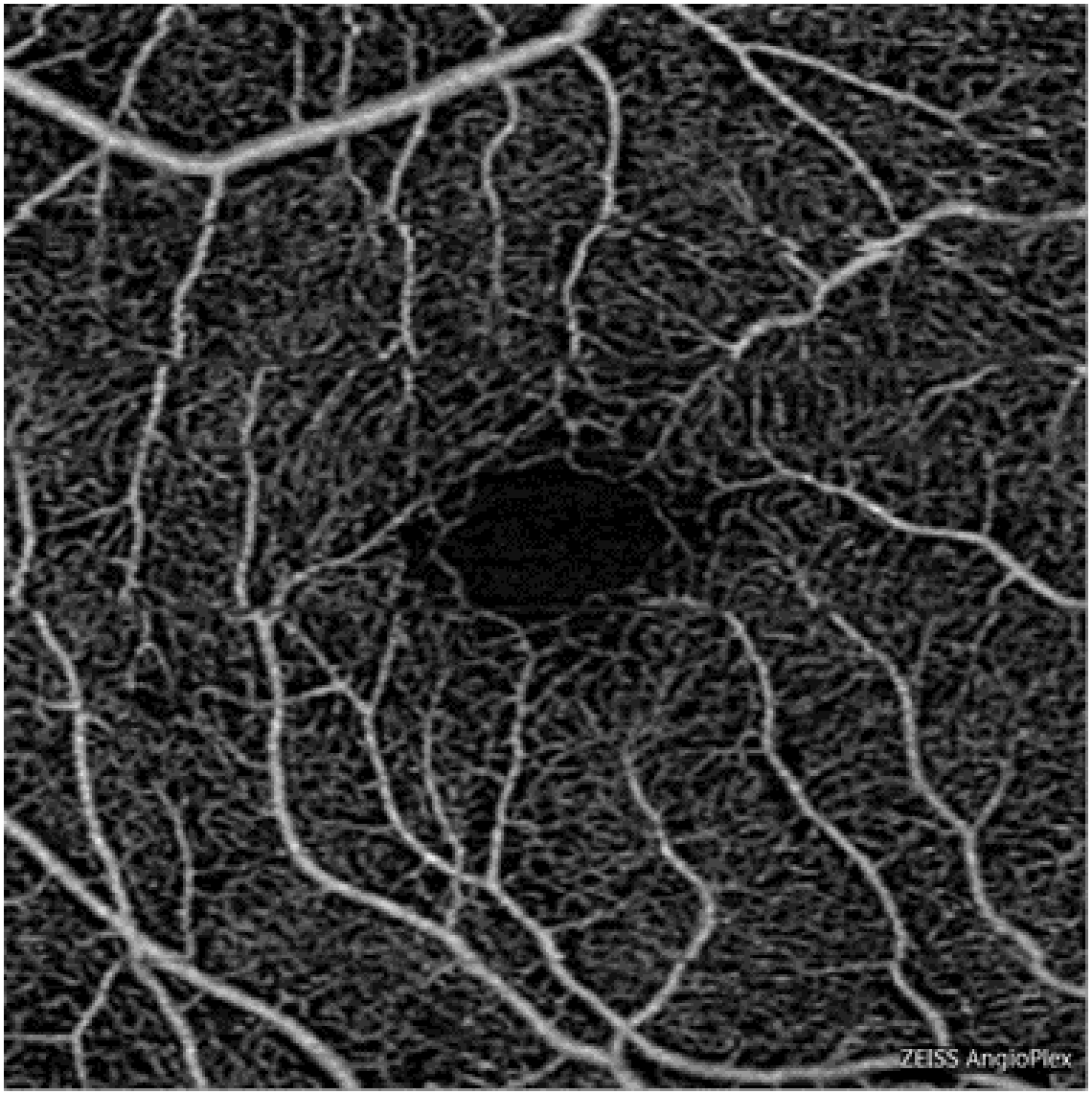
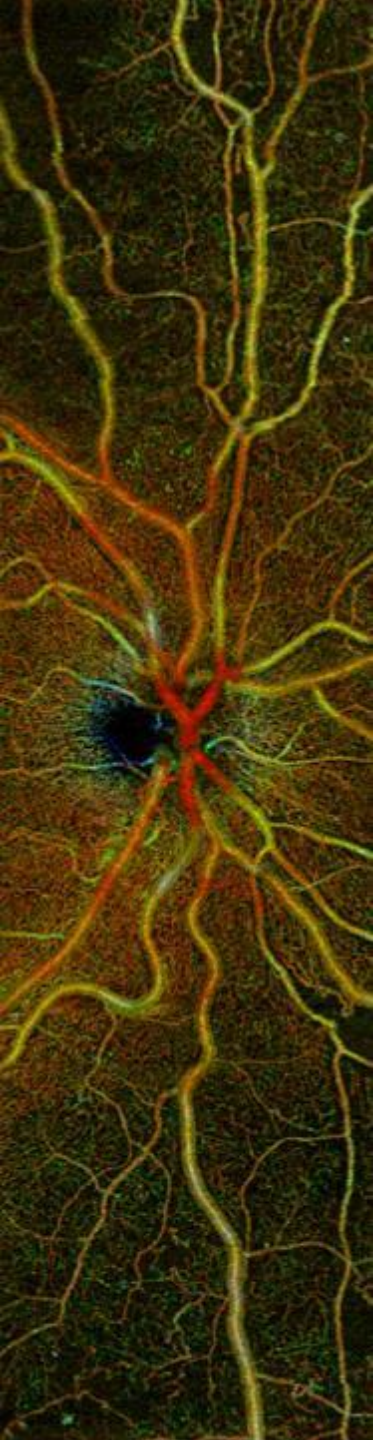


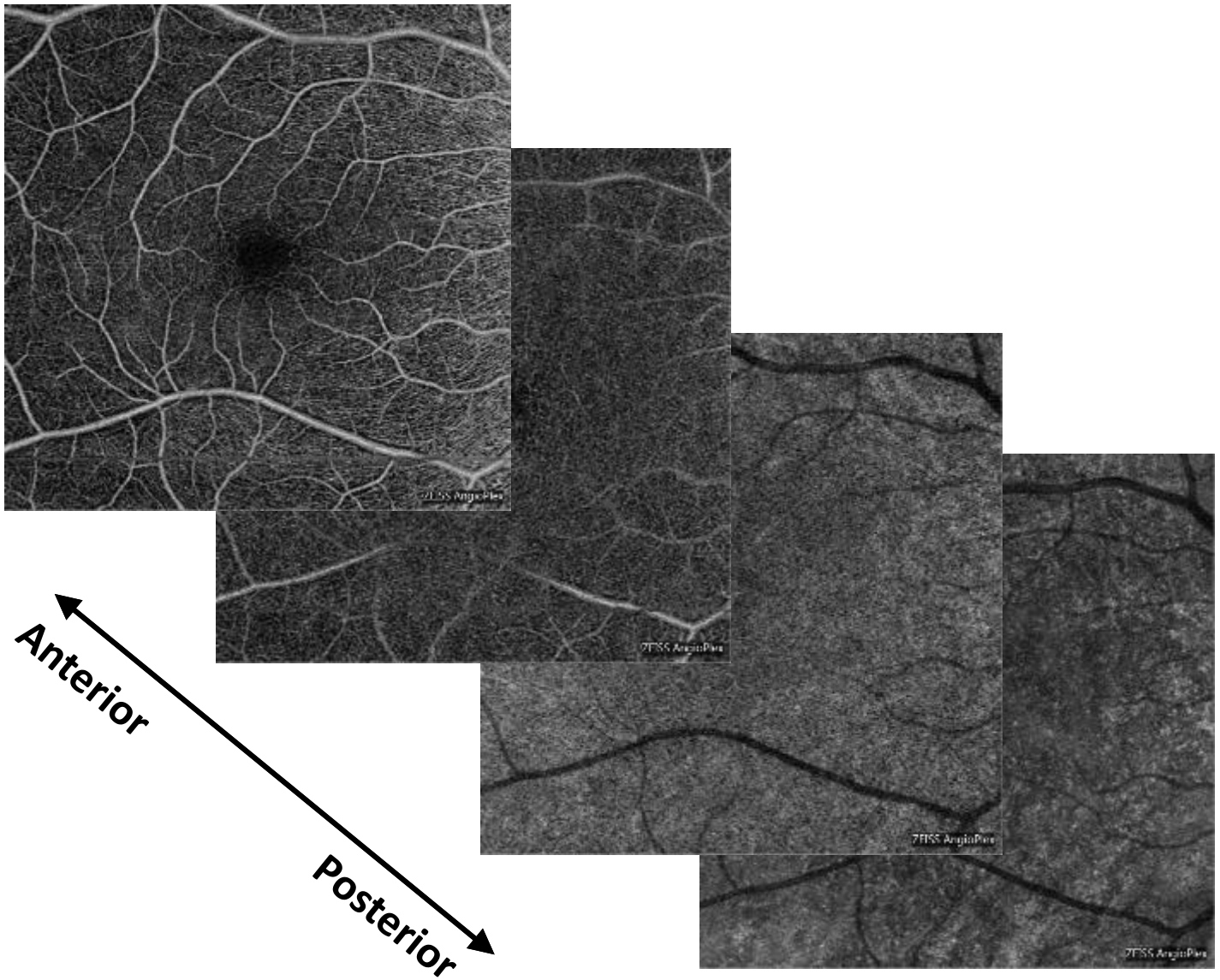


MOTION CONTRAST



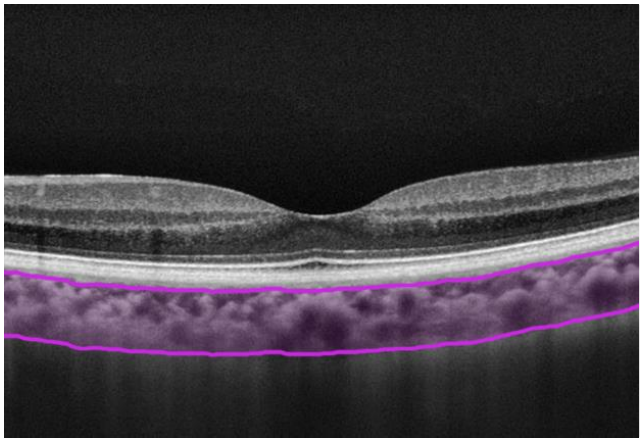


DISPLAY- En Face

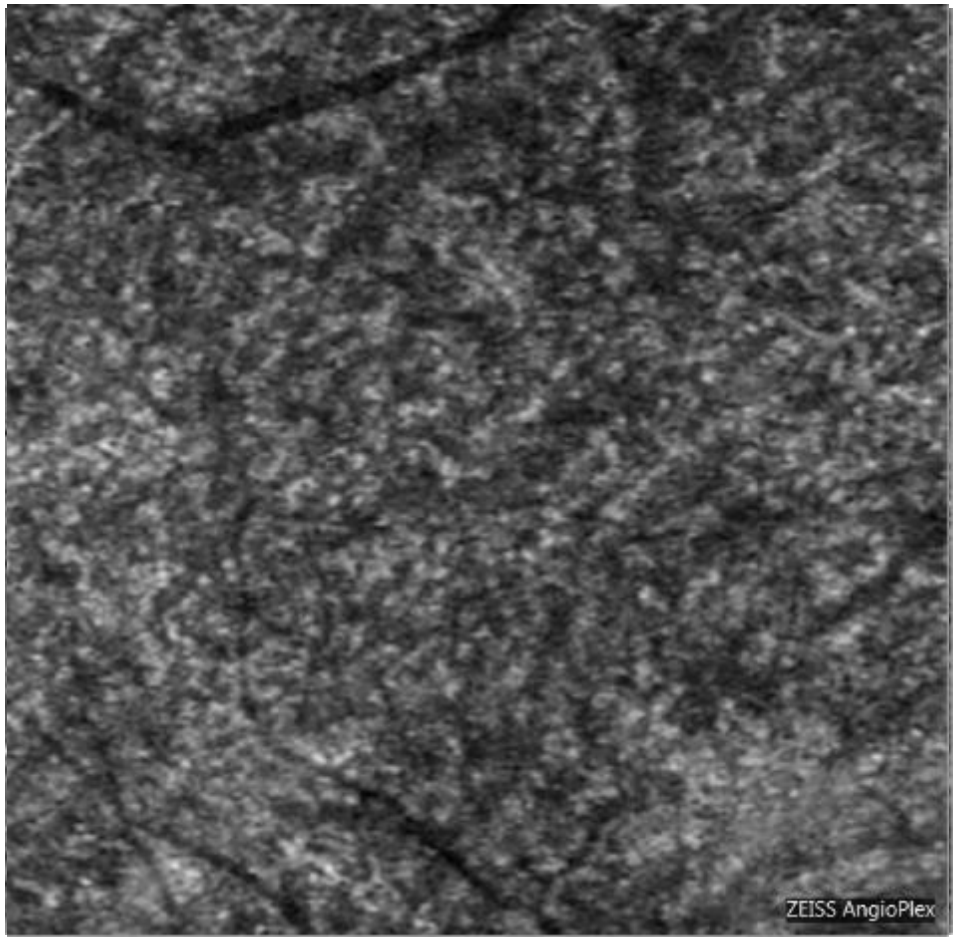


DISPLAY- En Face

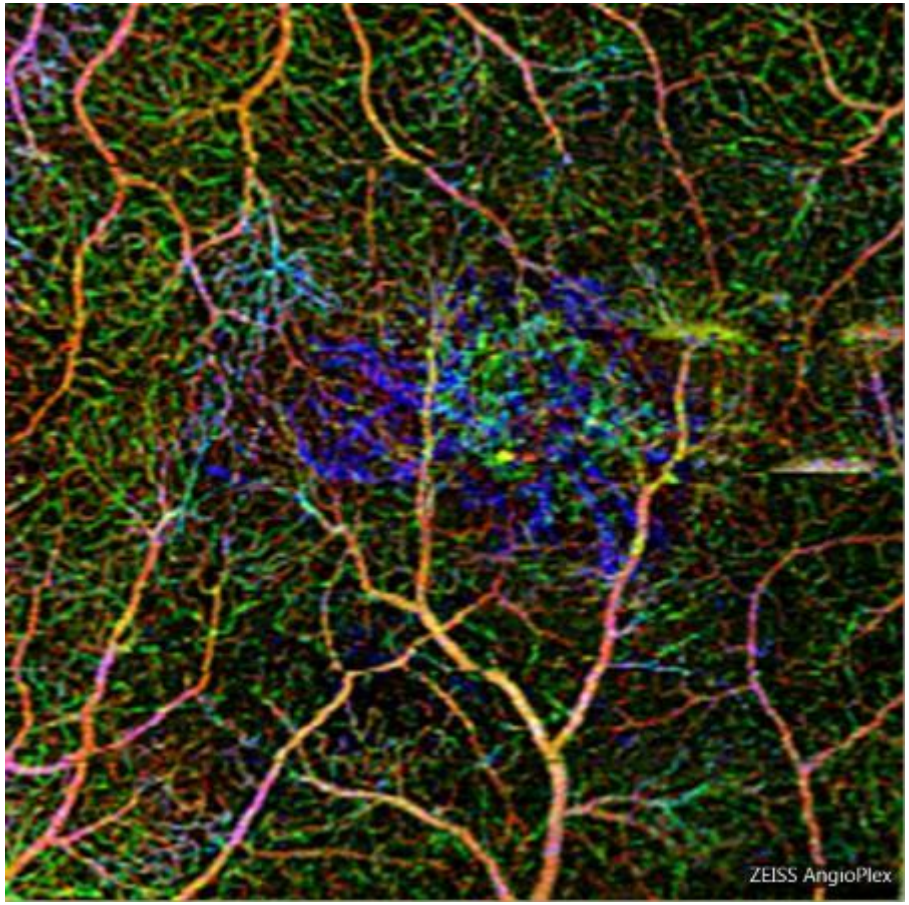
Segmentation lines tell you what retinal layers are being displayed en-face

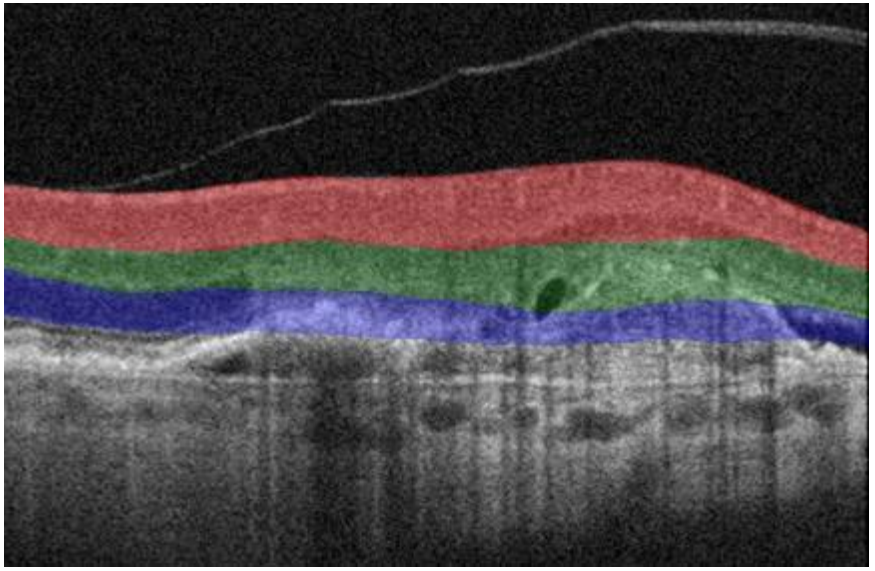


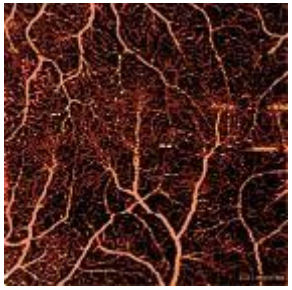
Choroid

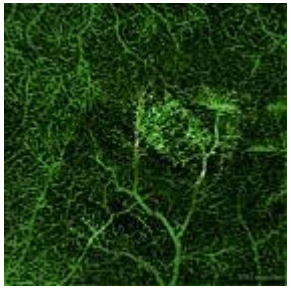


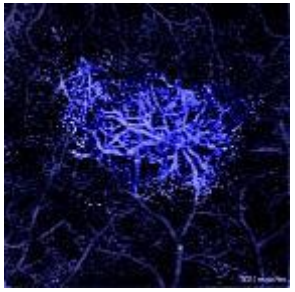
DISPLAY- Color En Face

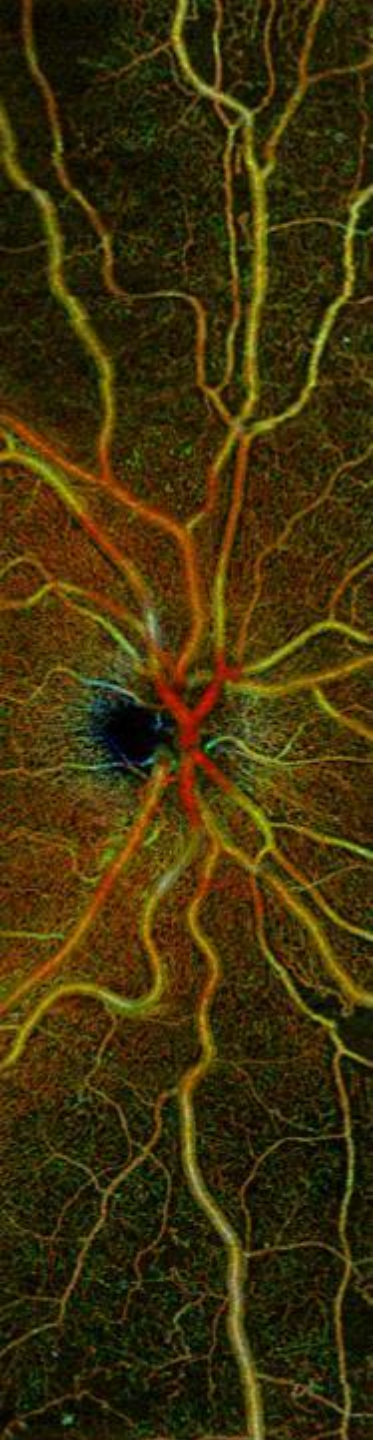




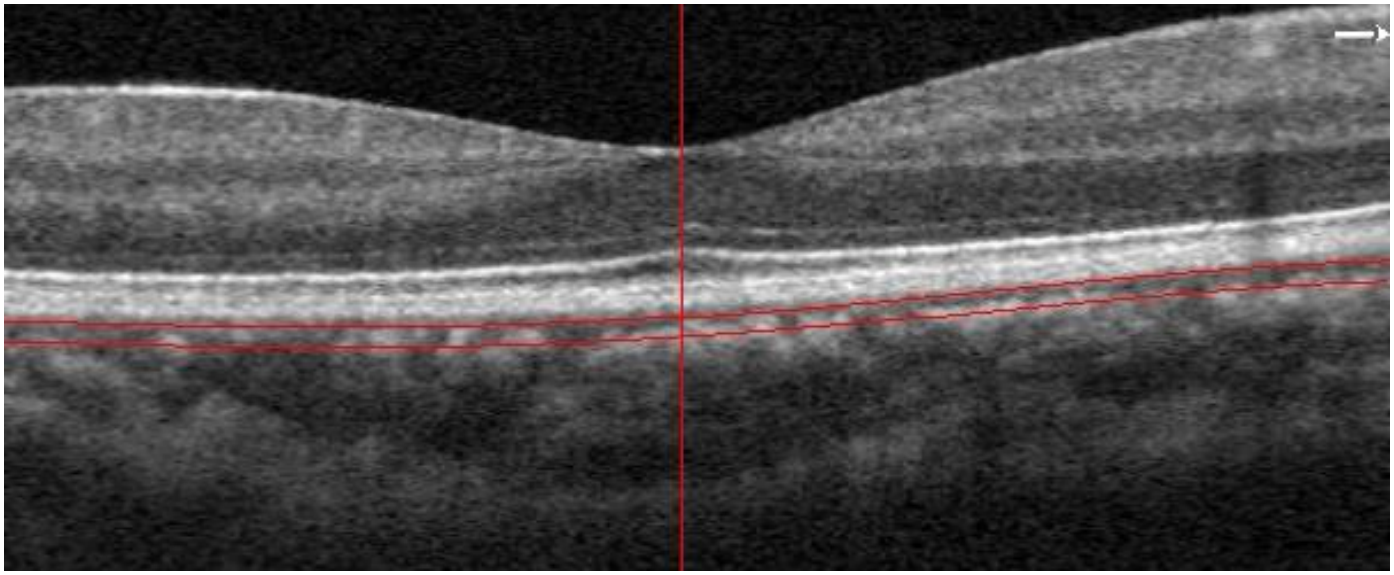


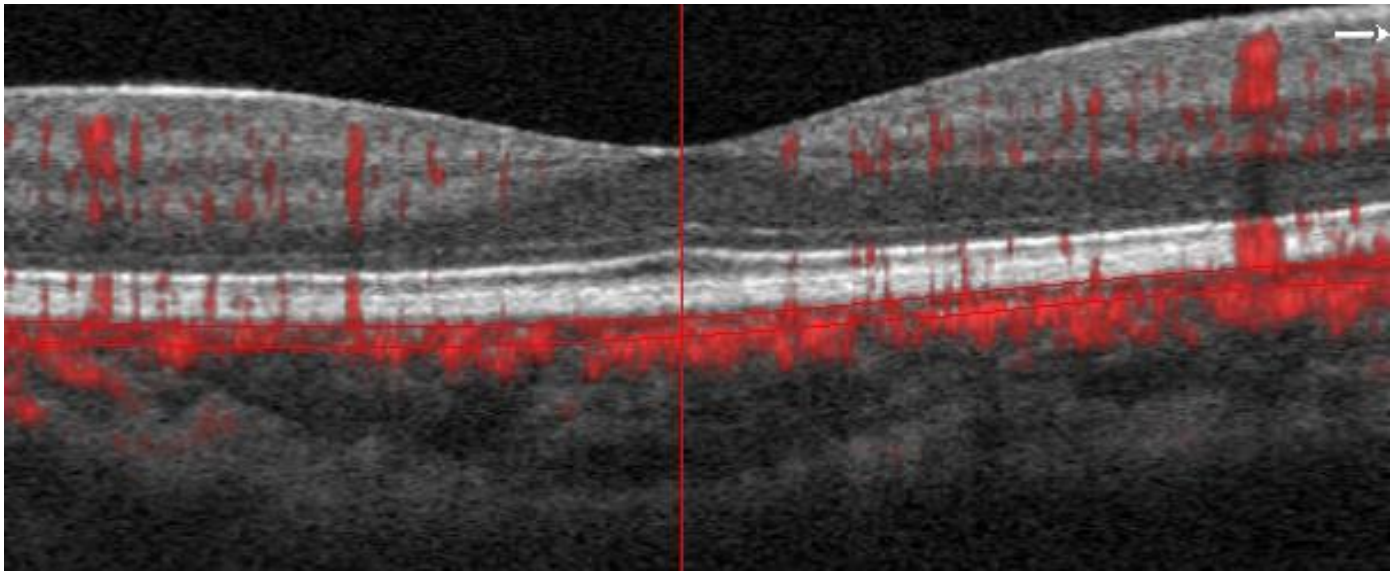






DISPLAY- B Scan Overlay





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DOB:		Exam Time:	11:22 AM
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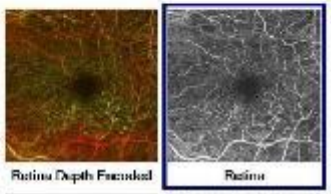
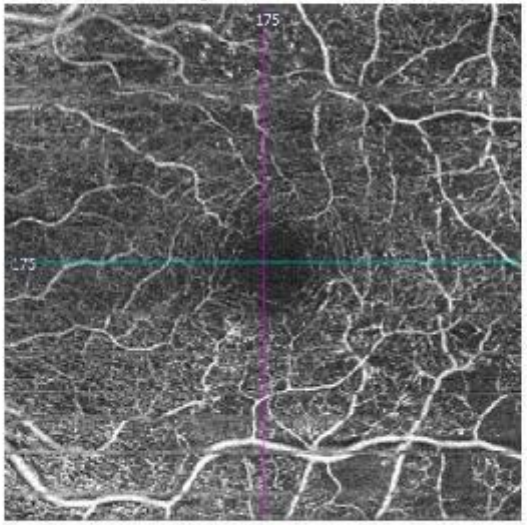
Technician:	Operator, Cirrus	Signal Strength:	5/10

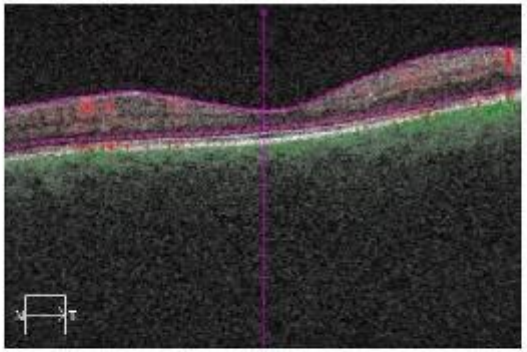
Angiography Analysis : Angiography 6x6 mm

OD ○ | ● OS



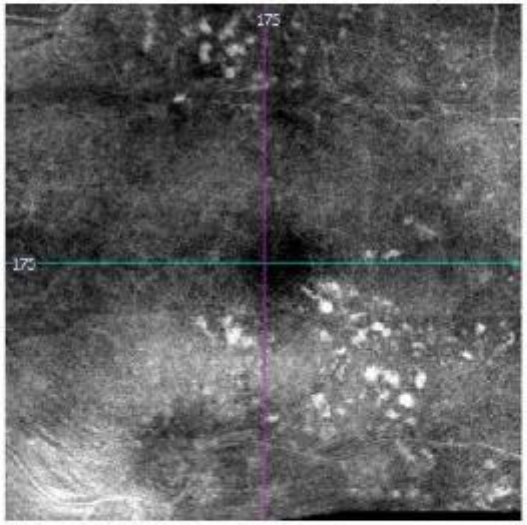
AngioPlex - Retina





Slice: 175

Structure - Retina



Current View:Retina

Reference	Offset
Top: ILM	0
Bottom: RPEFit	-70

Comments

Doctor's Signature

OCT Angiography Overview
SPECTRALIS® Tracking Laser Tomography

HEIDELBERG ENGINEERING

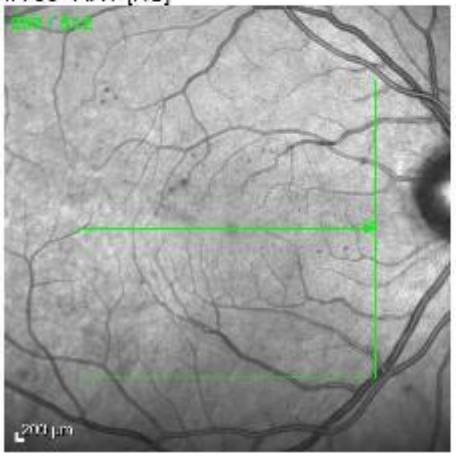
Patient:
Patient ID:
Diagnosis: ---

DOB:
Exam.: Jul/30/2021
Comment: ---

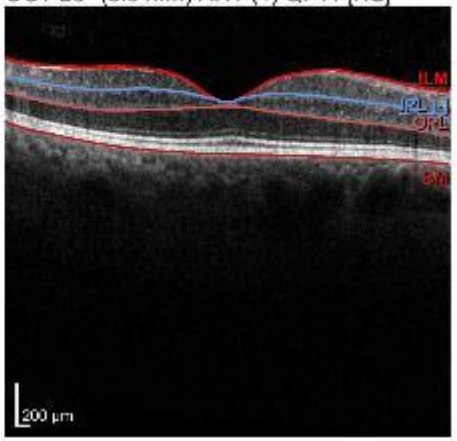
Sex: M

OD

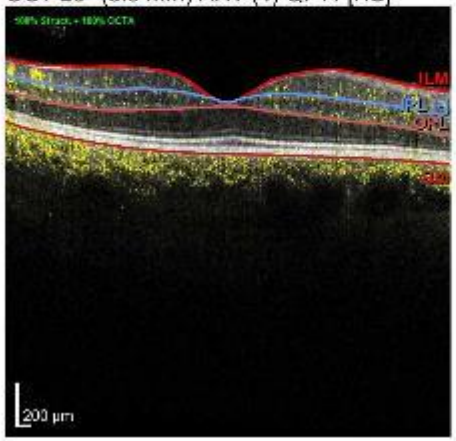
IR 30° ART [HS]

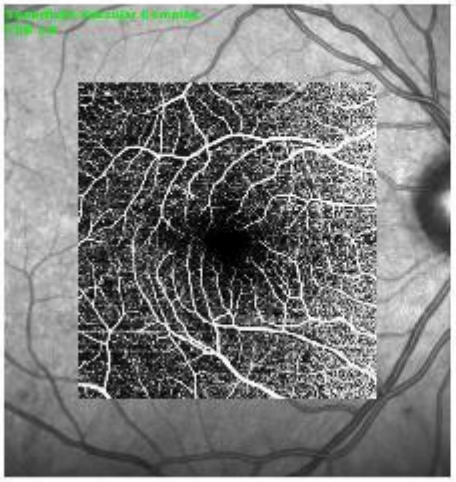


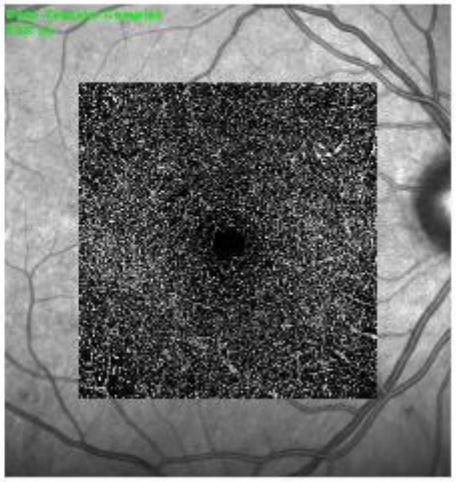
OCT 20° (5.9 mm) ART (4) Q: 44 [HS]

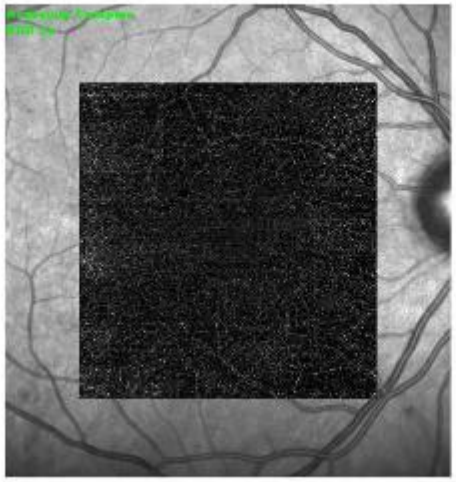


OCT 20° (5.9 mm) ART (4) Q: 44 [HS]









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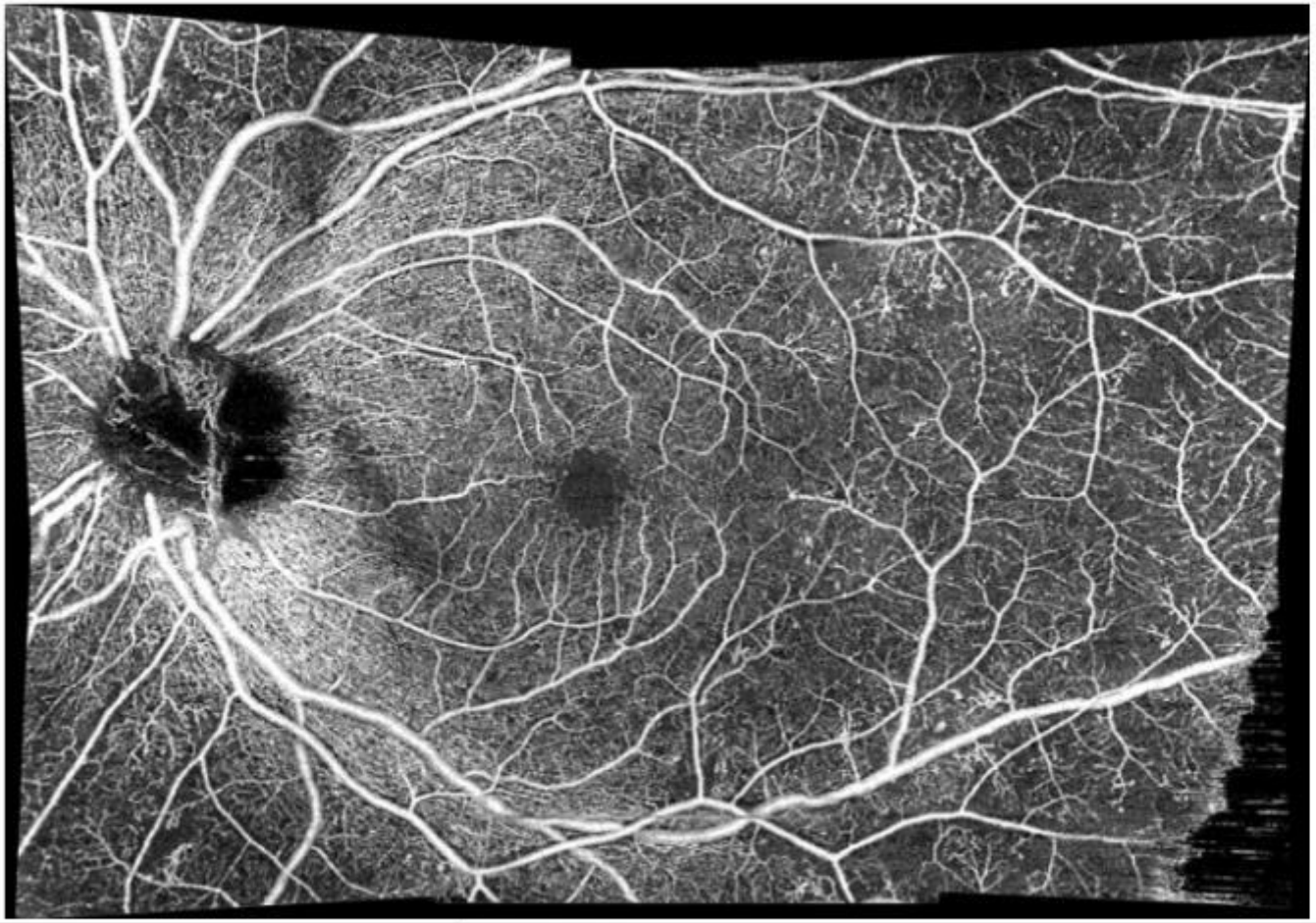
Gender:	Male	Serial Number:	5000-20078	
Technician:	Operator, Cirrus	Signal Strength:	N/A	

Montage Angio Analysis : Montage Angio 6x6 mm

OD ○ | ● OS



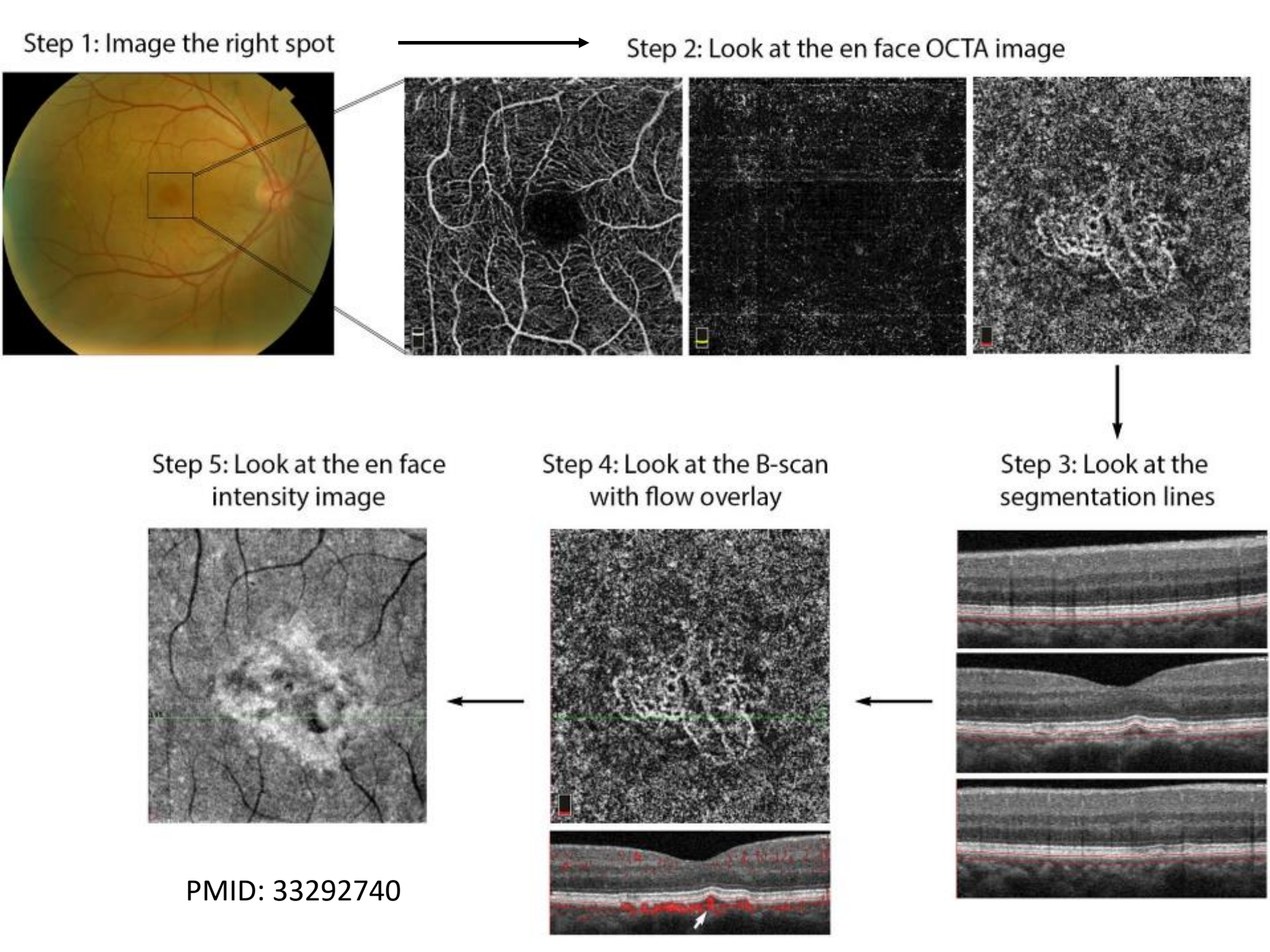
Superficial
AngioPlex

Top
ILM, Offset: 0

Bottom
IPL, Offset: 0

Comments

Doctor's Signature



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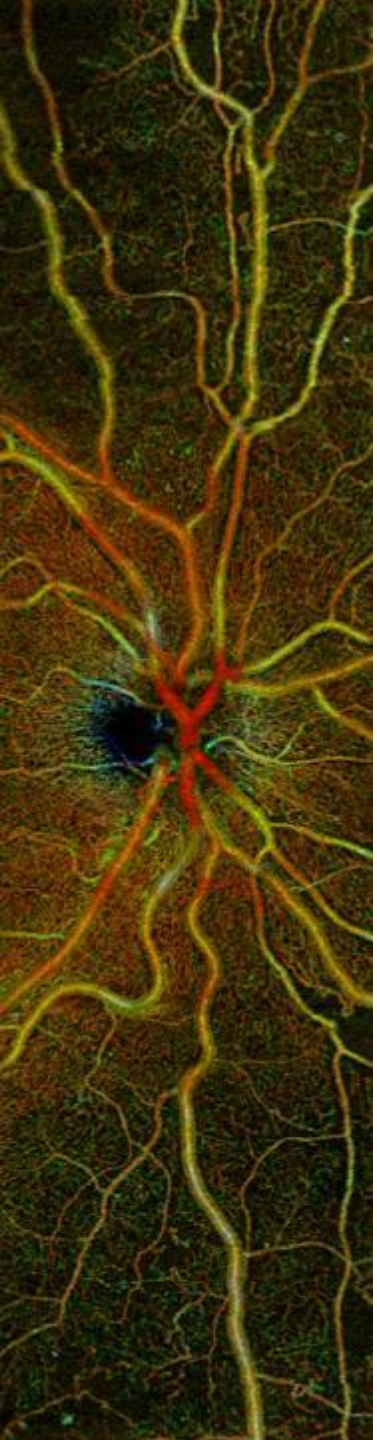
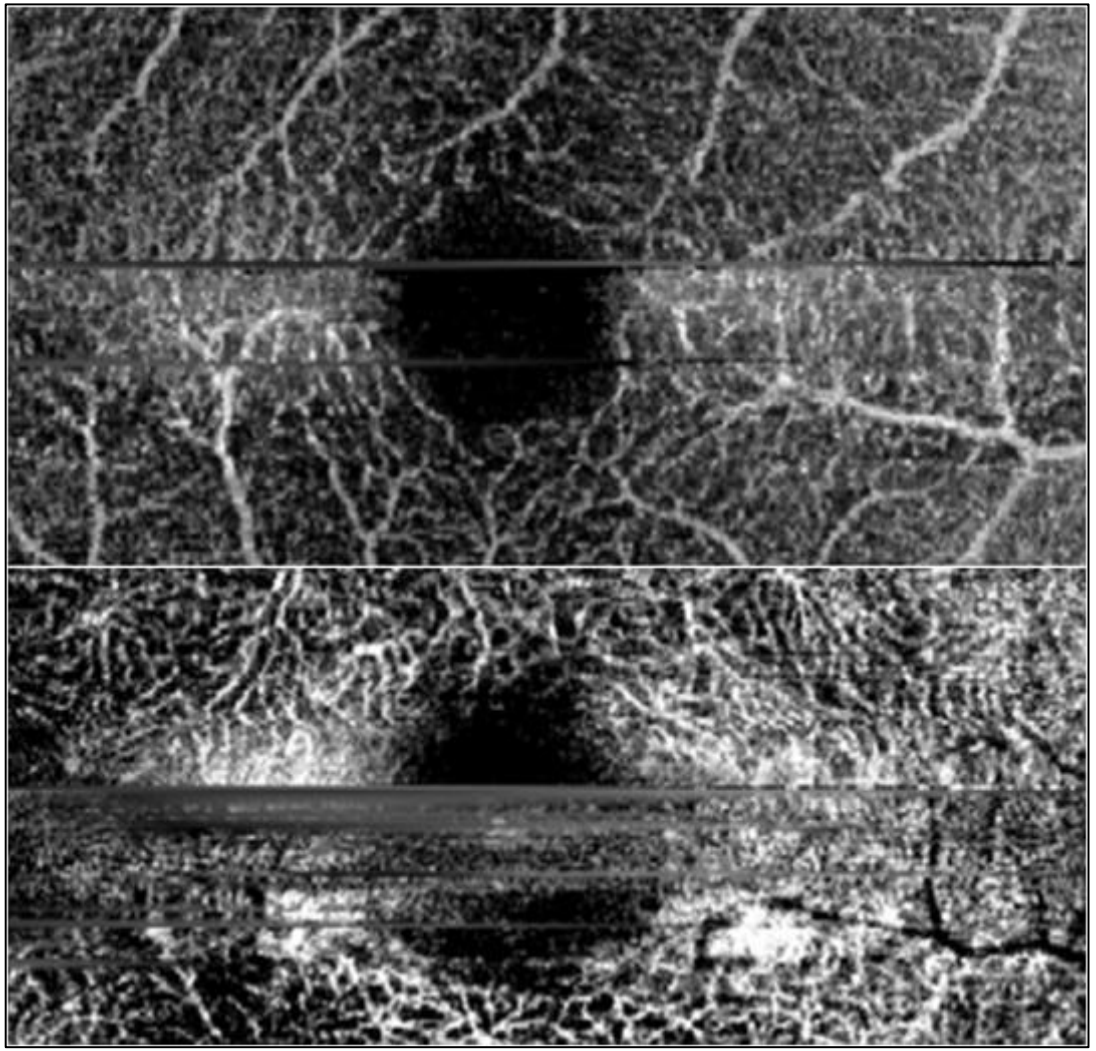
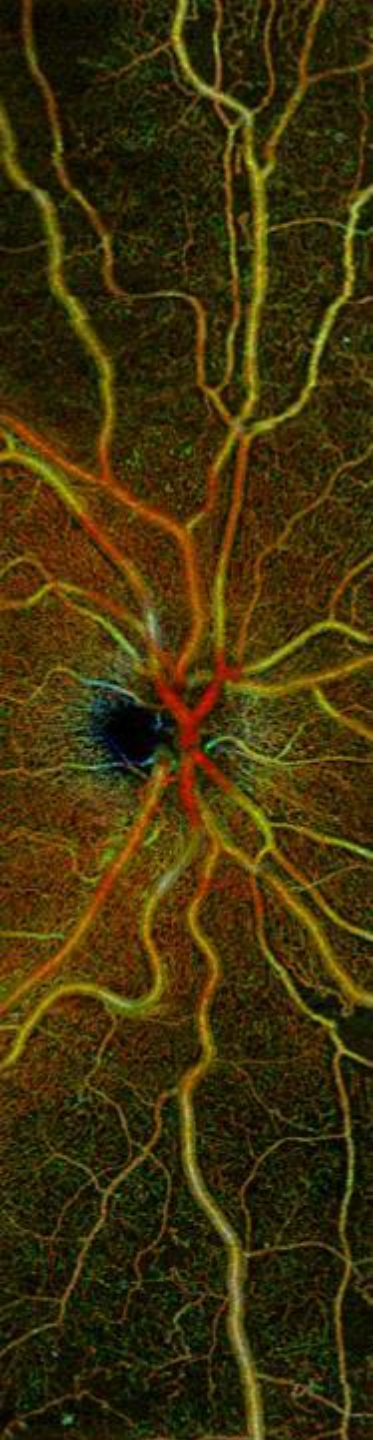
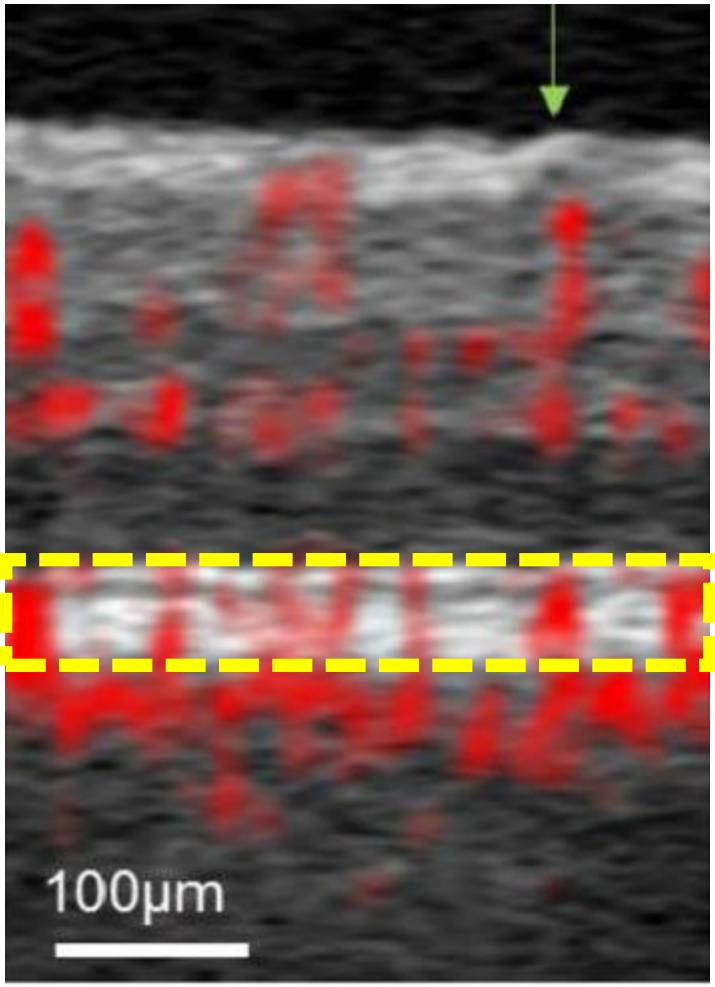


ARTIFACTS- Motion

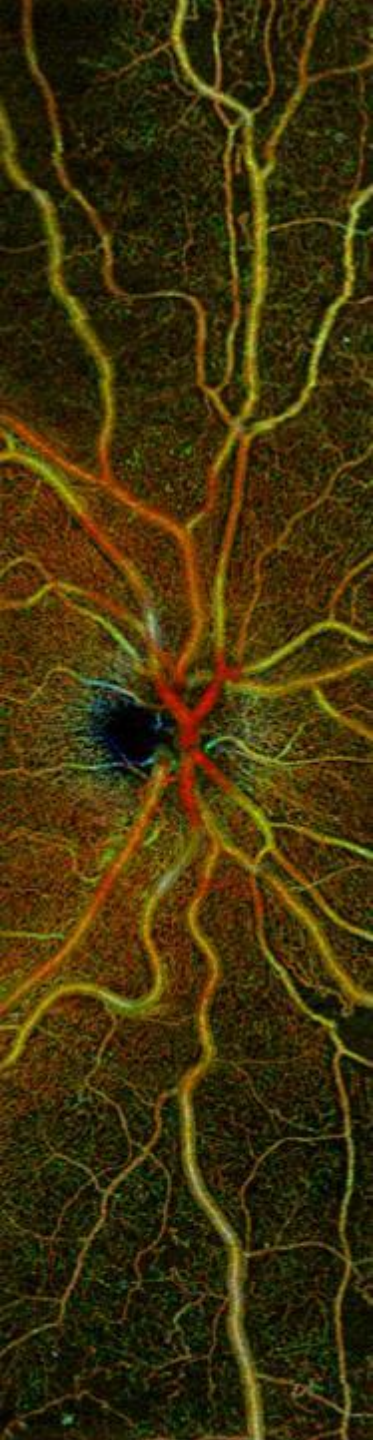




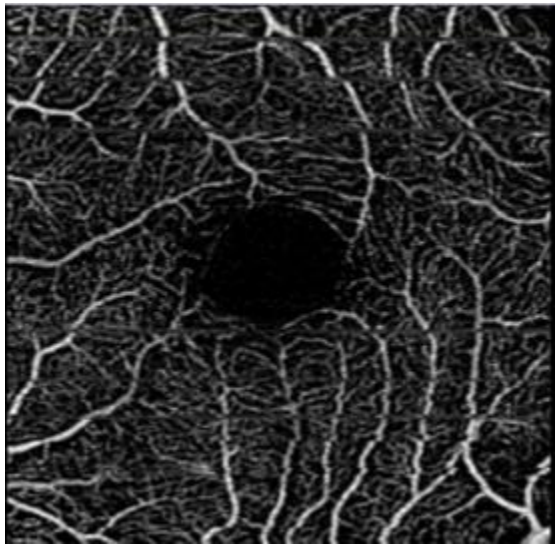
ARTIFACTS- Projection

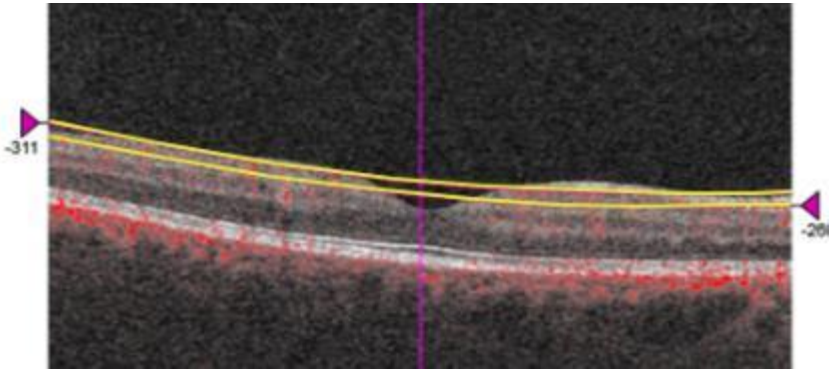


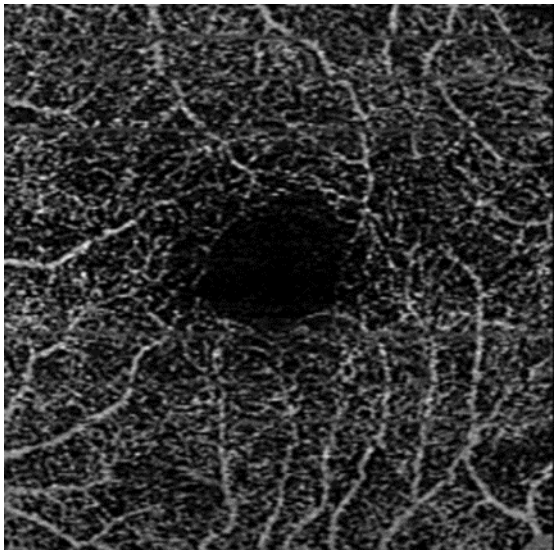
Spaide R, et al. Image Artifacts in OCTA. Retina. 35(11):2163-2180.

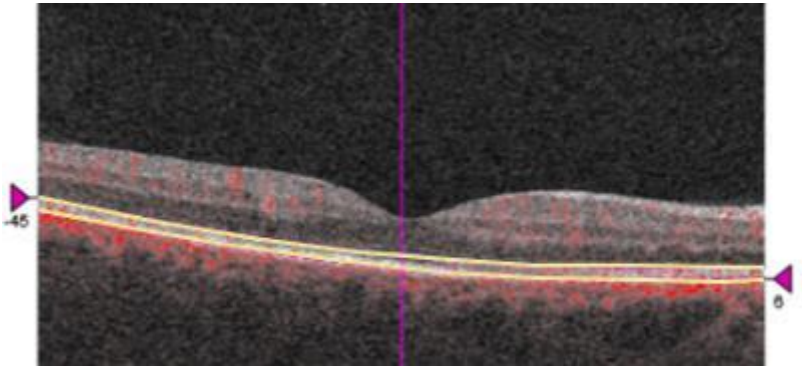


ARTIFACTS- Projection



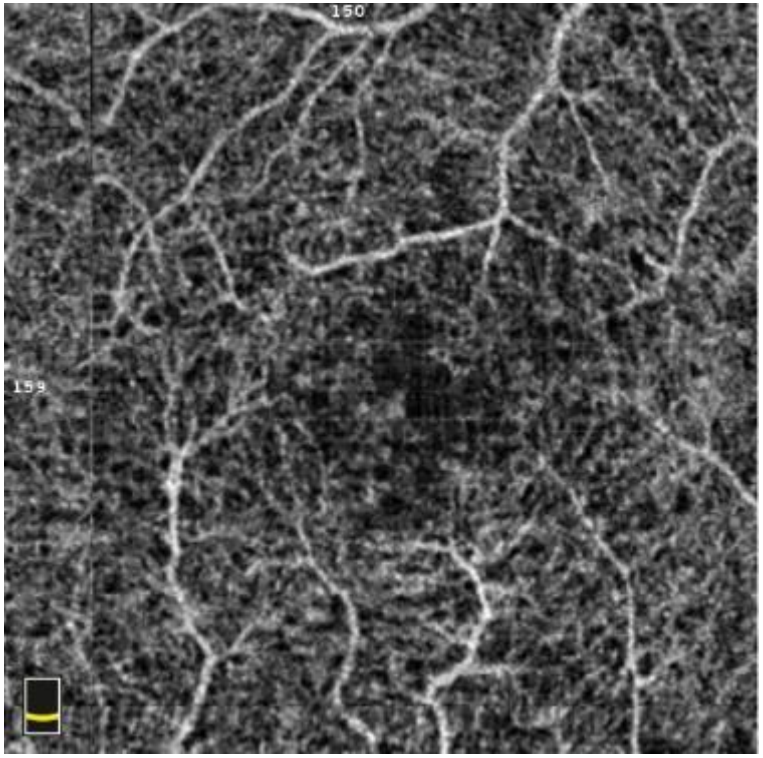




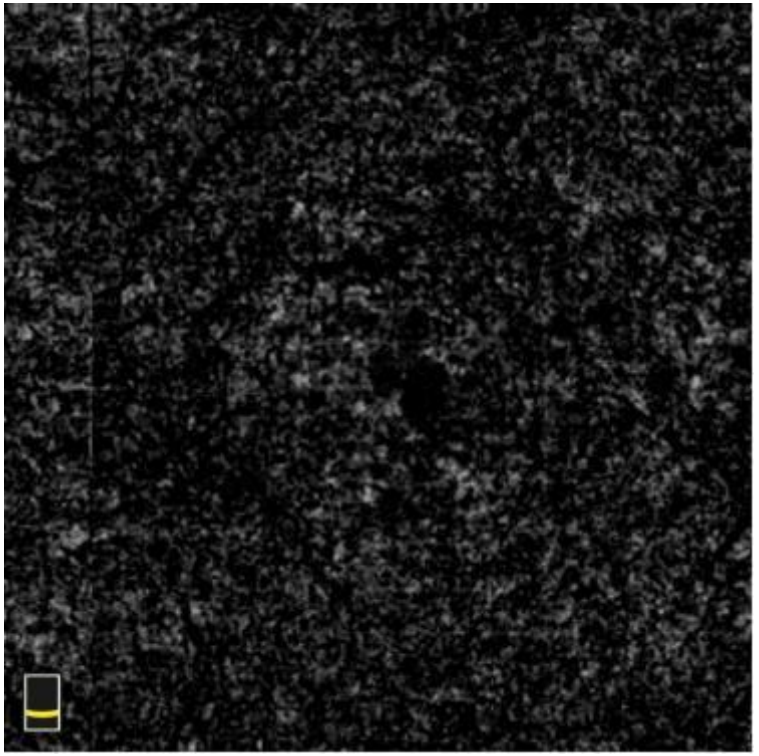


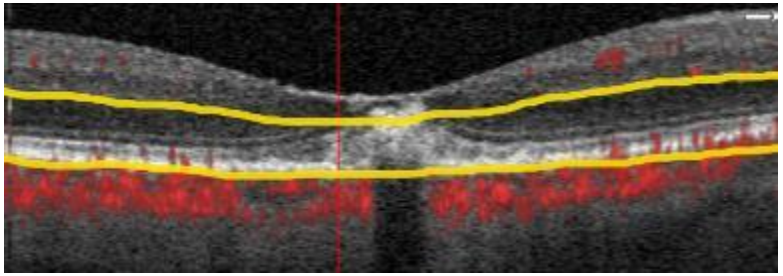
ARTIFACTS- Projection

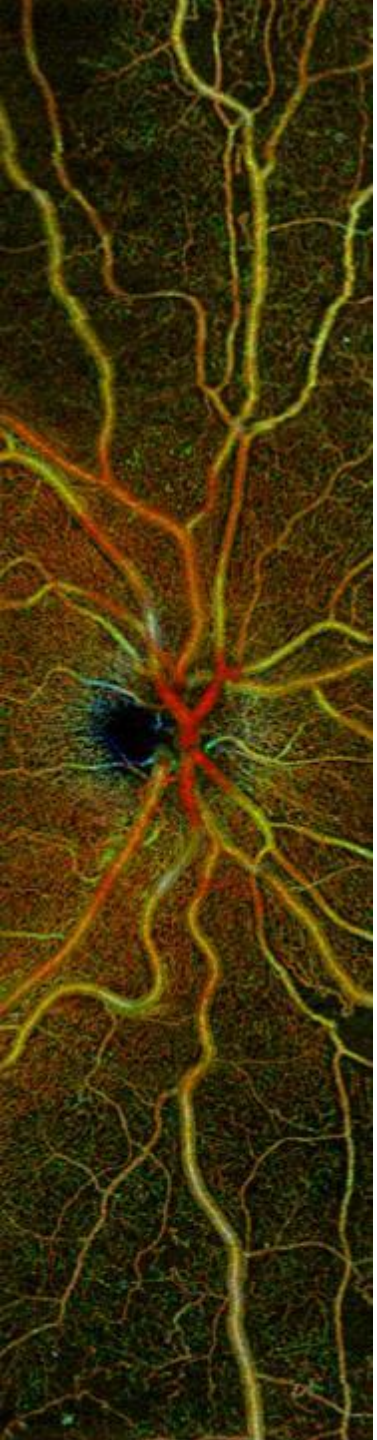
Without projection artifact removal



With projection artifact removal







QUANTITATIVE ANALYSIS

FAZ Area

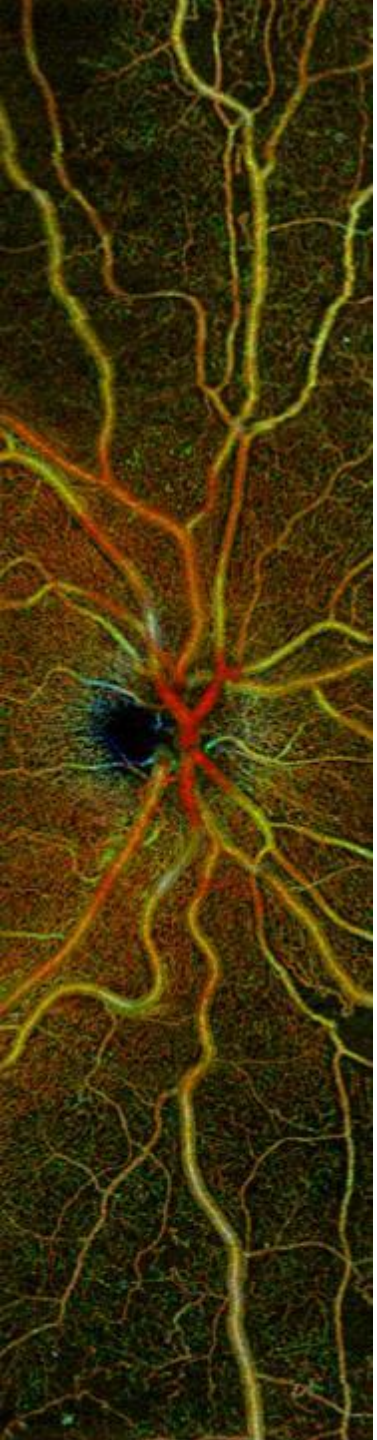
- FAZ area at the level of the superficial capillary plexus

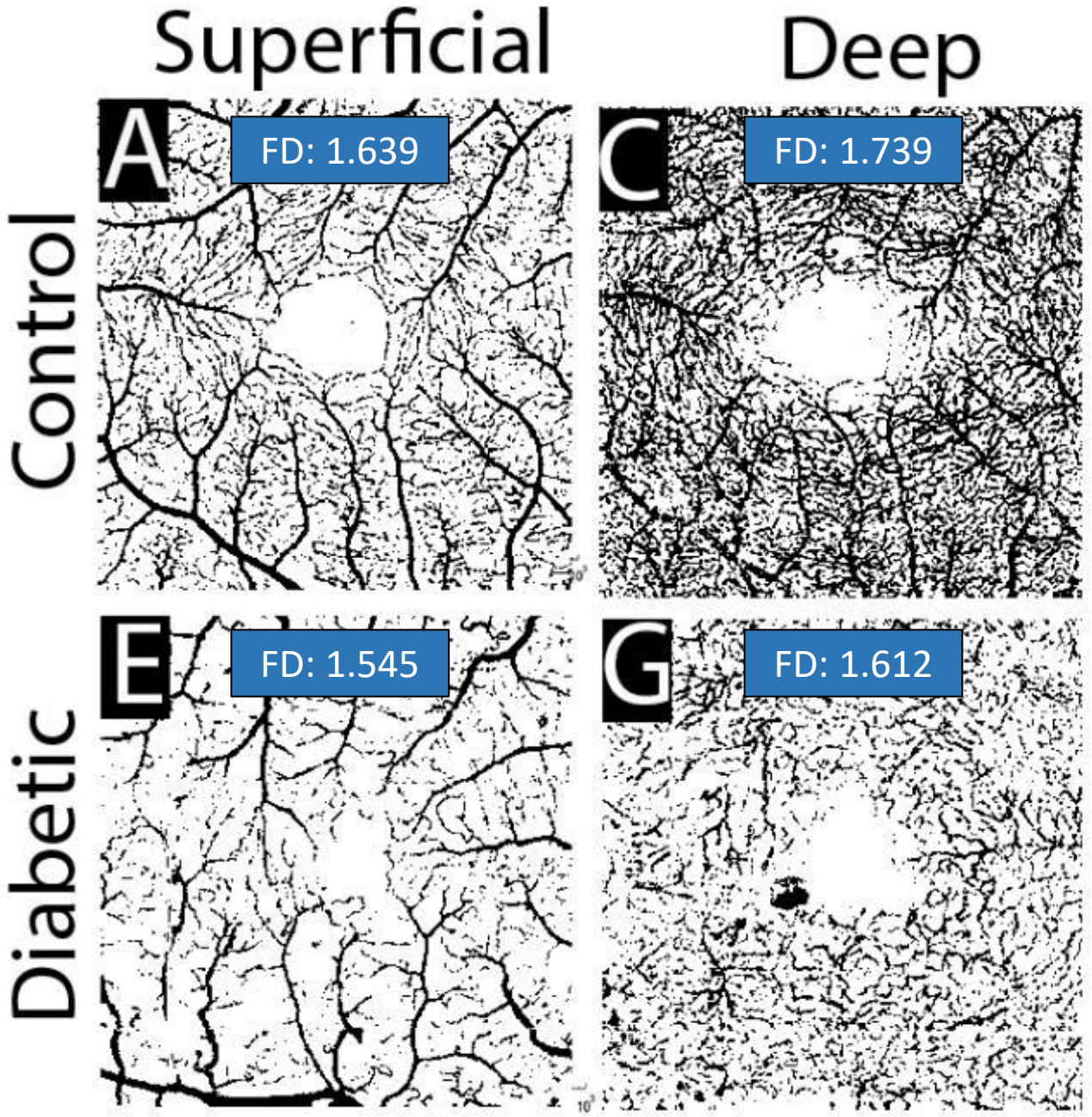
Vessel Density

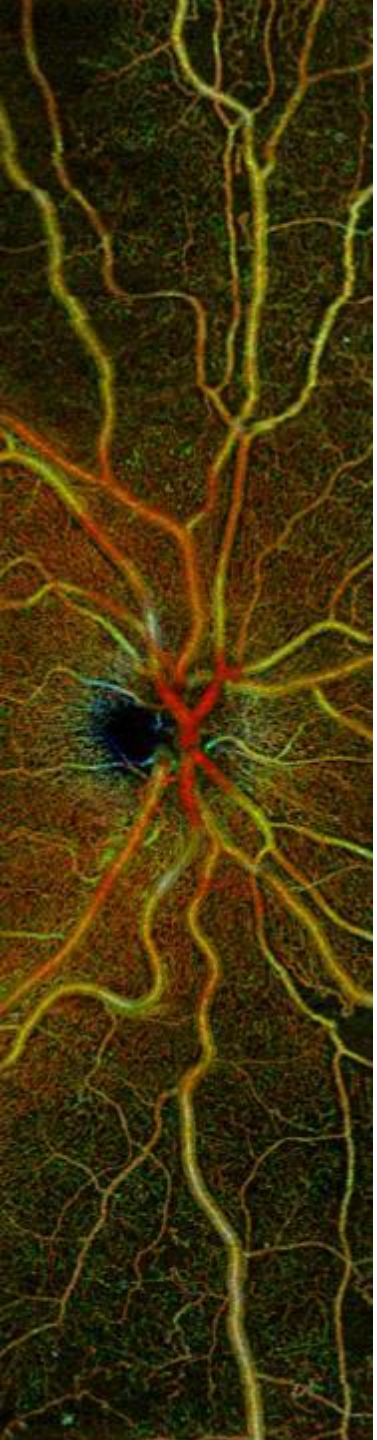
- Proportion of image area occupied by blood vessels

Fractal Dimension

- A mathematical parameter that describes the degree of complexity of the vascular pattern
- 1 = low complexity; 2 = high complexity



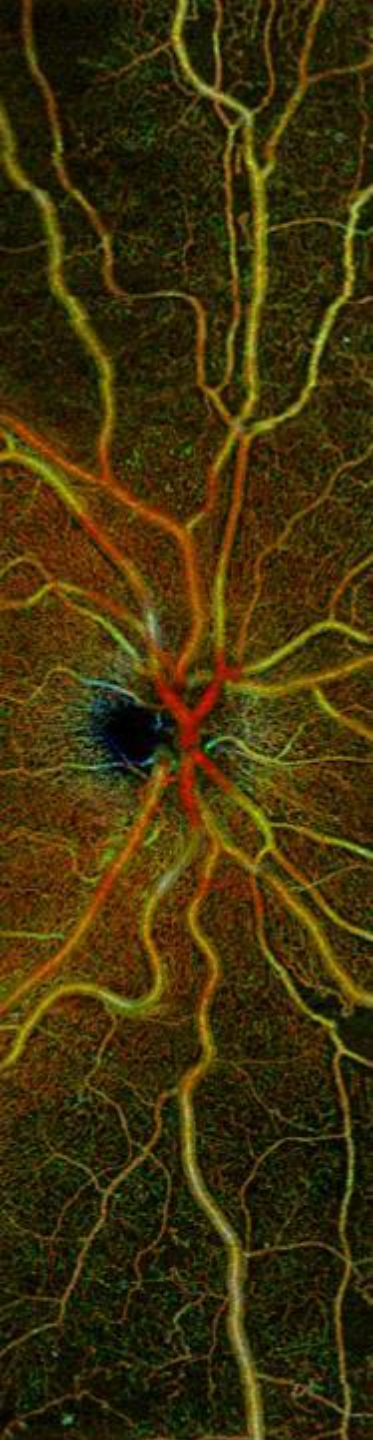

Superficial
Deep
Control
Diabetic
A
FD: 1.639
C
FD: 1.739
E
FD: 1.545
G
FD: 1.612



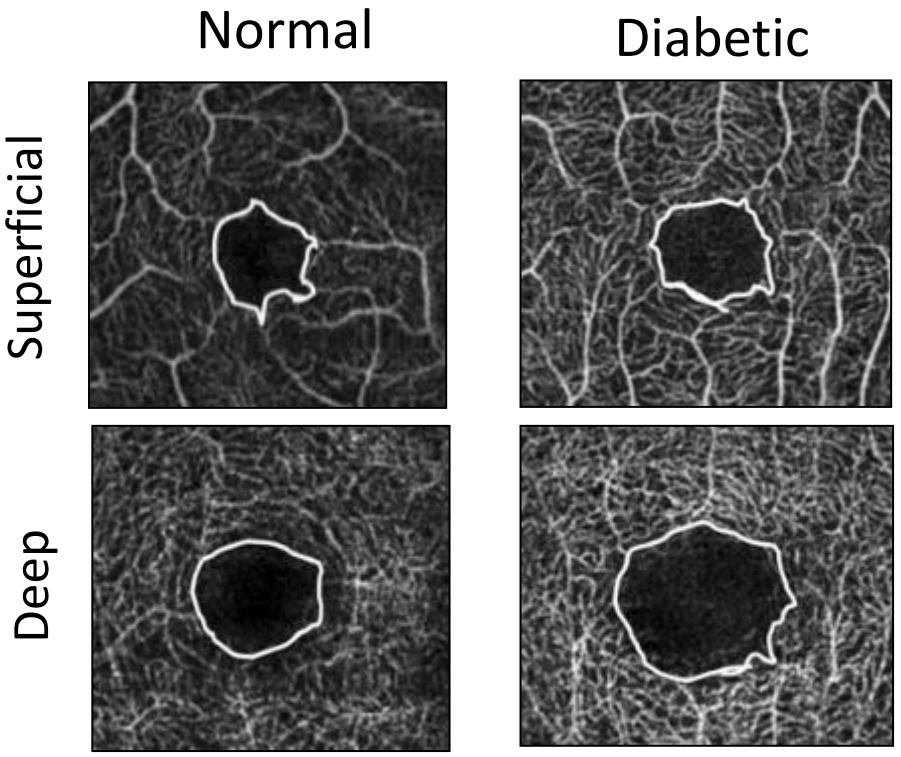
DIABETIC RETINOPATHY

OCTA Clinical Applications

- Early diabetic retinopathy detection
- Identify vascular abnormalities (IRMA)
- Identify non-perfusion
- Evaluation of FAZ
- Visualize the deep capillary plexus
- Differentiate IRMA from early NVE
- Localization of microaneurysms
- Follow response to treatment



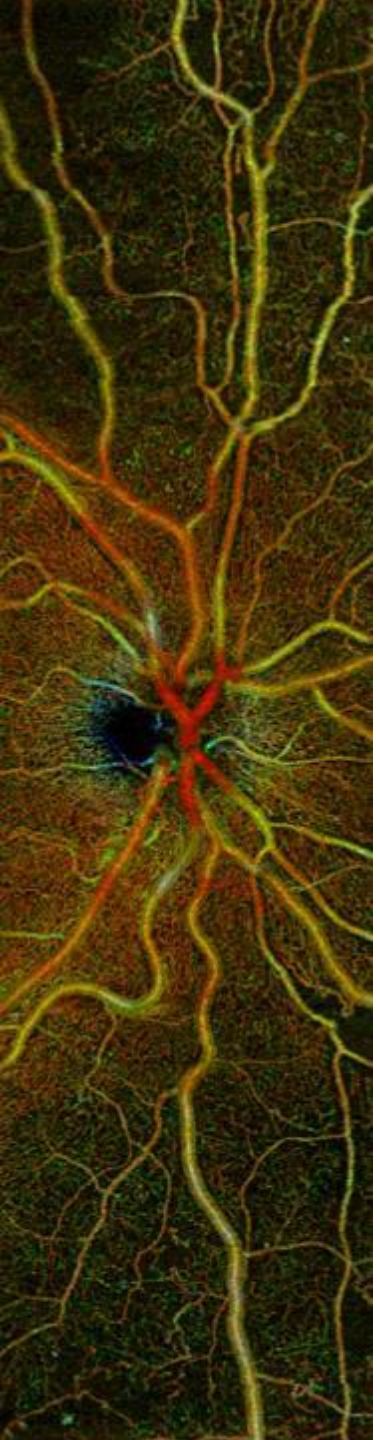
DIABETIC RETINOPATHY



	Control	Diabetics Without DR	Diabetic Retinopathy
Mean FAZ area in the superficial plexus (mm2)	0.25	0.37 (p<0.01*)	0.38 (p<0.01*)
Mean FAZ area in the deep plexus (mm2)	0.38	0.54 (p<0.01*)	0.56 (p<0.01*)

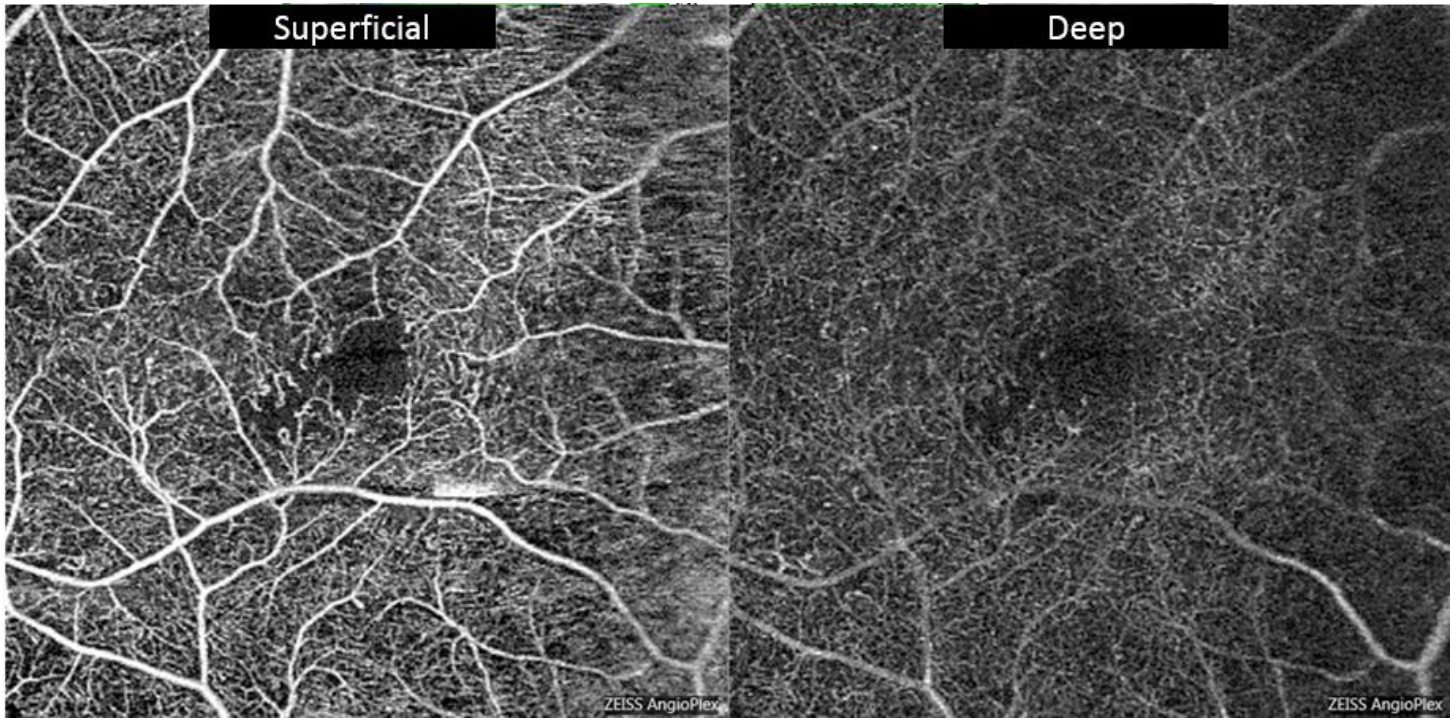
*compared to controls (no sig diff between diabetic grps)

Takase N, et al. Enlargement of FAZ in Diabetic eyes evaluated by En Face OCTA. Retina 2015. 35(11):2377-2383.



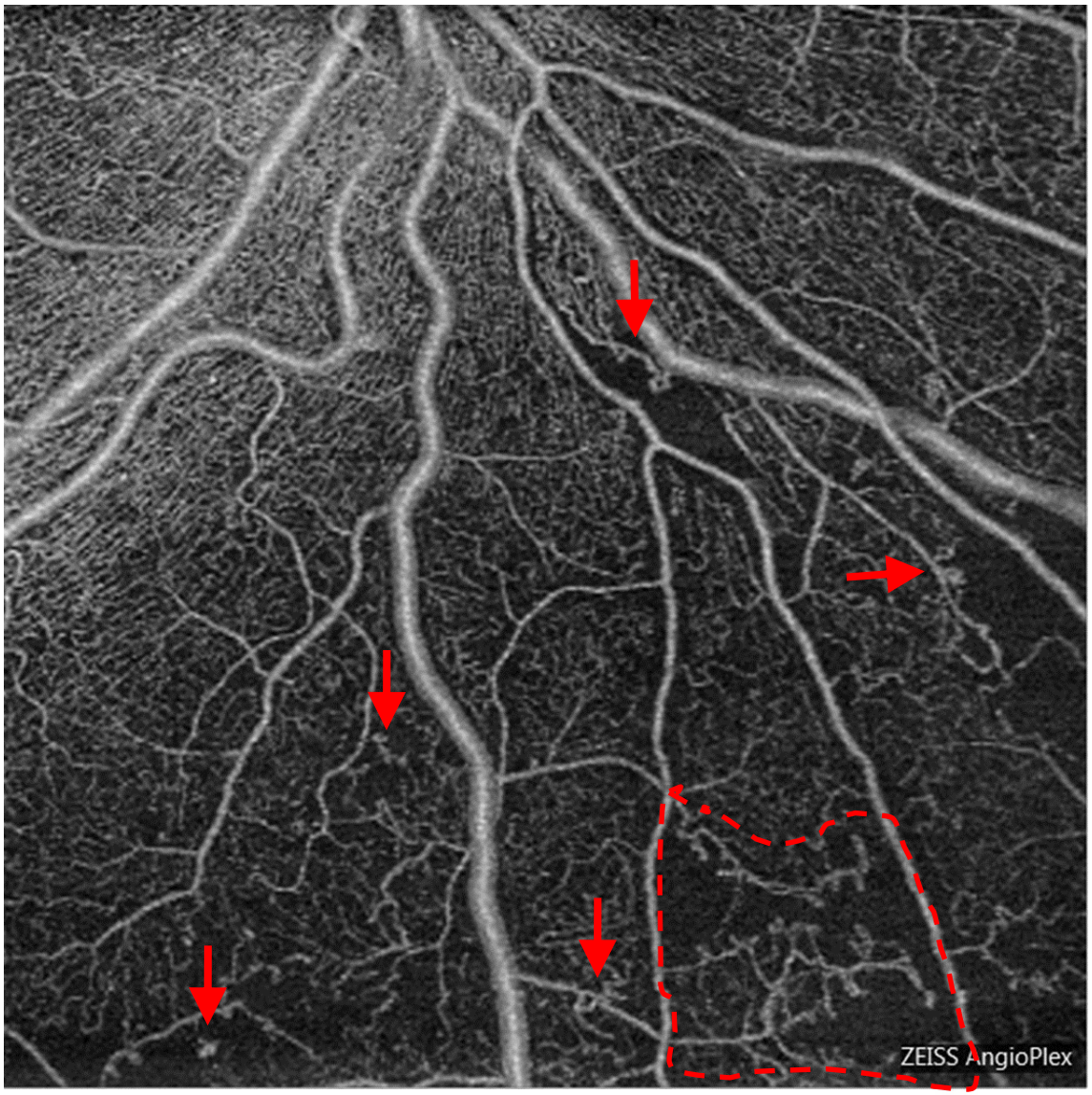
DIABETIC RETINOPATHY

Mild NPDR with reduction in BCVA



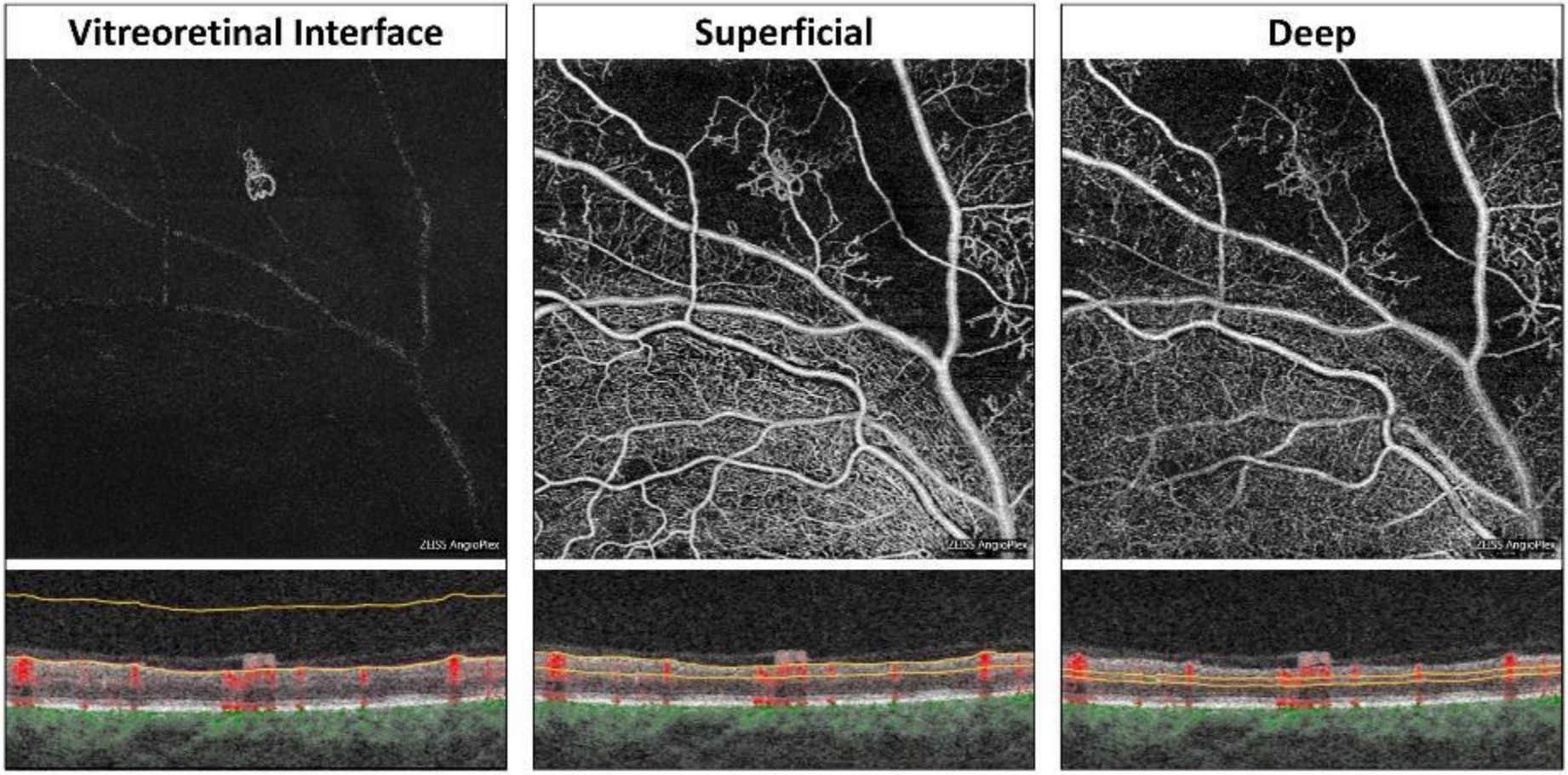
DIABETIC RETINOPATHY

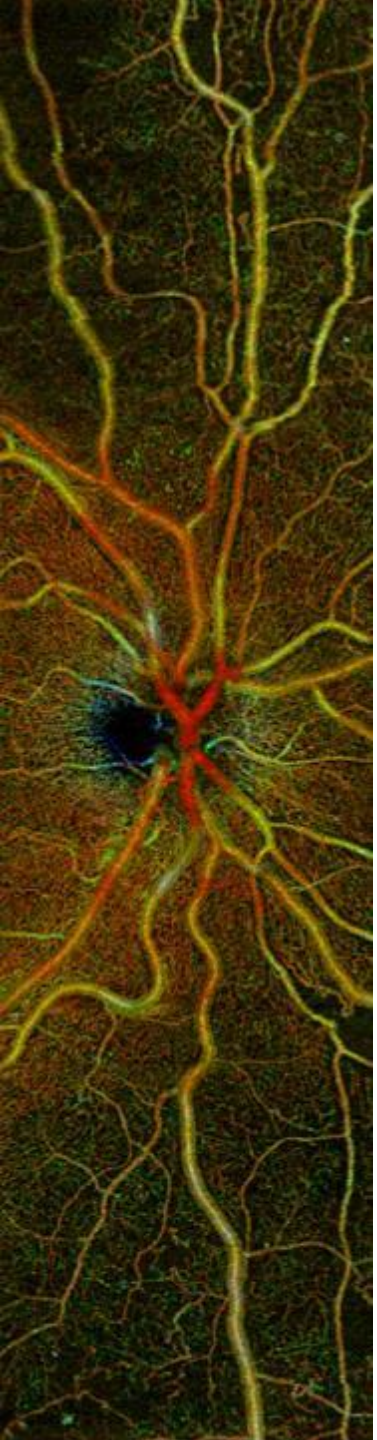
Intraretinal microvascular abnormalities (IRMA)



DIABETIC RETINOPATHY

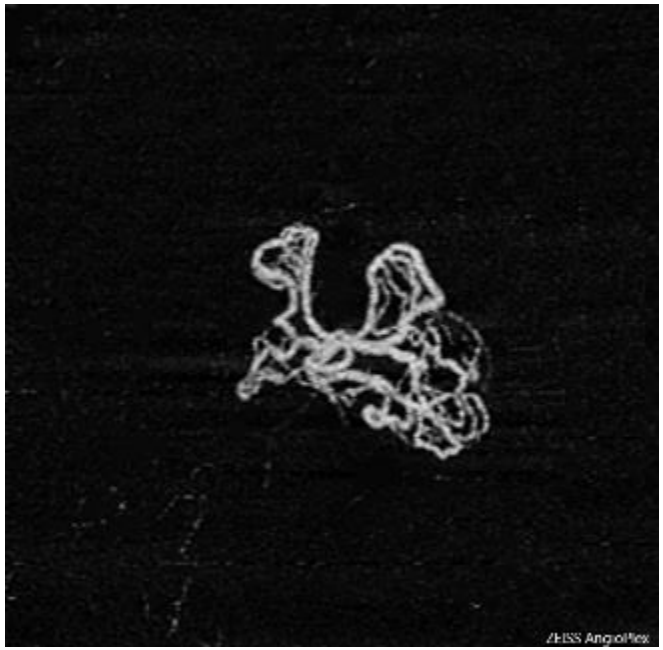
IRMA or early NVE???

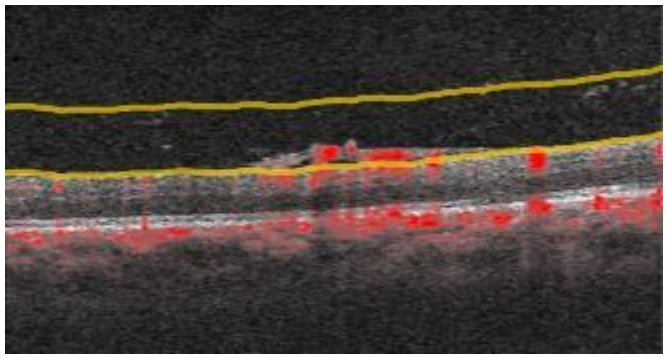




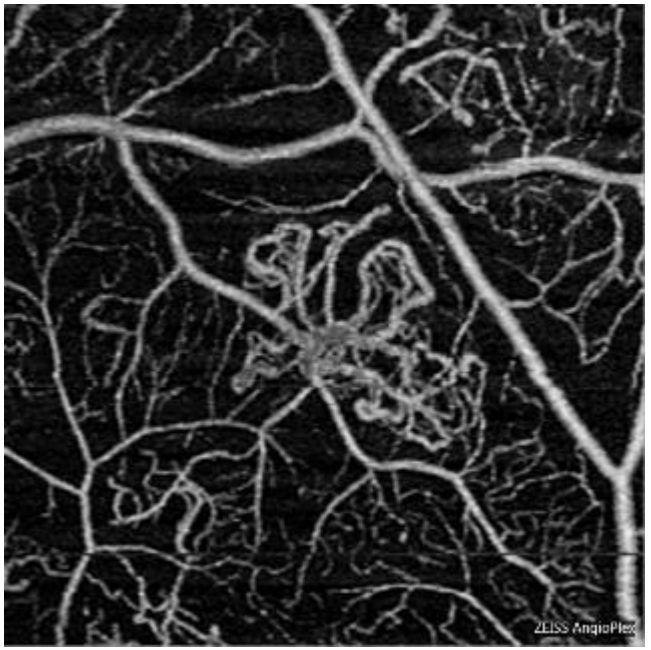
DIABETIC RETINOPATHY

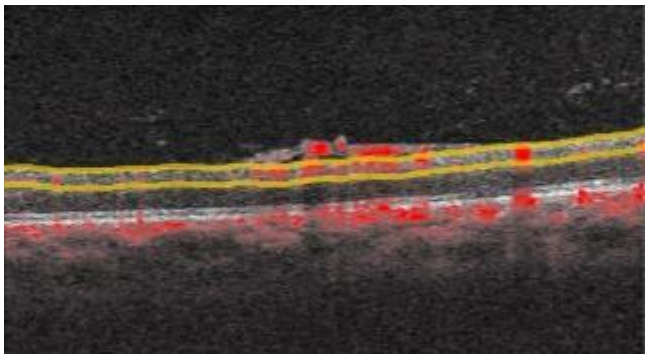
VRI

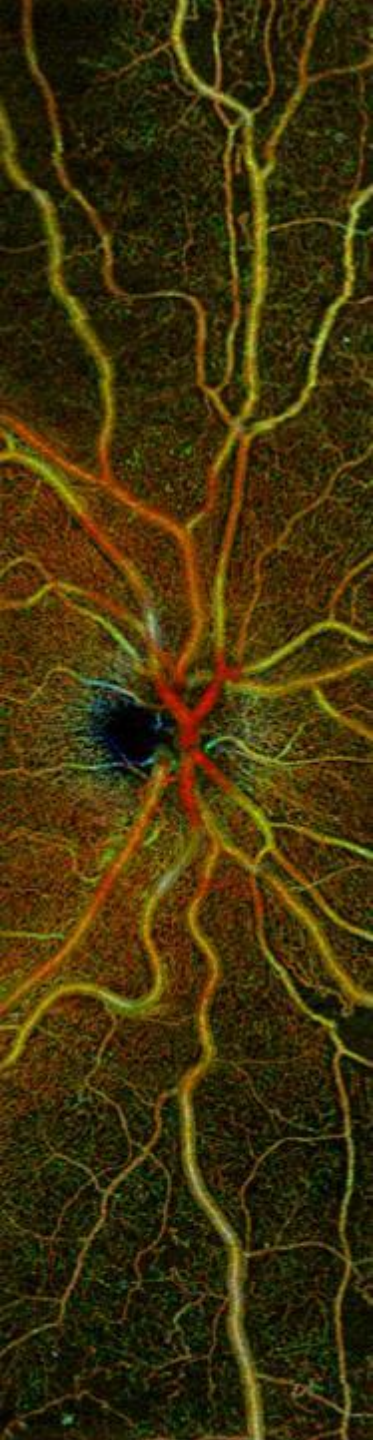




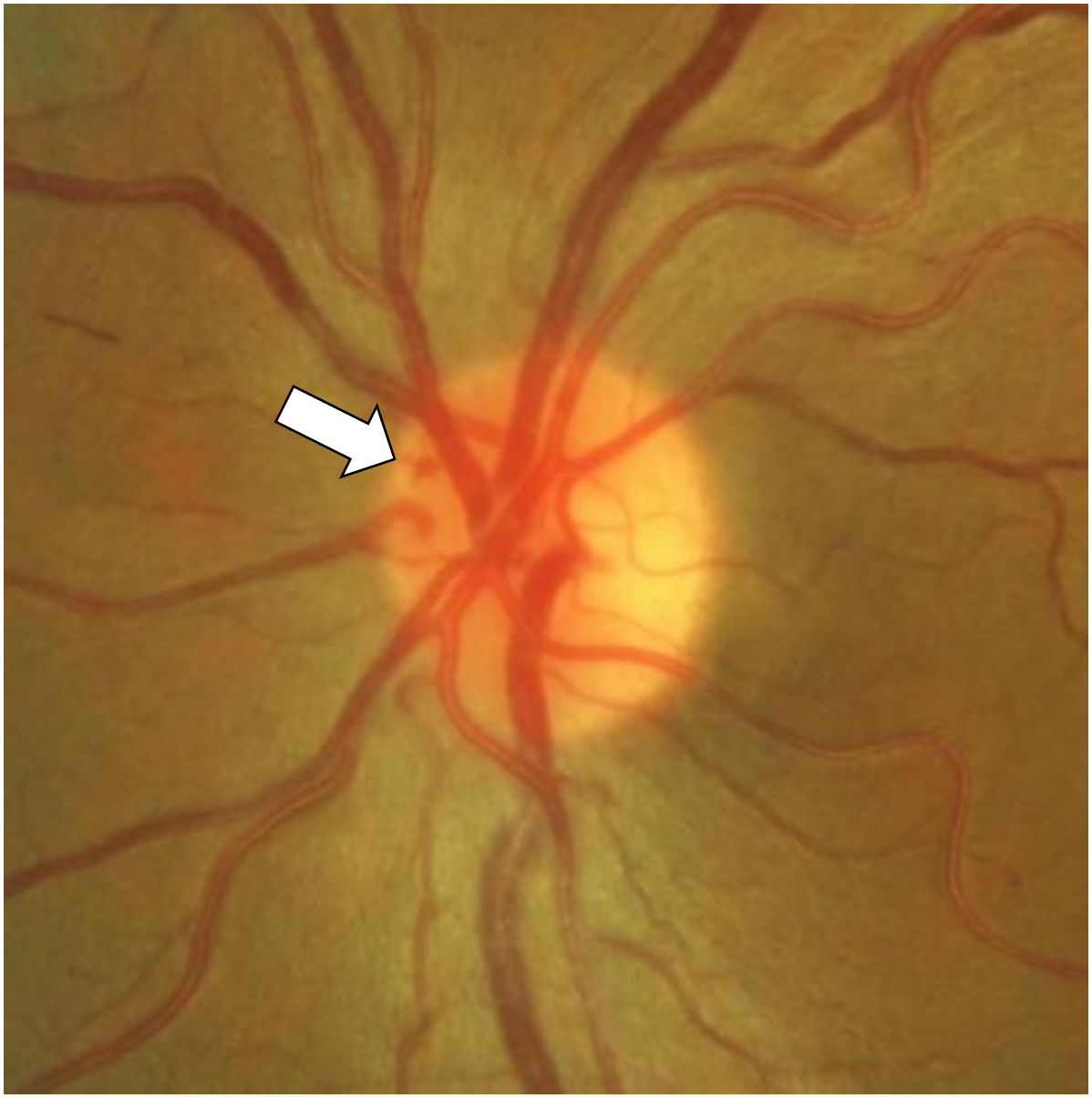
Superficial

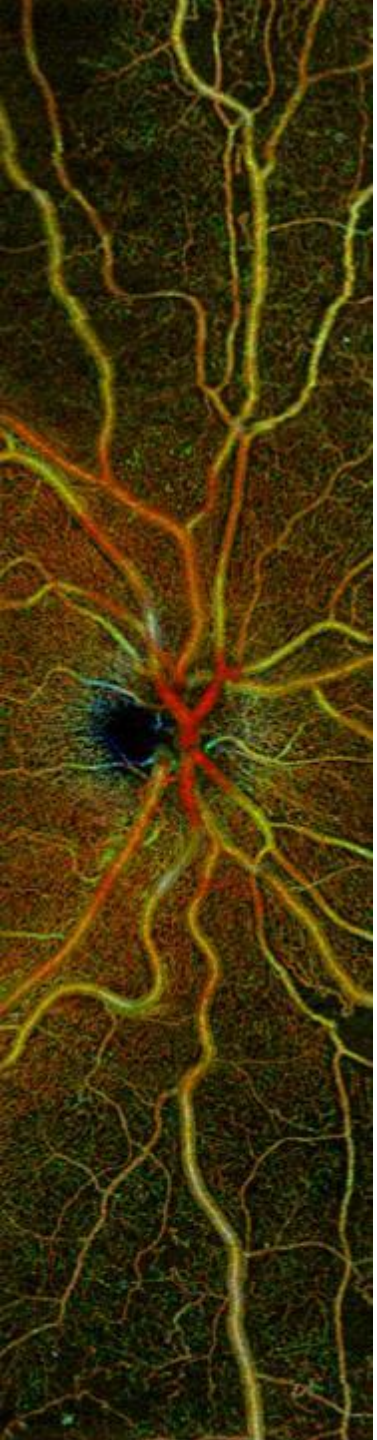






DIABETIC RETINOPATHY

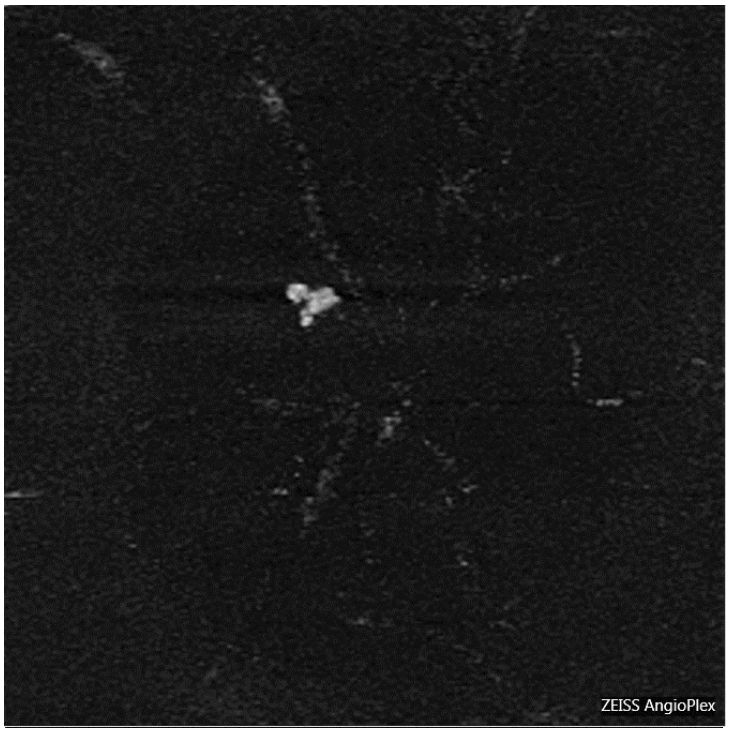


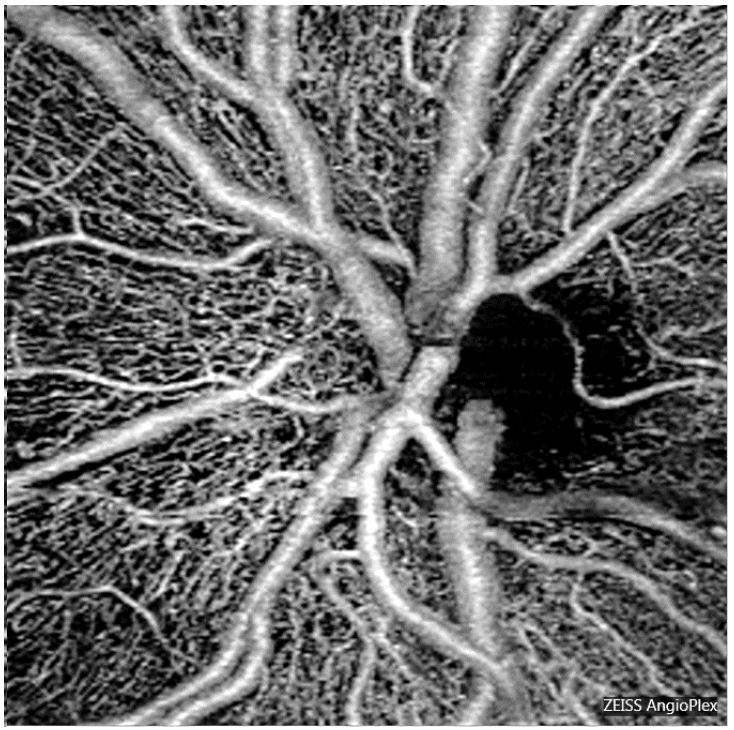


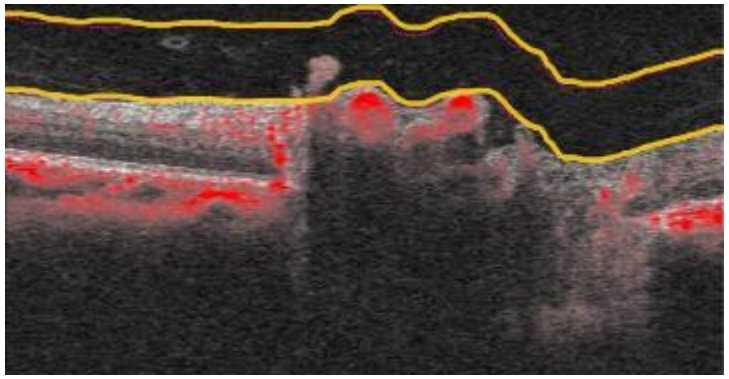
DIABETIC RETINOPATHY

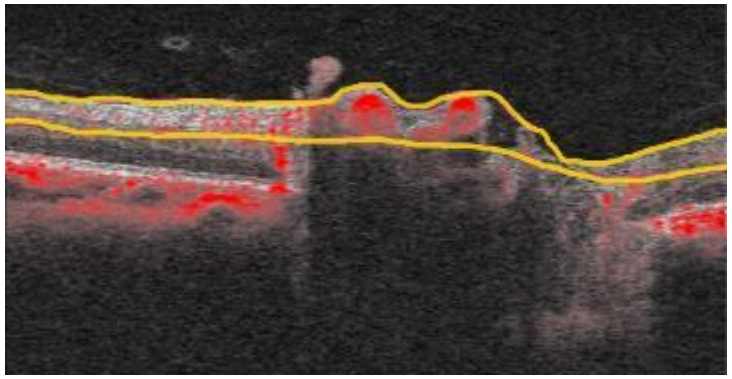
VRI

Superficial









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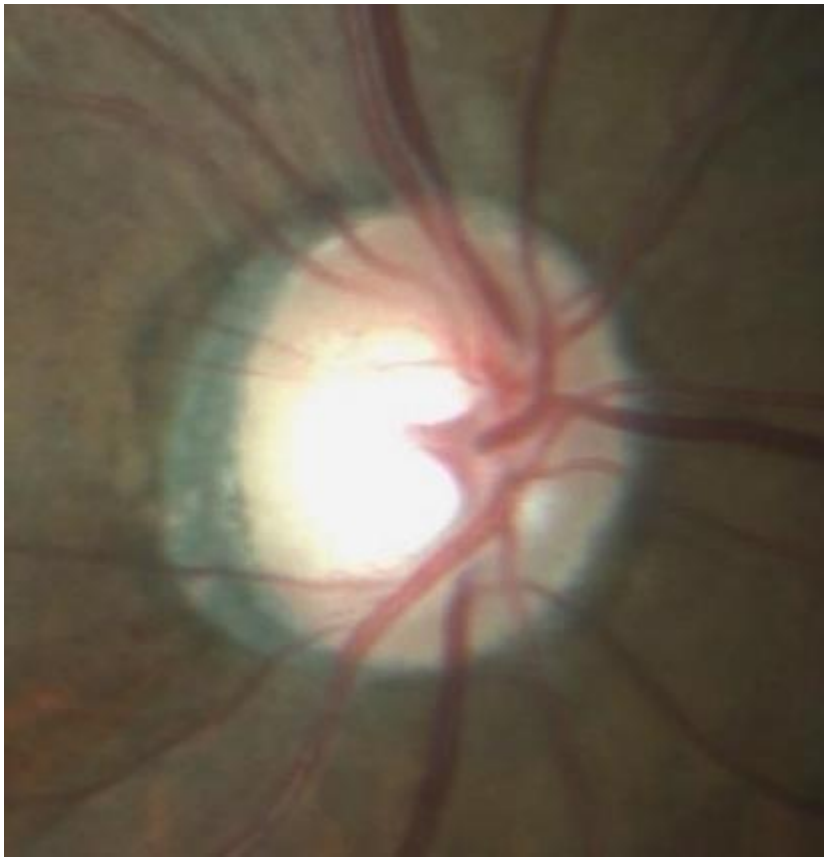
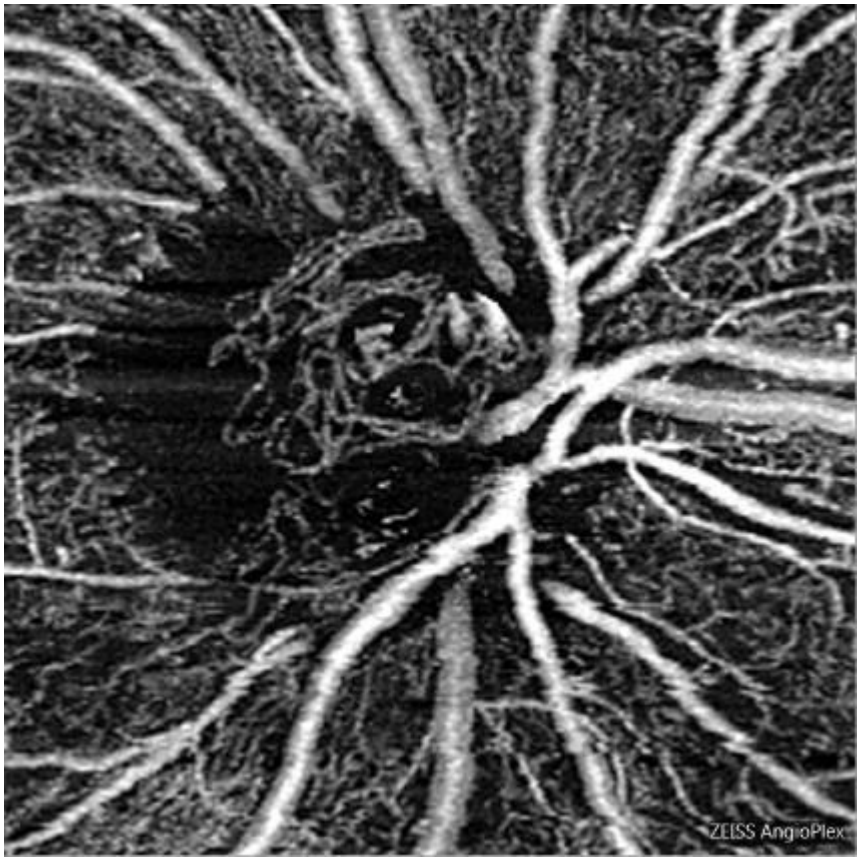
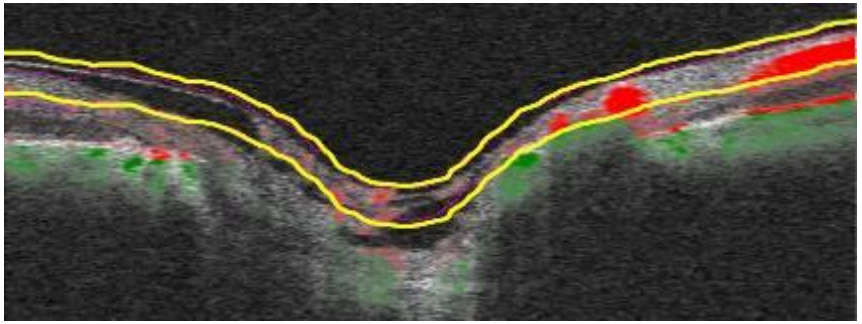
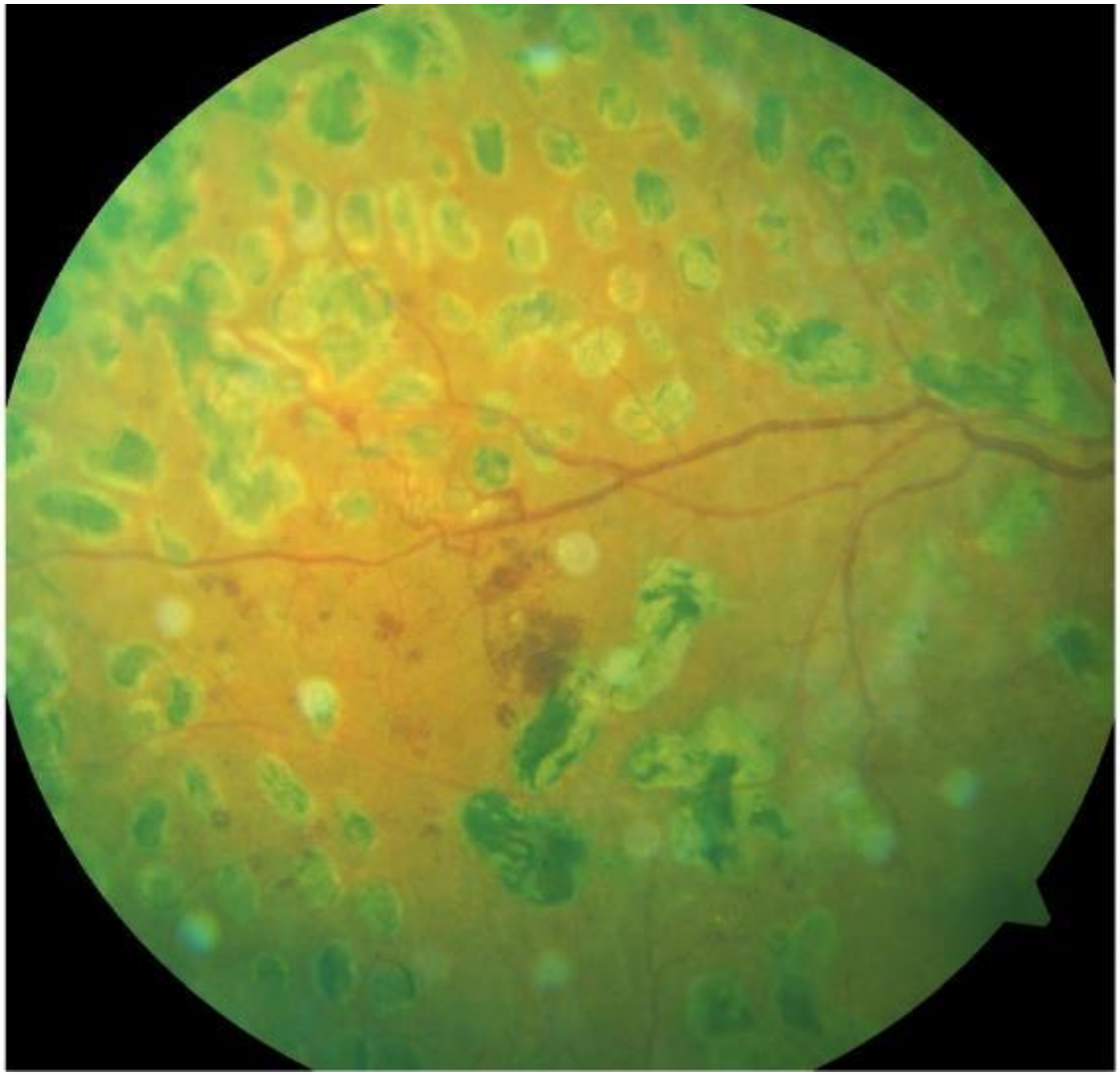
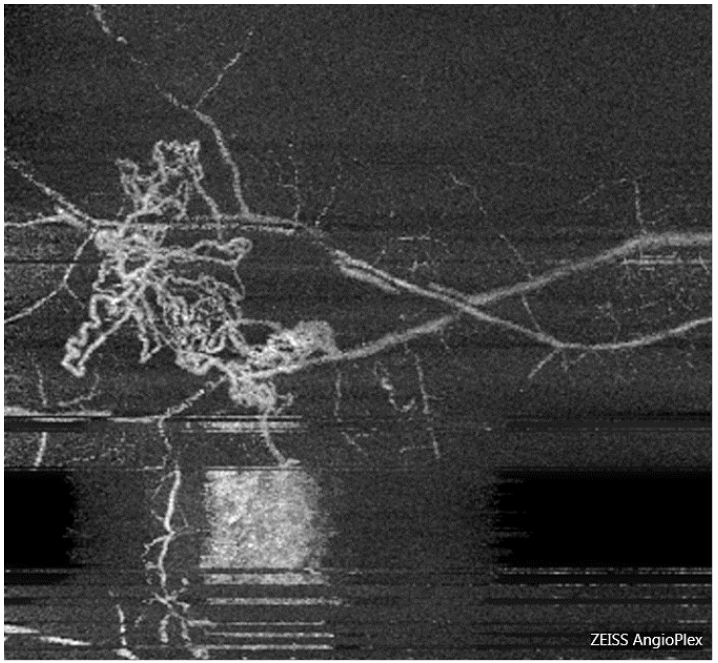


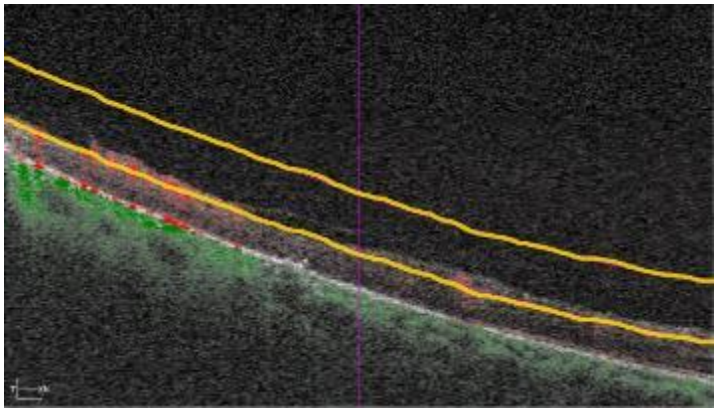


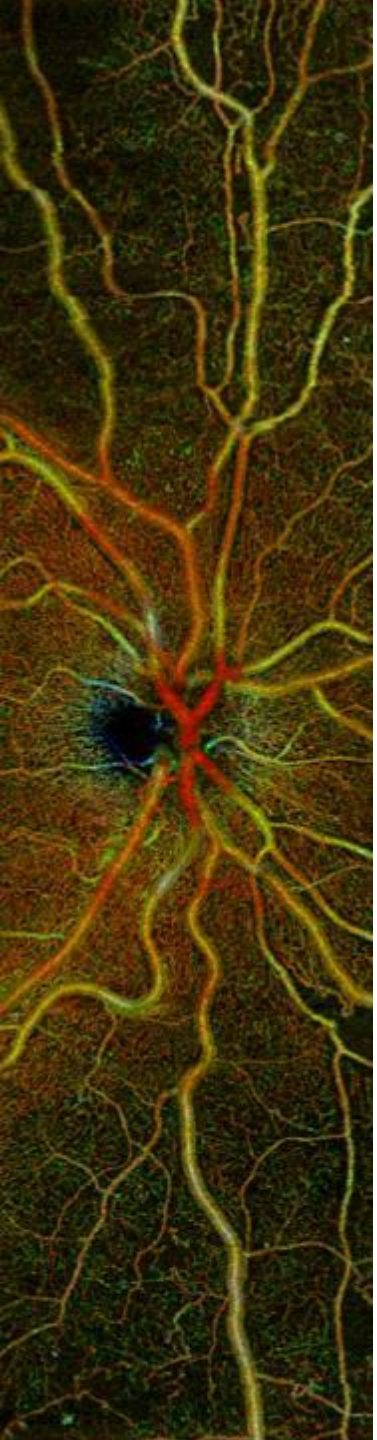


DIABETIC RETINOPATHY





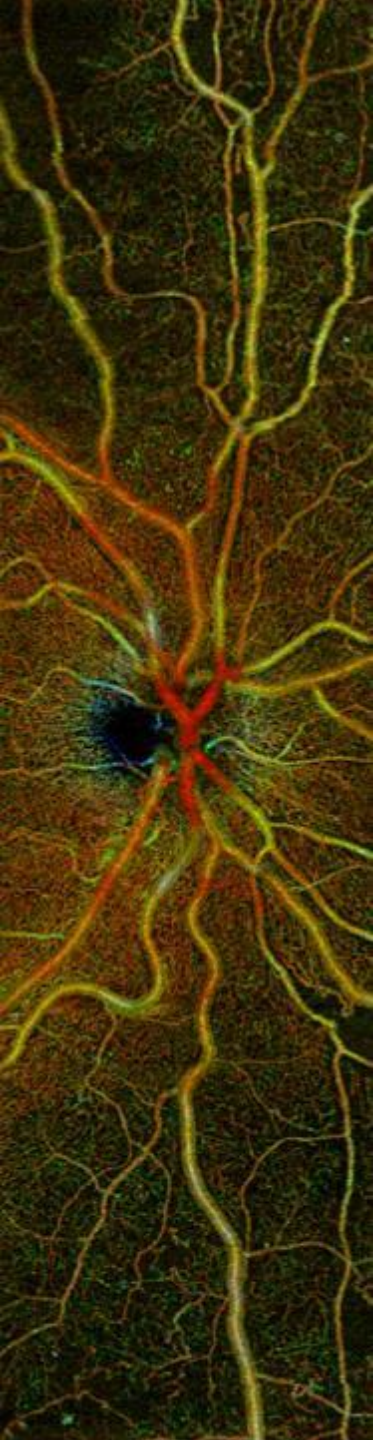




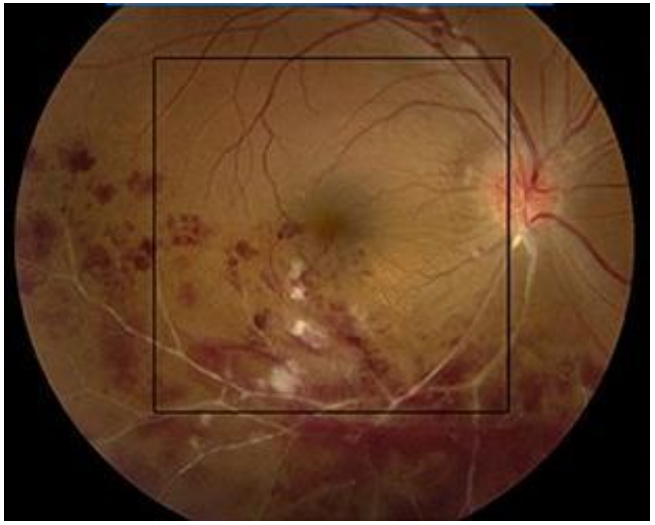
VENOUS OCCLUSION

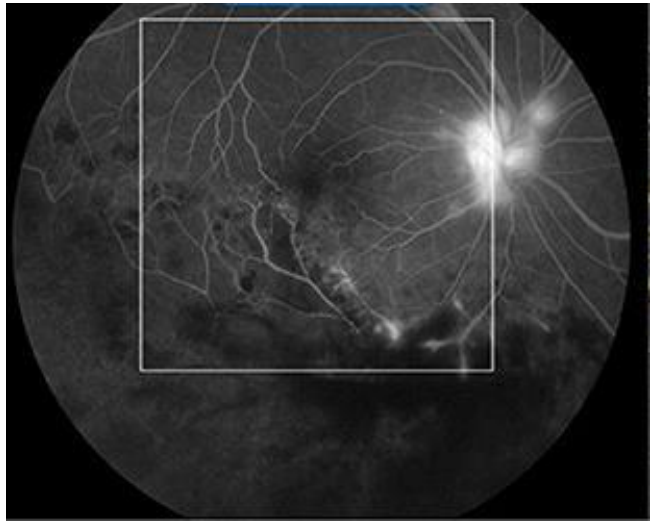
OCTA Clinical Applications

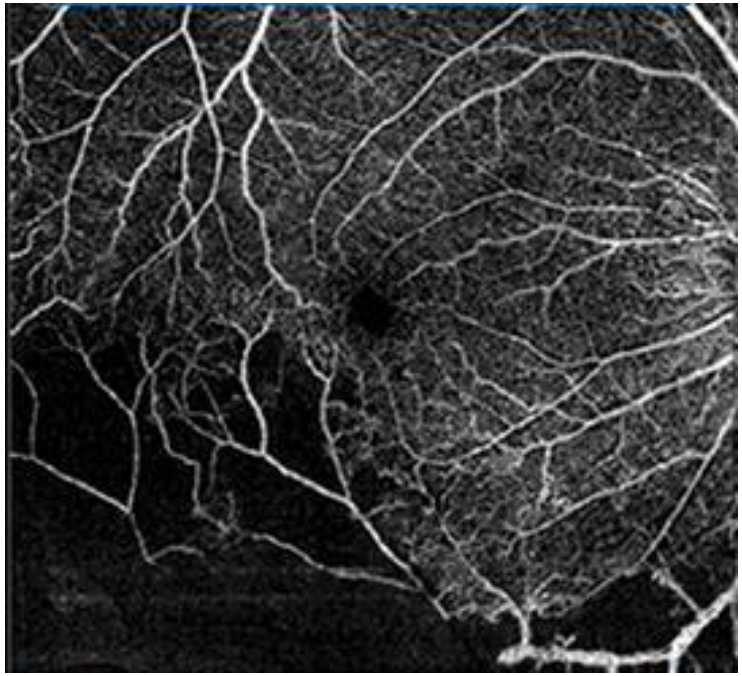
- Quantify non-perfusion
  - Ischemic vs non-ischemic?
  - BRVO: Risk of post segment neo
  - CRVO: Risk of ant segment neo and NVG
- Visualization of macular ischemia
- Earlier detection of posterior segment neo

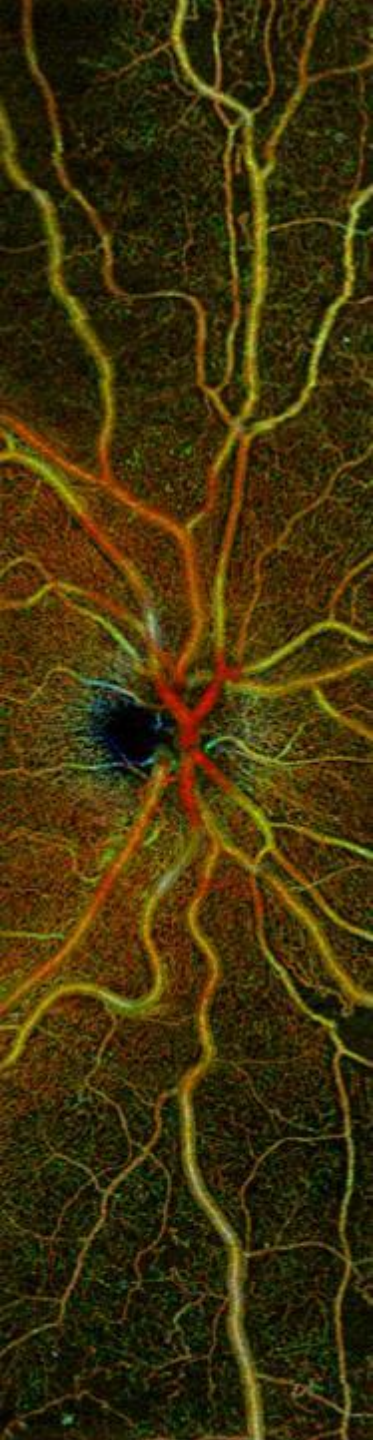


BRVO - Ischemic

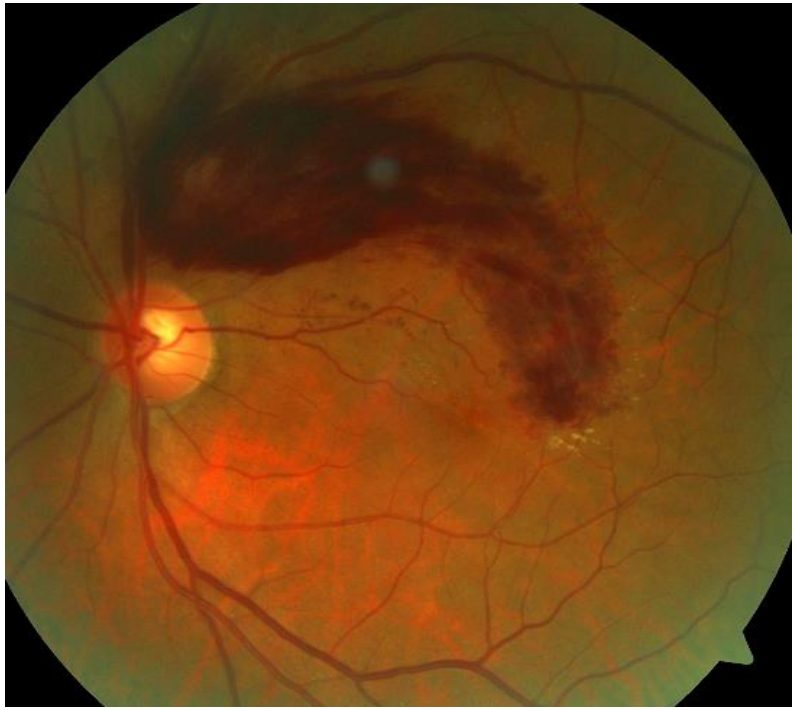




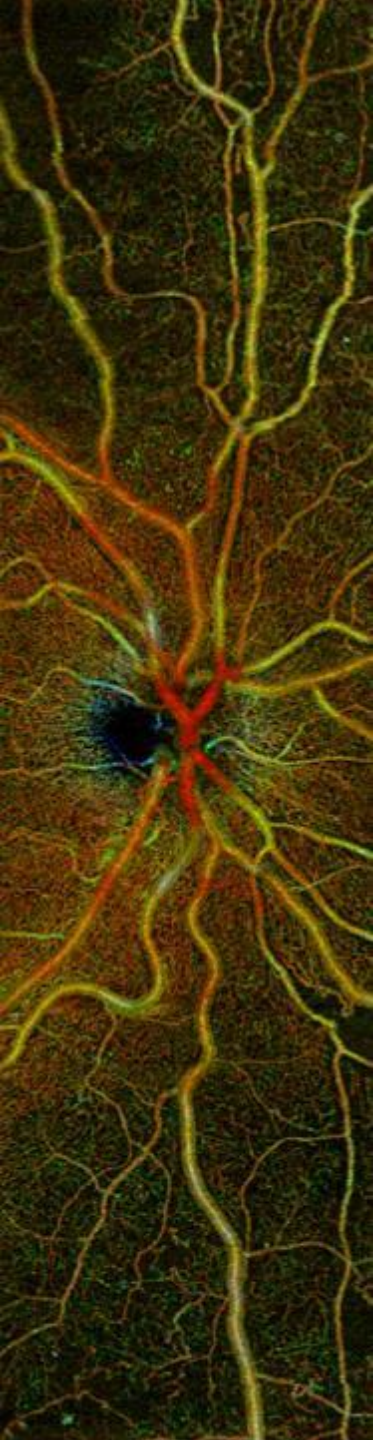


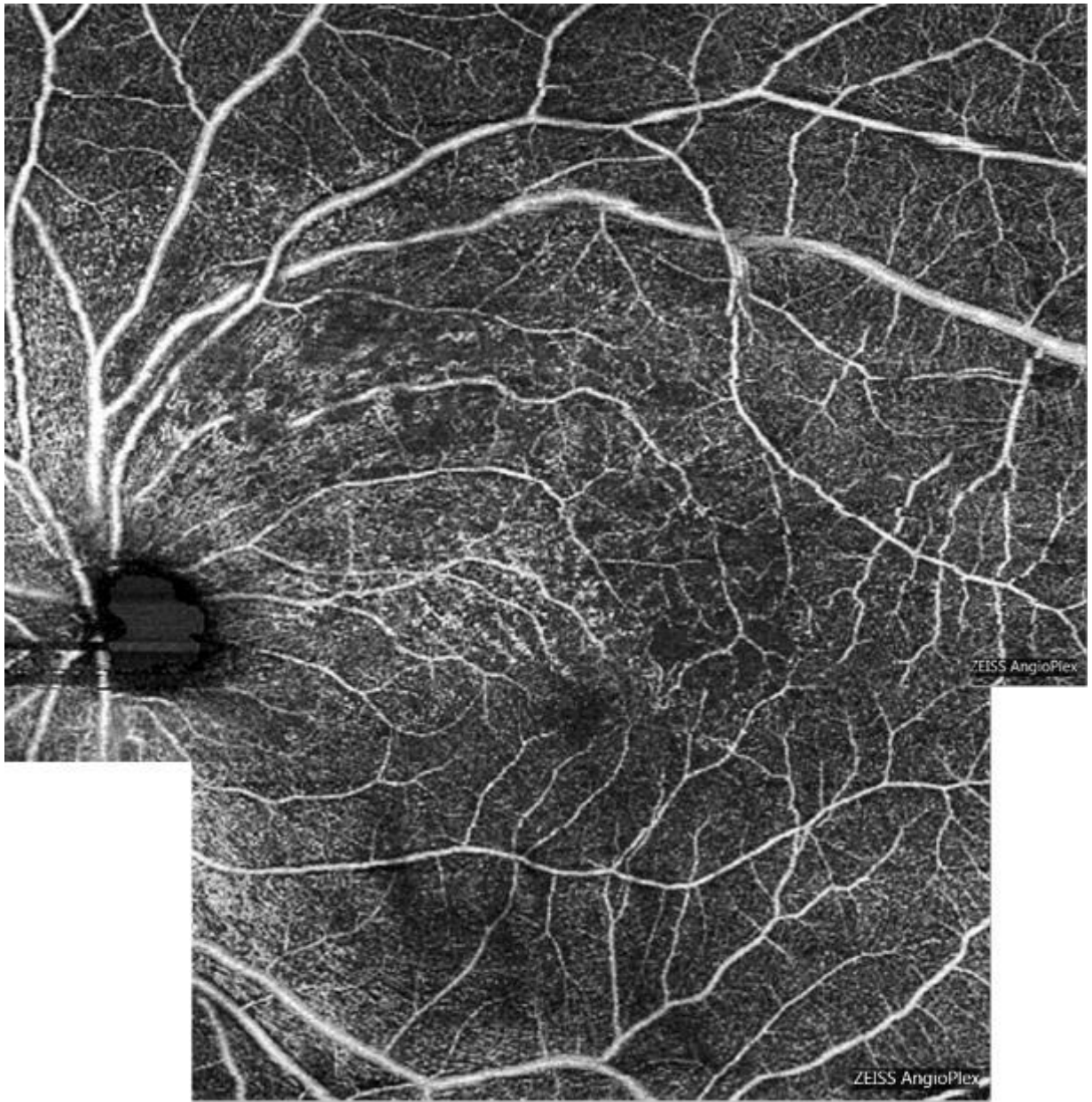


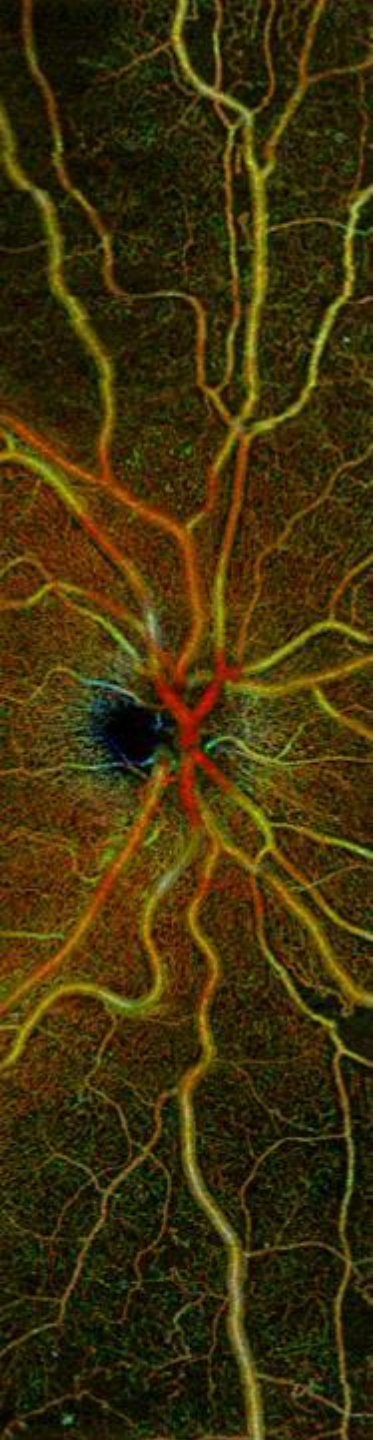
BRVO – Nonischemic



BRVO – Nonischemic







Retinal Vein Occlusion

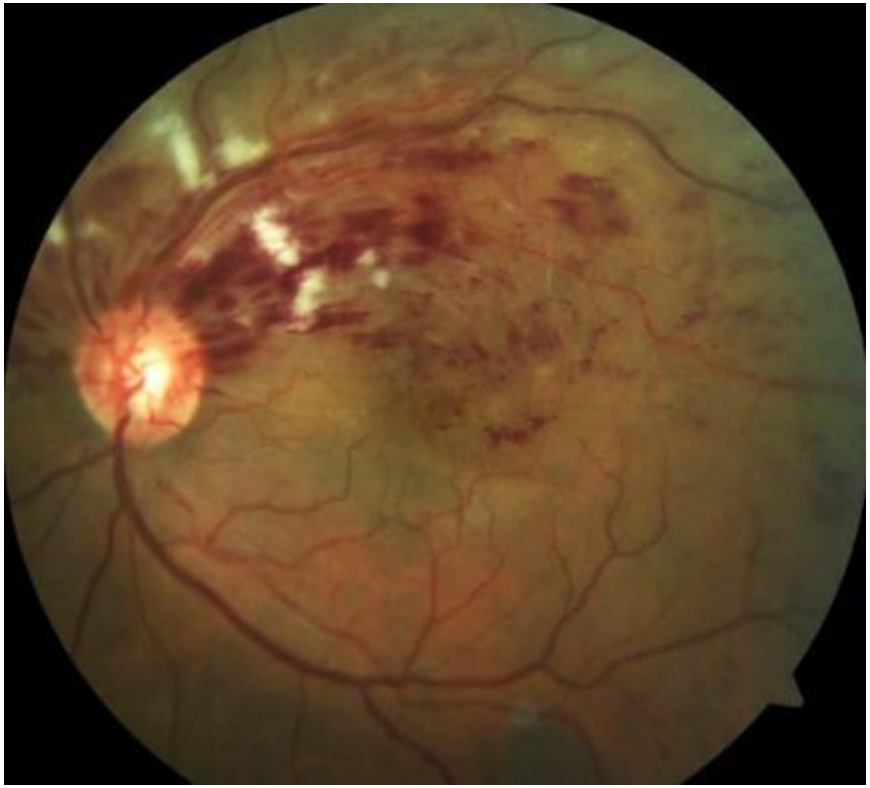
CASE REPORT

52yo HM

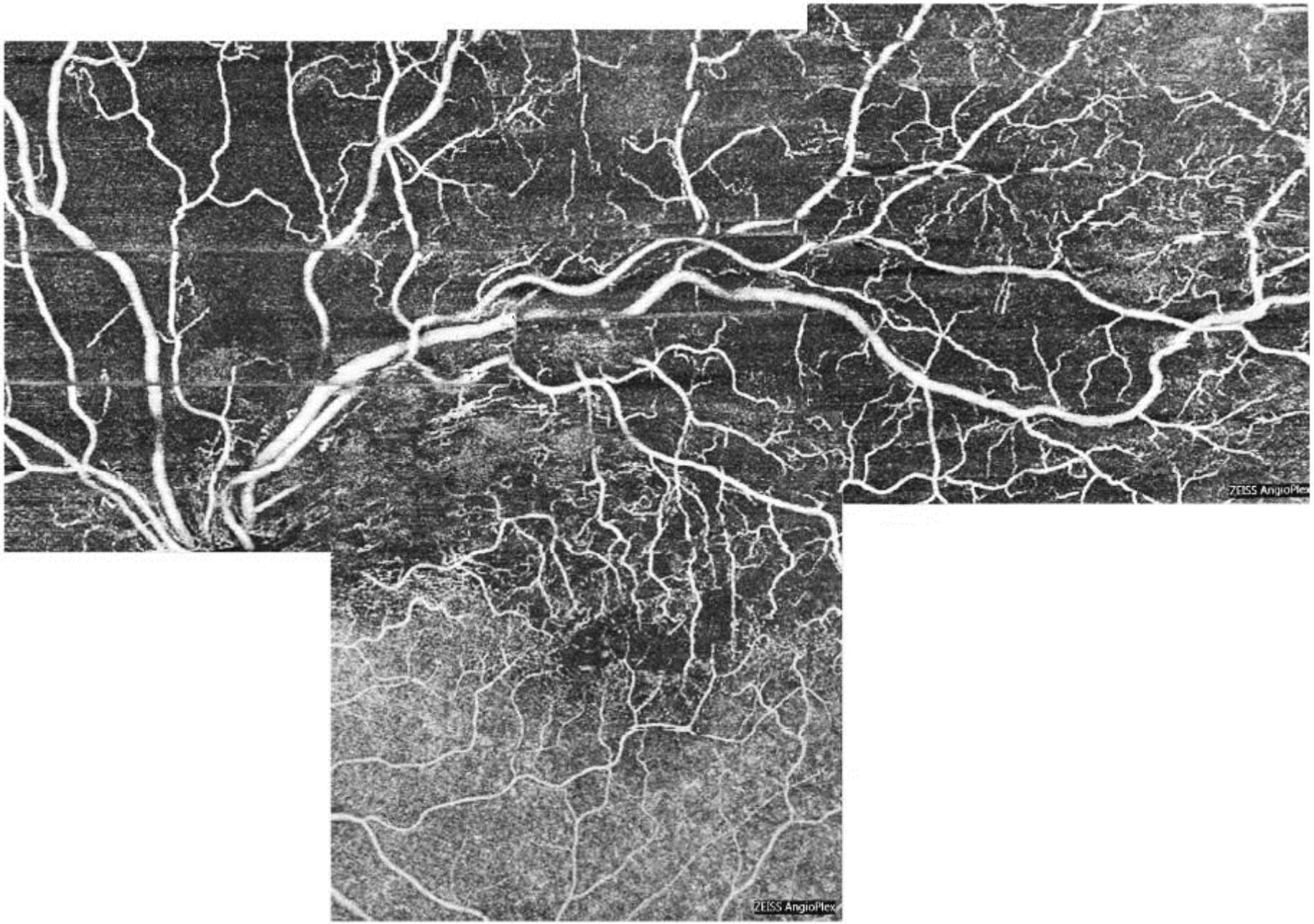
- Referred to our retinal service for evaluation of RVO OS
- Pt c/o blur OS x 5 days – getting worse

- BCVA: 20/25 OD, 20/200 OS
- Ta 19/14
- SLE: WNL OU, No NVI

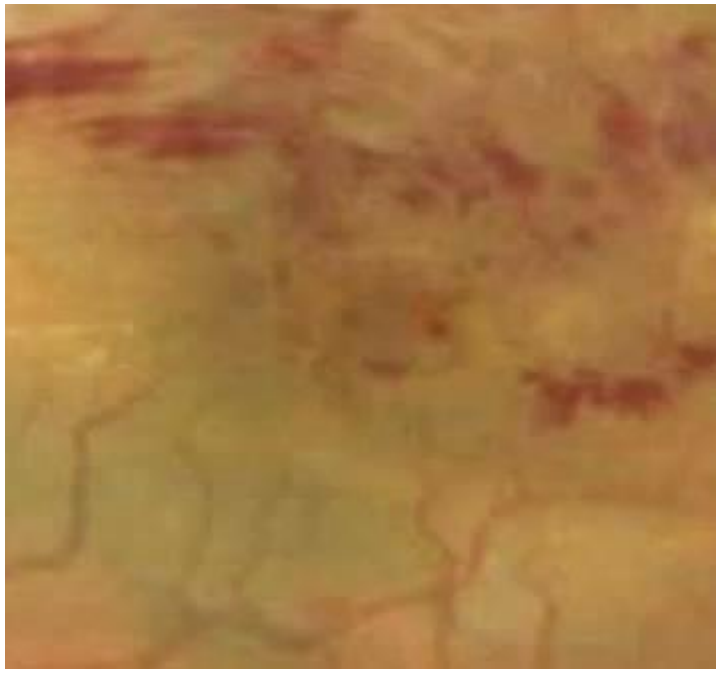
Hemicentral Vein Occlusion

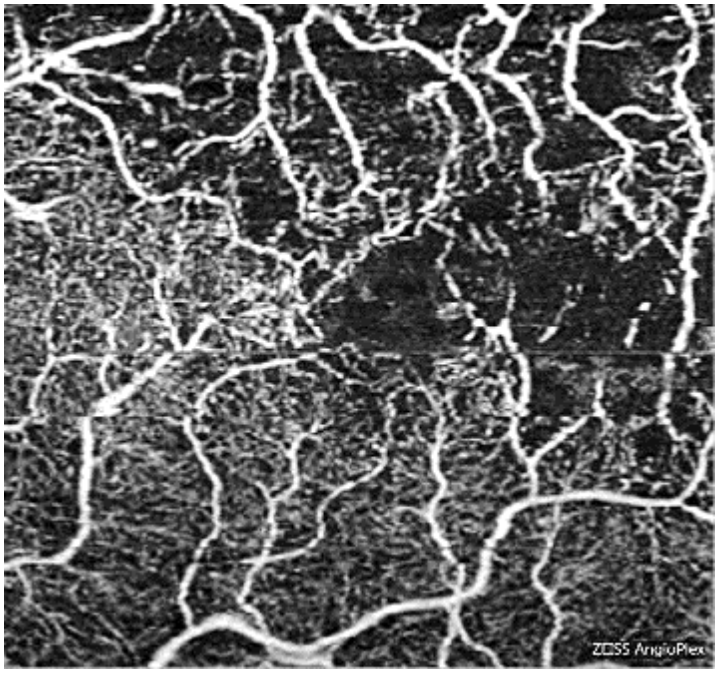


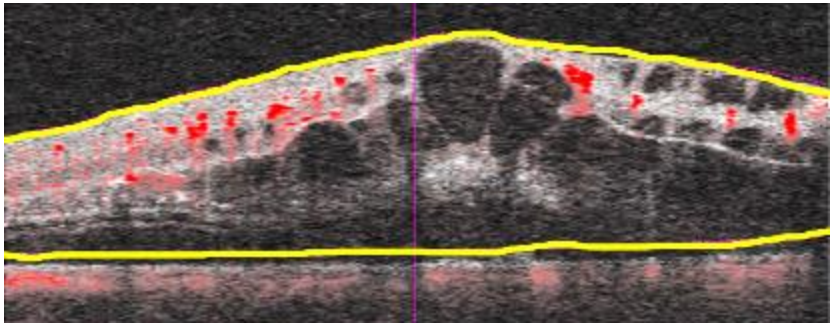
Hemicentral Vein Occlusion



Hemicentral Vein Occlusion

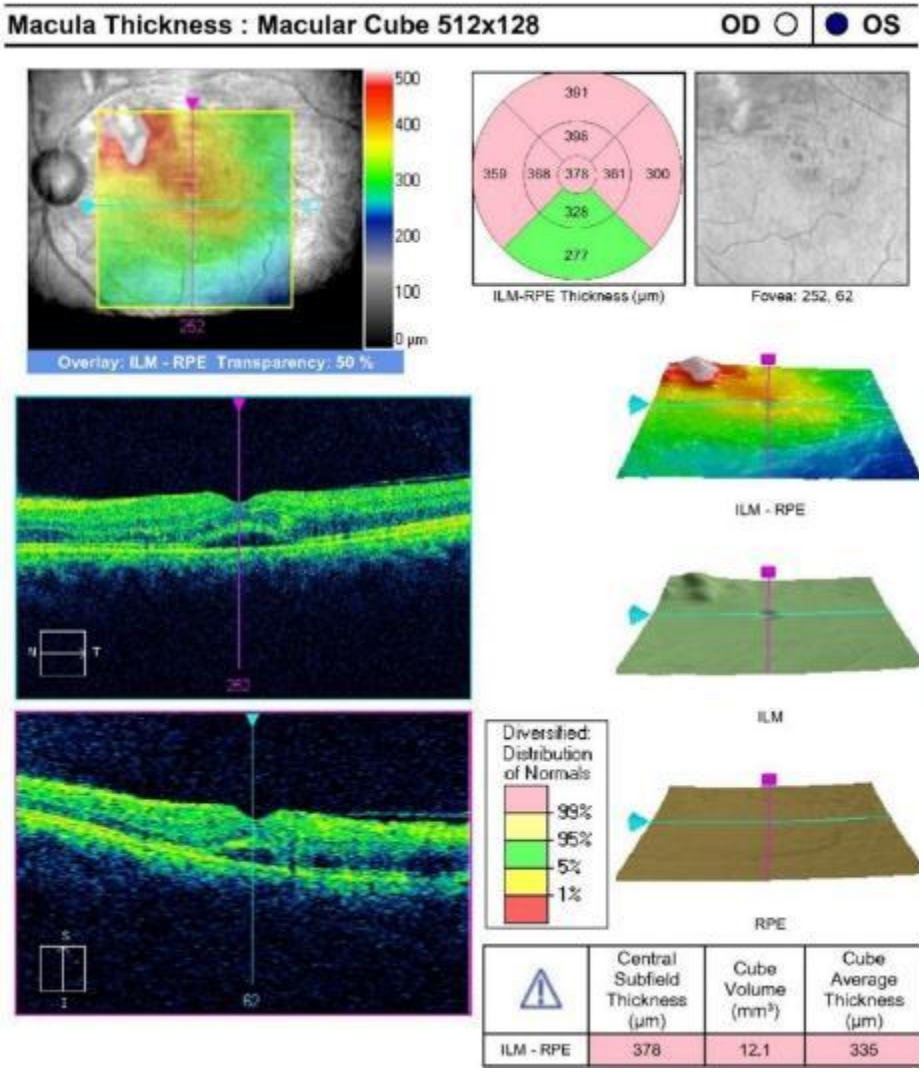




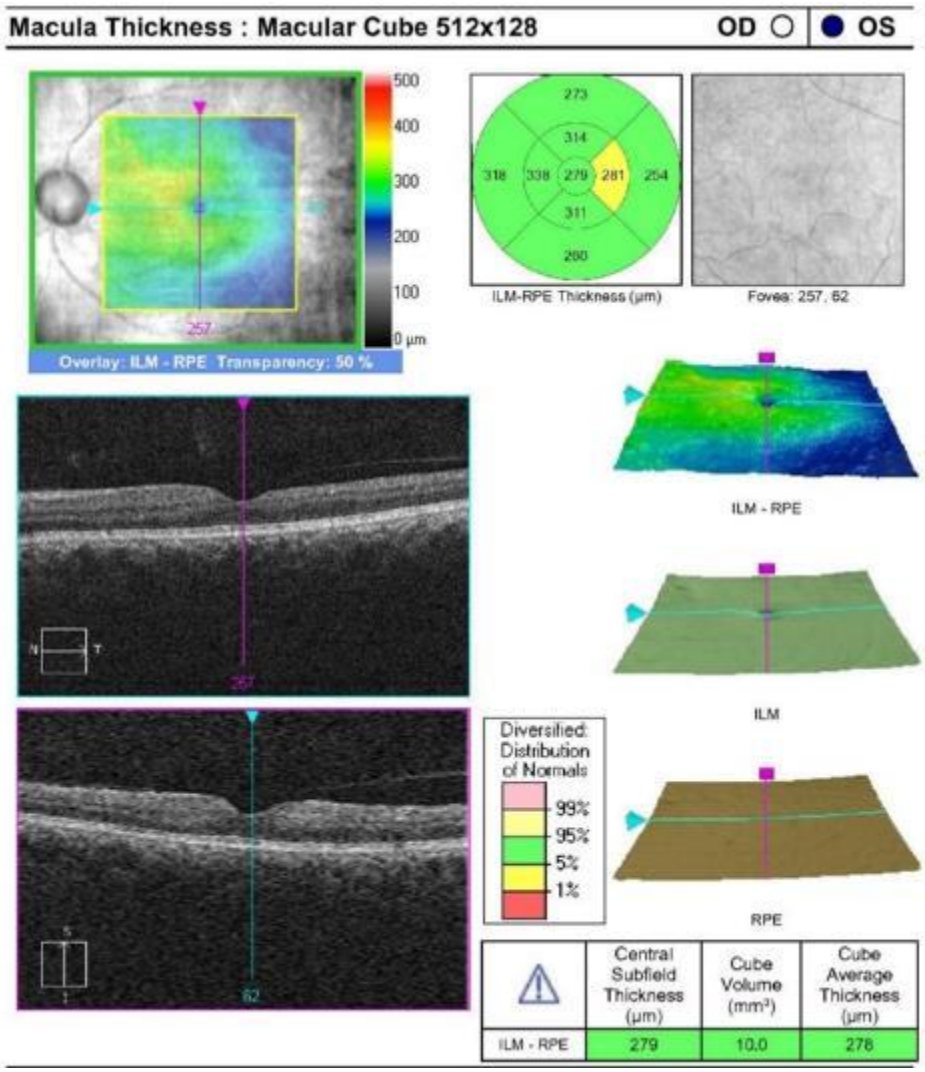


Hemicentral Vein Occlusion

S/P IVB x 1

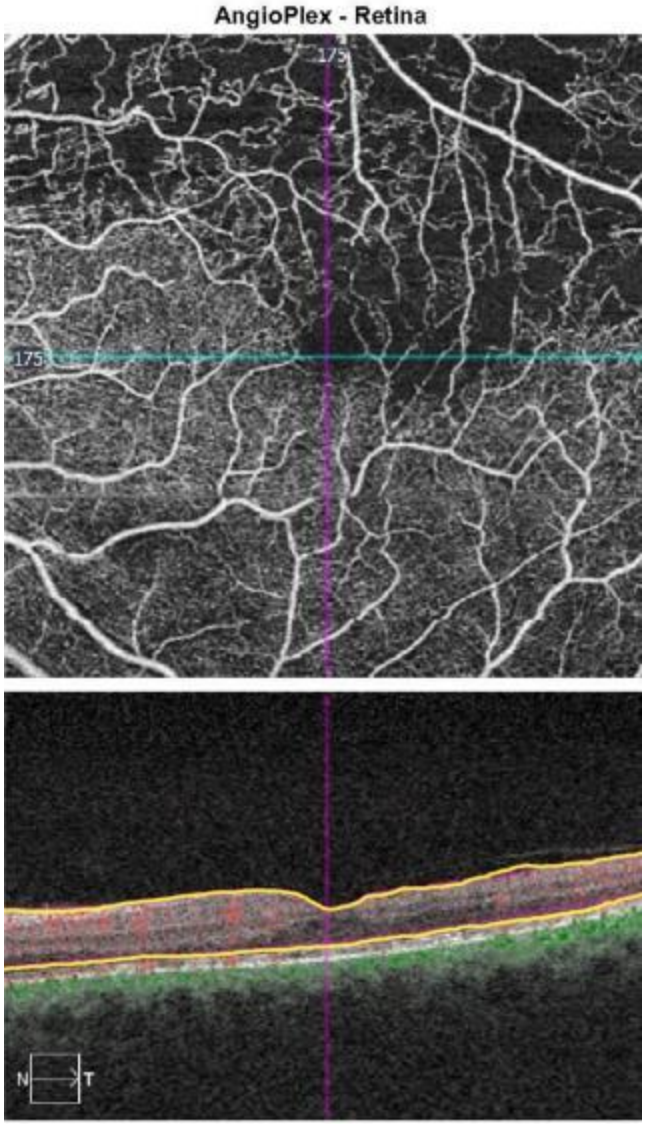


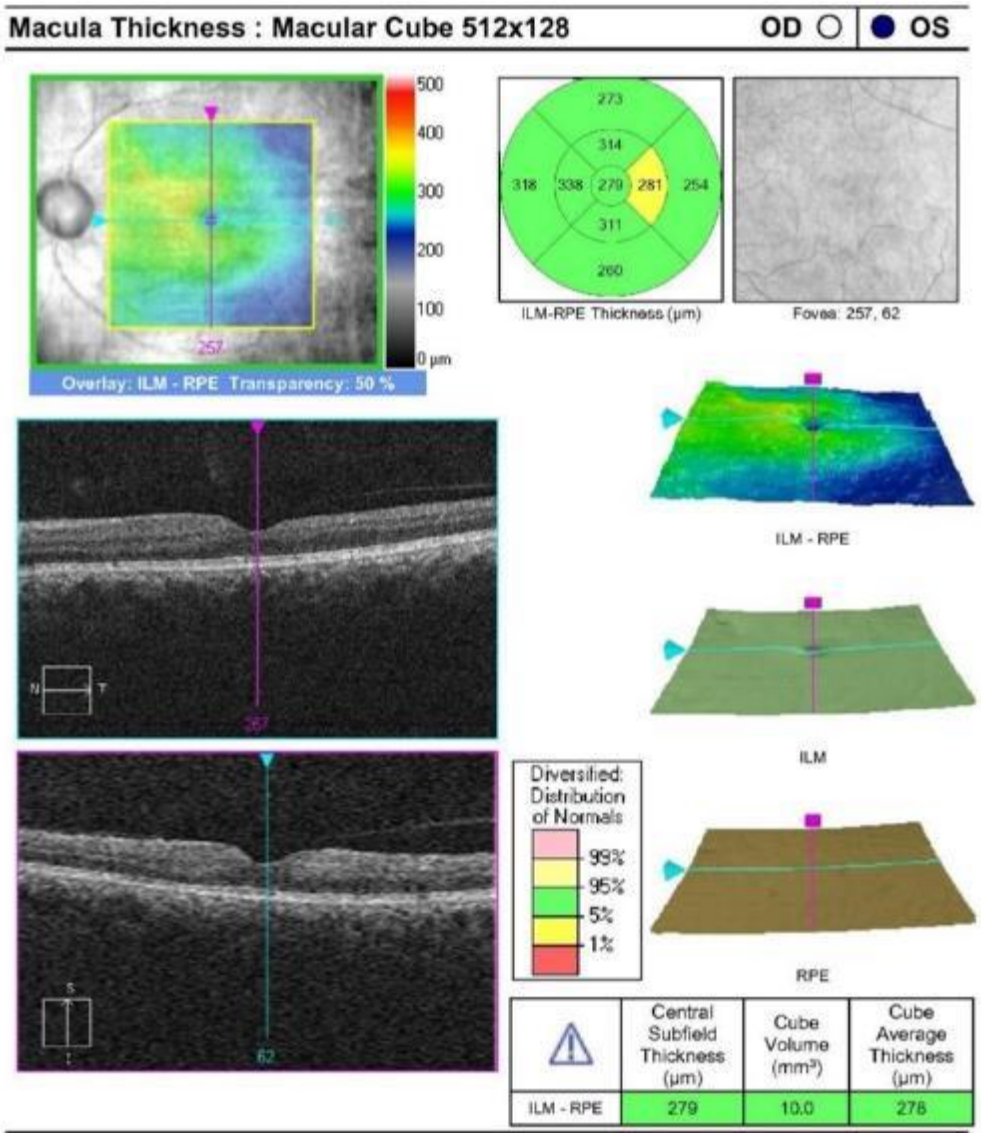
S/P IVB x 3 (5 mos after presentation)



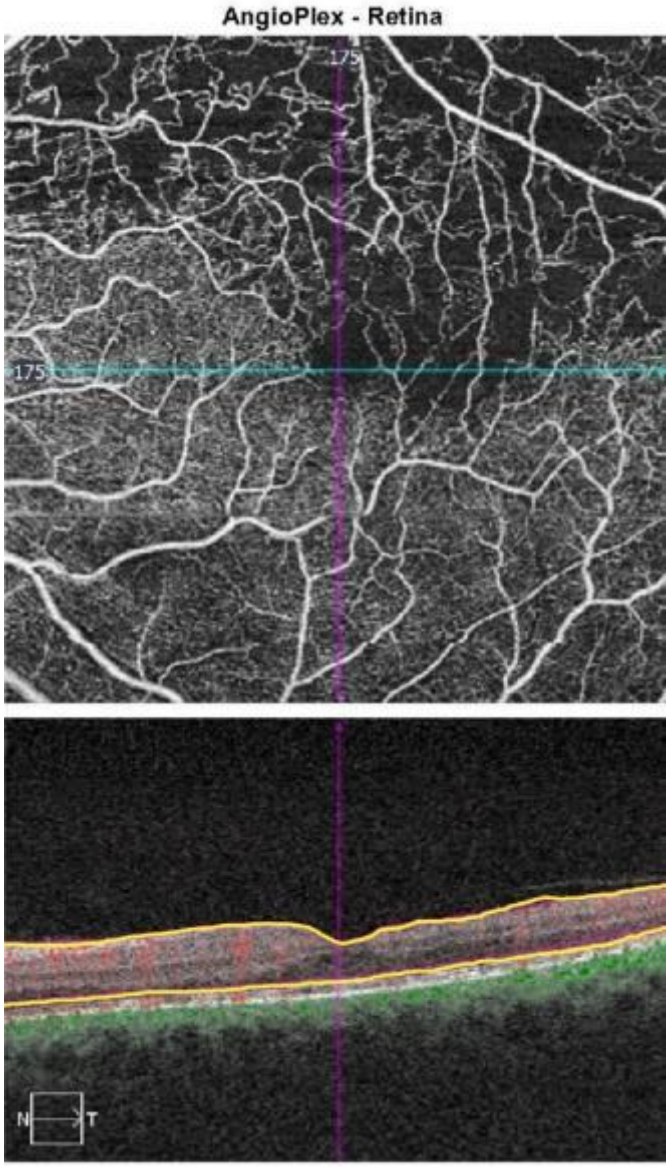
Hemicentral Vein Occlusion

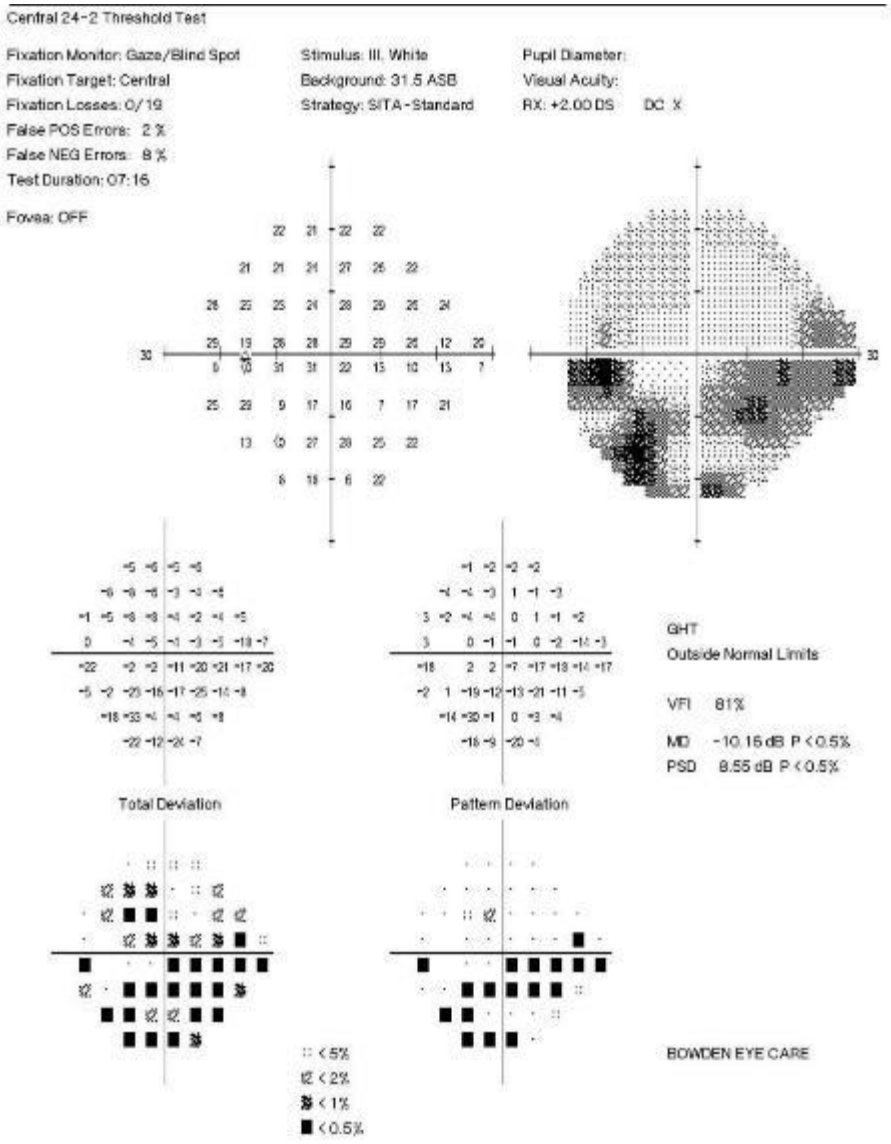
BCVA 20/40

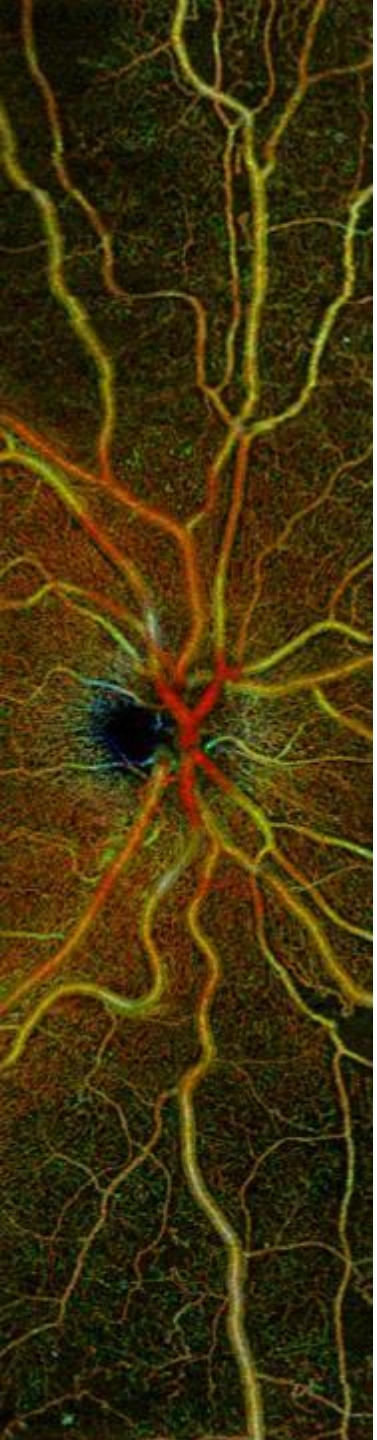




Hemicentral Vein Occlusion



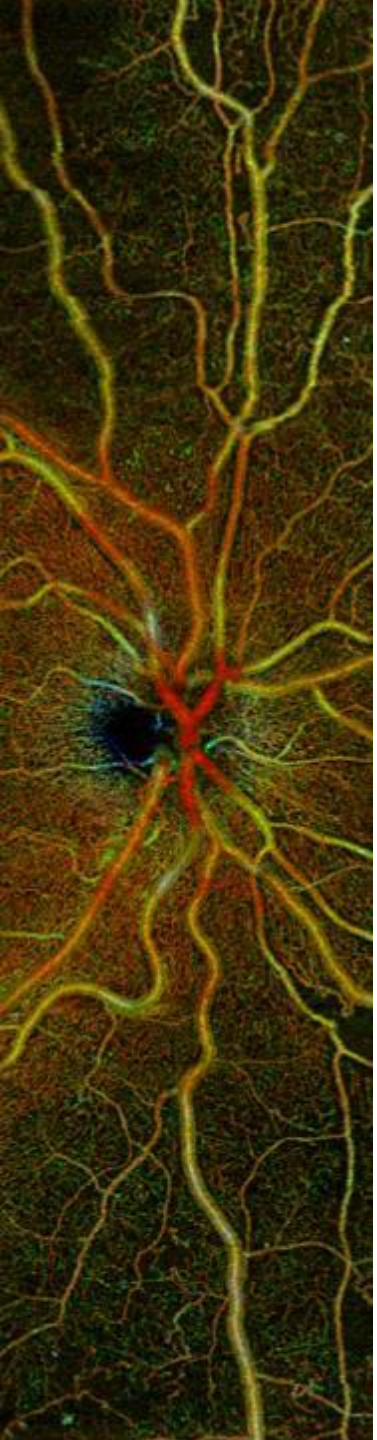




Retinal Vein Occlusion

KEY POINTS

- Vision loss from RVO may be a consequence of macular ischemia and/or edema
- More extensive retinal ischemia increases the risk of neovascular complications
- OCTA is an excellent tool for evaluating retinal perfusion and detecting preretinal neovascularization following RVO

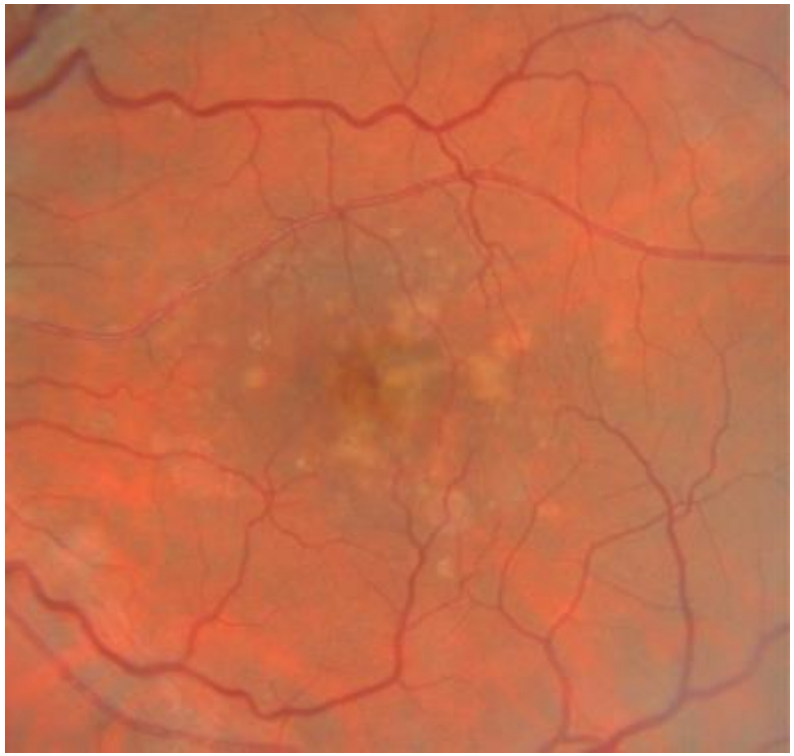


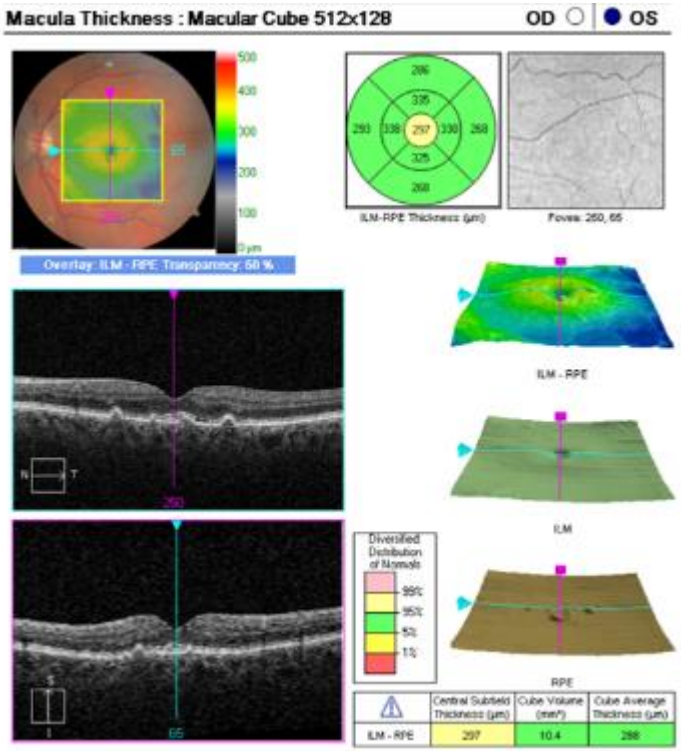
AMD & OTHER CAUSES OF CNV

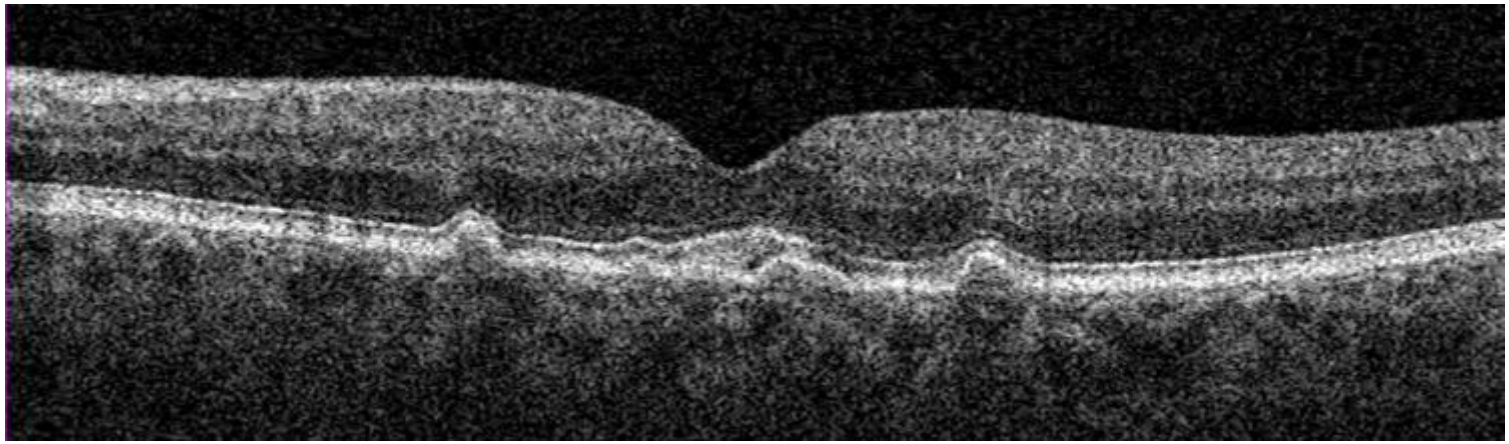
OCTA Clinical Applications

- CNV detection, classification and quantification
- Assess responsiveness to treatment
- Assess need for retreatment
- Detect quiescent (inactive) CNV membranes

AMD

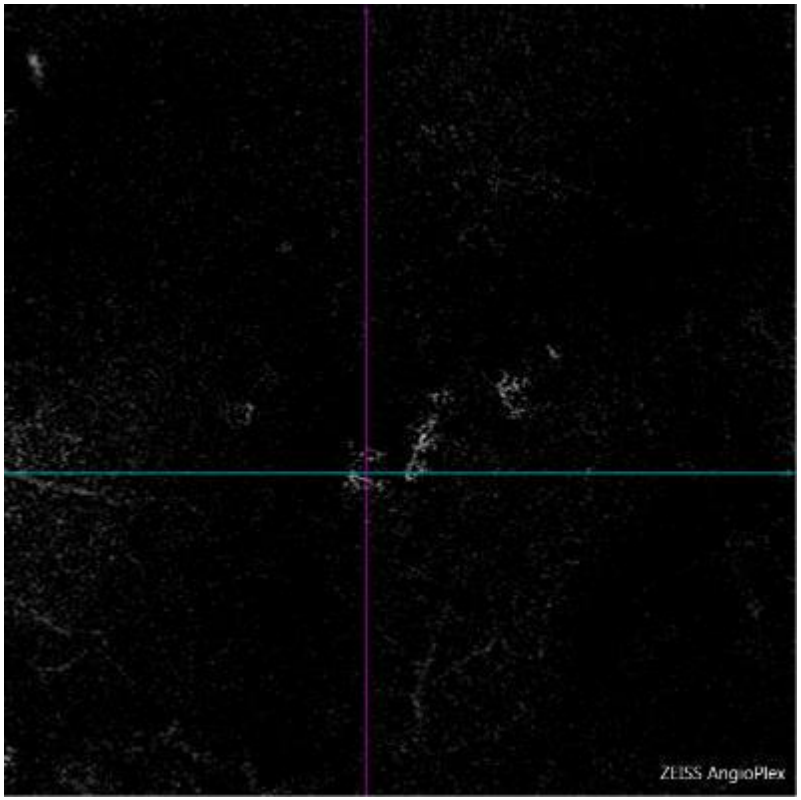



Macula Thickness : Macular Cube 512x128
OD
OS
Overlay: ILM - RPE Transparency: 50 %
ILM-RPE Thickness (µm)
Fovea: 260, 65
ILM - RPE
ILM
RPE
Diversified Distribution of Normals
99%
95%
5%
1%
Central Subfield Thickness (µm)
Cube Volume (mm³)
Cube Average Thickness (µm)
ILM - RPE
297
10.4
288

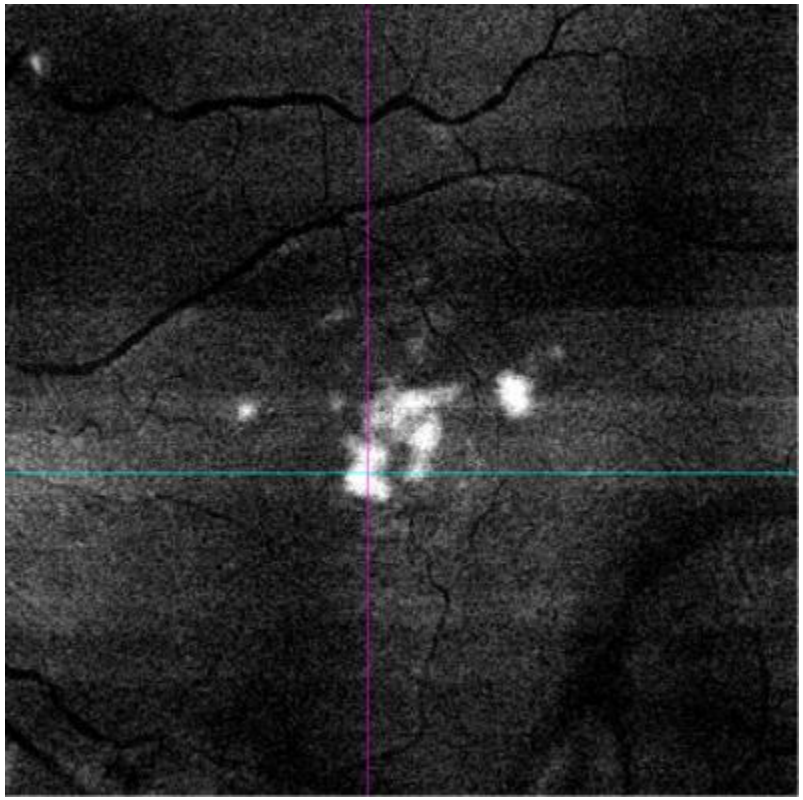


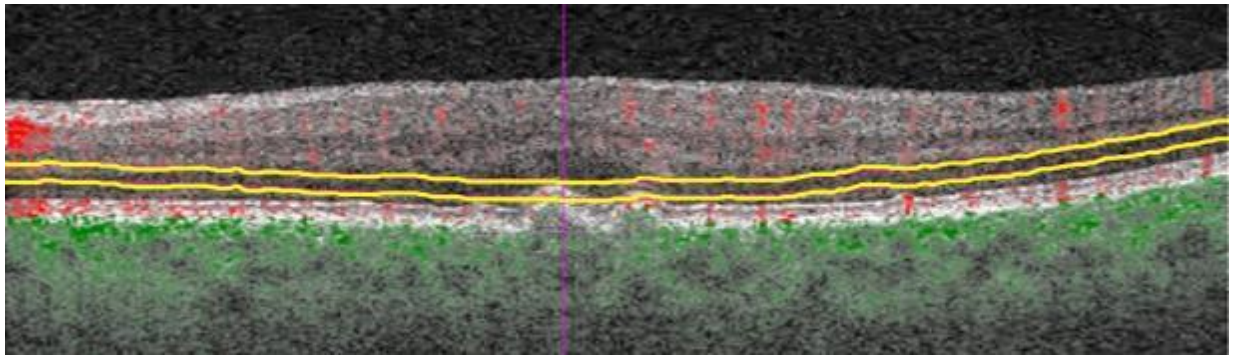
AMD - Drusen

Avascular Angio



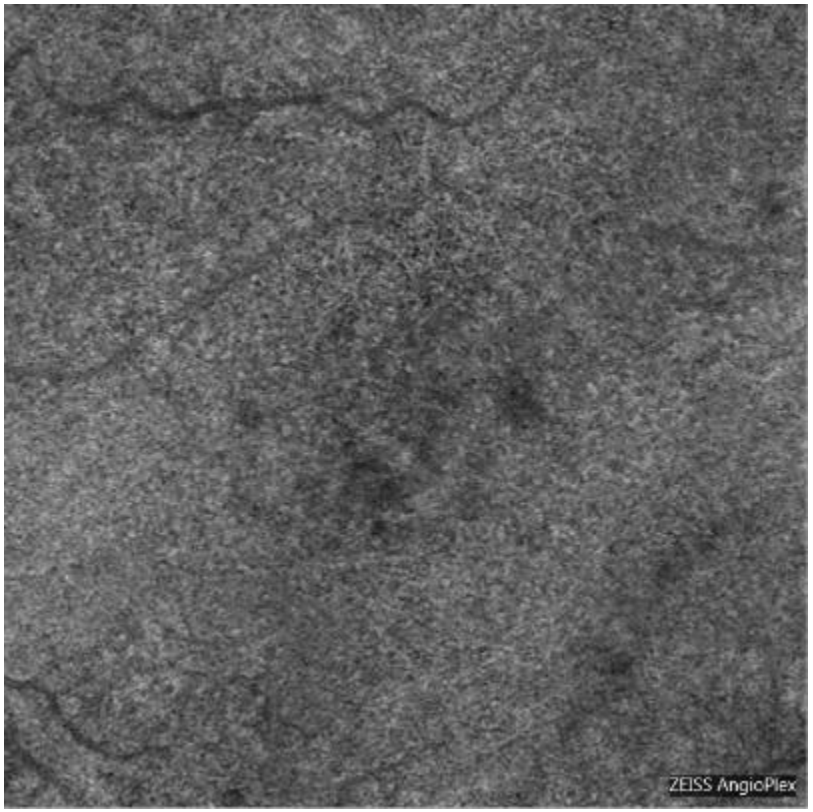
Avascular Structural



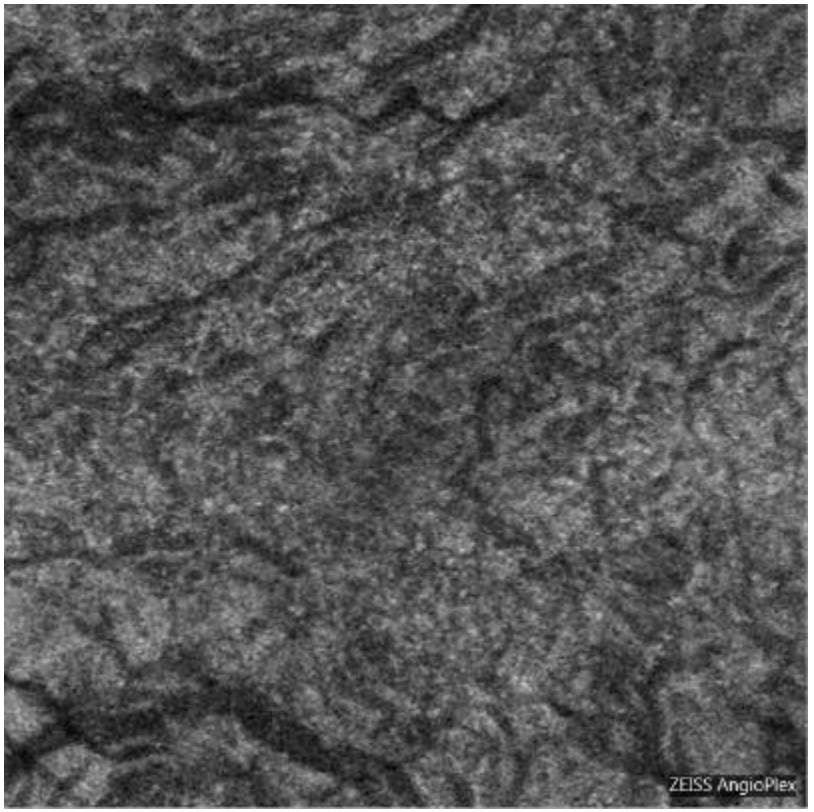


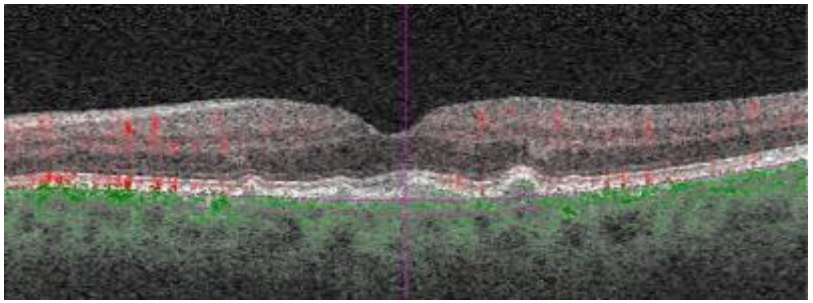
AMD - Drusen

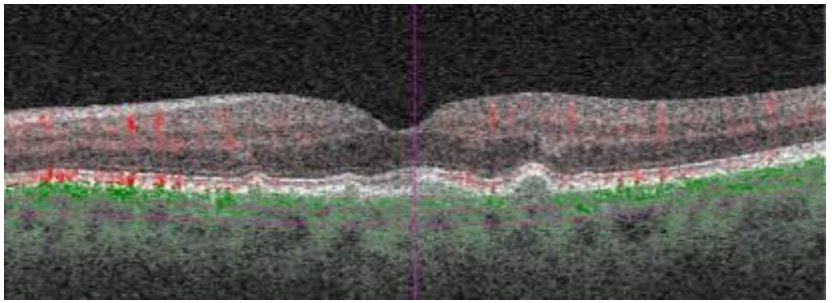
Choriocapillaris



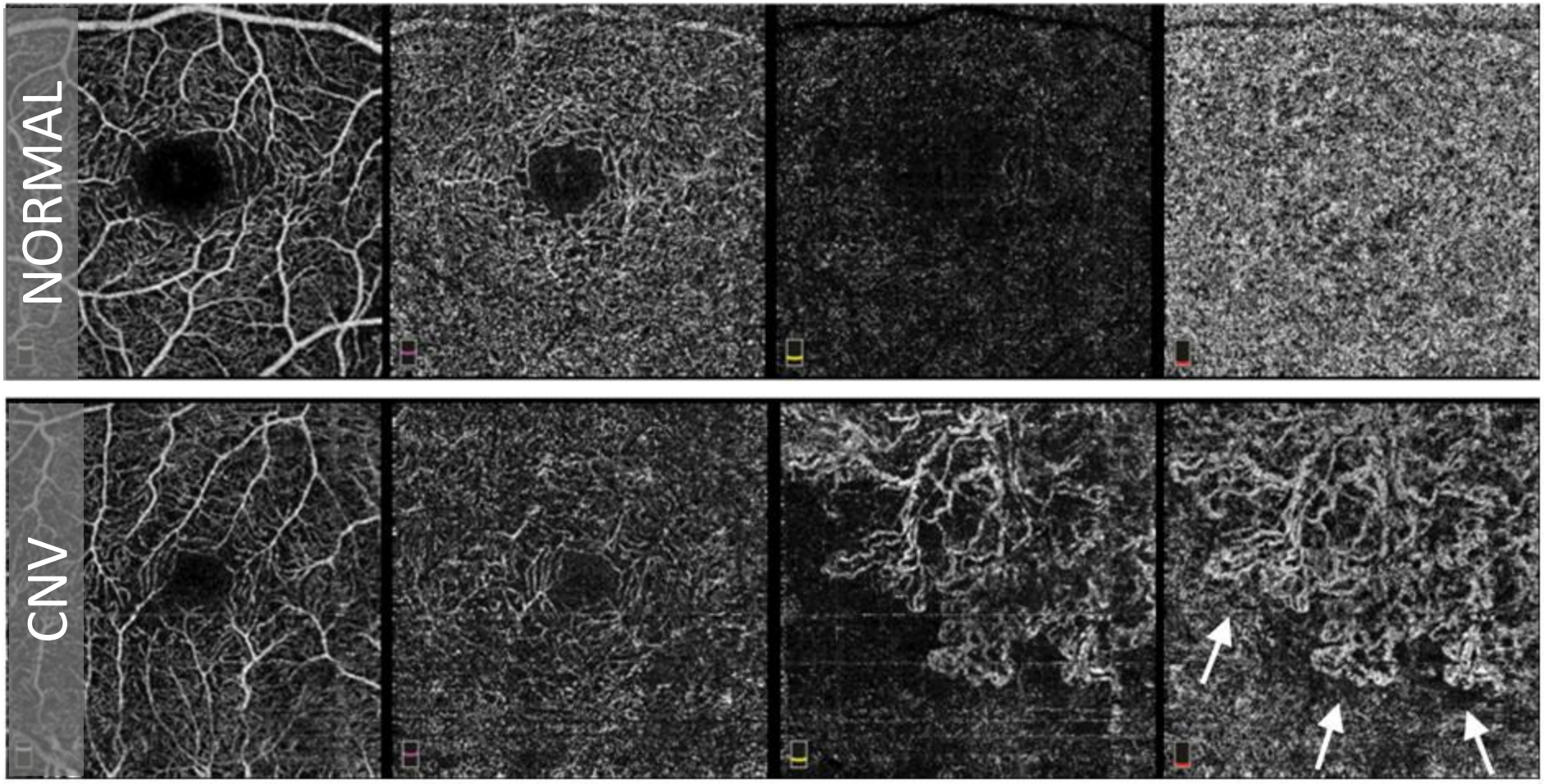
Choroid







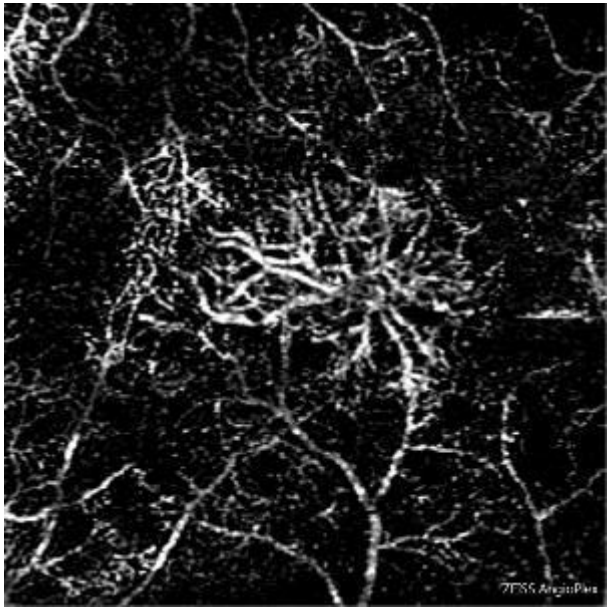
AMD- CNV



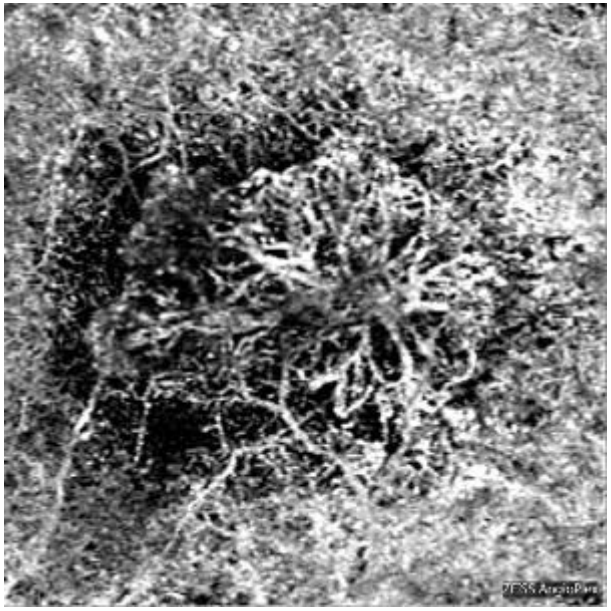
PMID: 32826223

AMD- Exudative

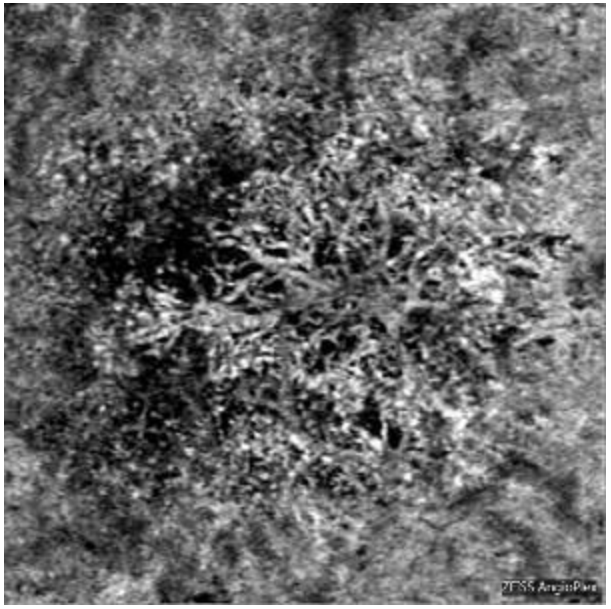
Avascular

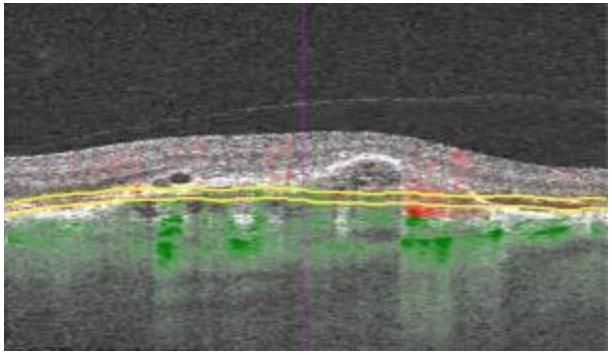


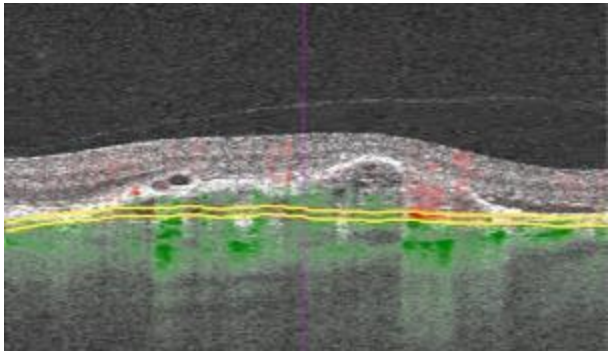
Choriocapillaris

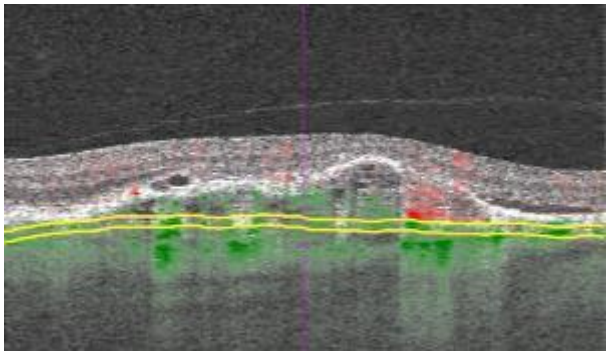


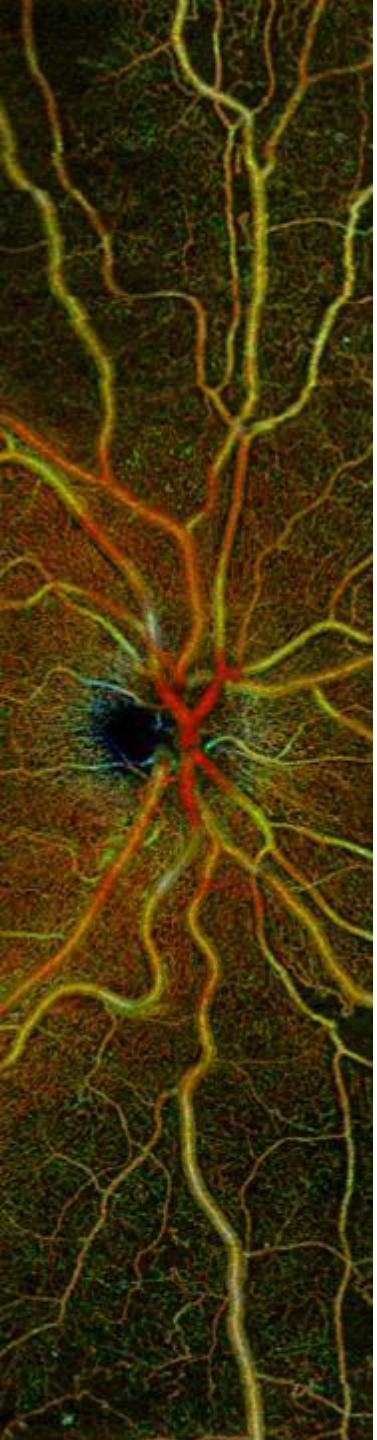
Choroid





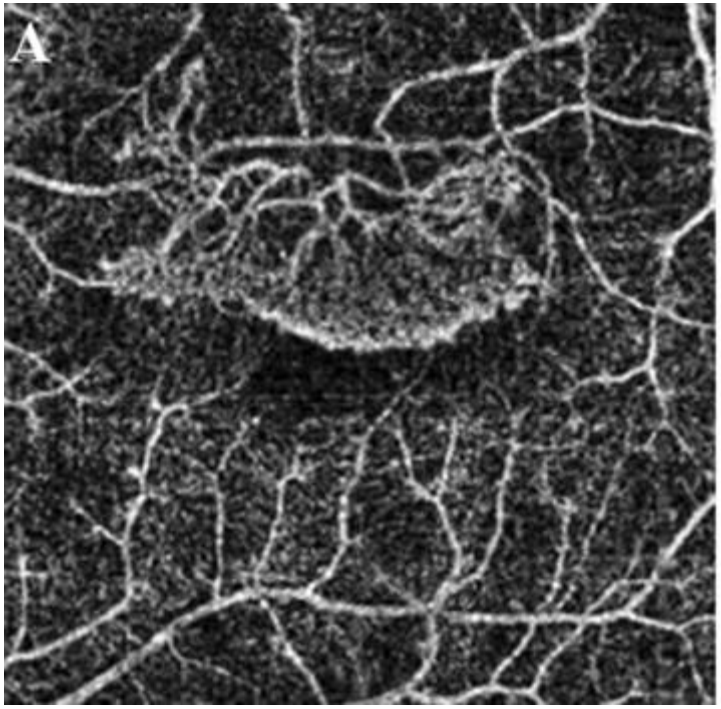






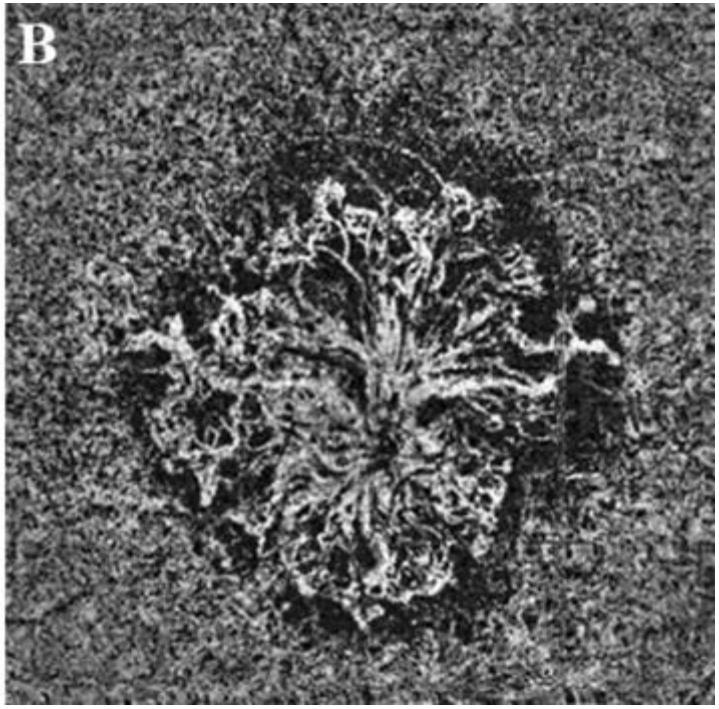
AMD- Exudative

Seafan Pattern



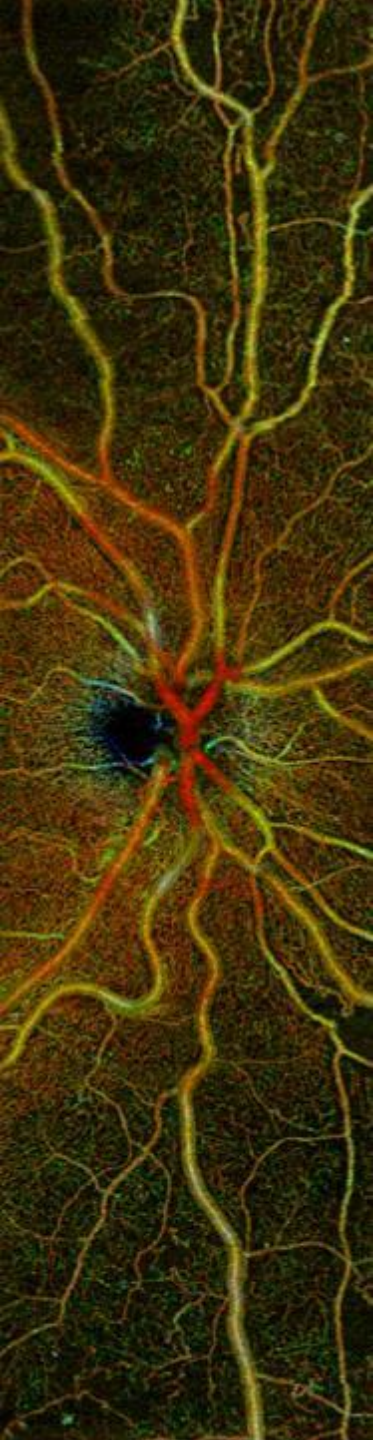
Vessels radiate from one side of the lesion

Medusa Pattern



Vessels branch in all directions from the center of the lesion

PMID: 30932032



AMD- Exudative

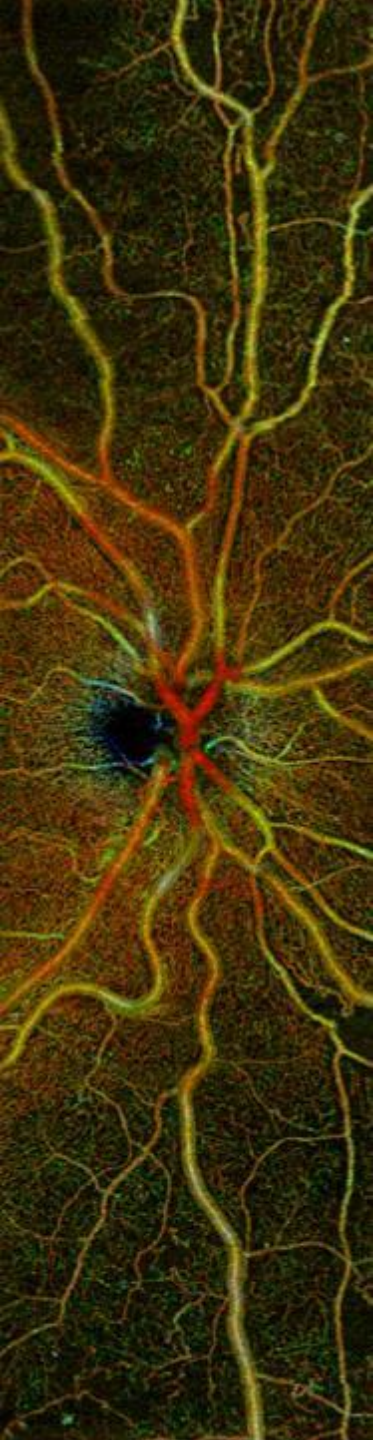
Clinical science

Evaluation of the clinical utility of optical coherence tomography angiography in age-related macular degeneration

Melina Cavichini,[1,2] Kunny C Dans,[1] Mahima Jhingan,[1,3] Manuel J Amador-Patarroyo,[1,4] Shyamanga Borooah,[5,6] Dirk-Uwe Bartsch,[1] Eric Nudleman,[1] William R Freeman [7]

Sensitivity	80%	Correctly identify presence of CNV
Specificity	85%	Correctly identify absence of CNV
Positive Predictive Value	60%	CNV found after positive result
Negative Predictive Value	94%	CNV not found after negative result

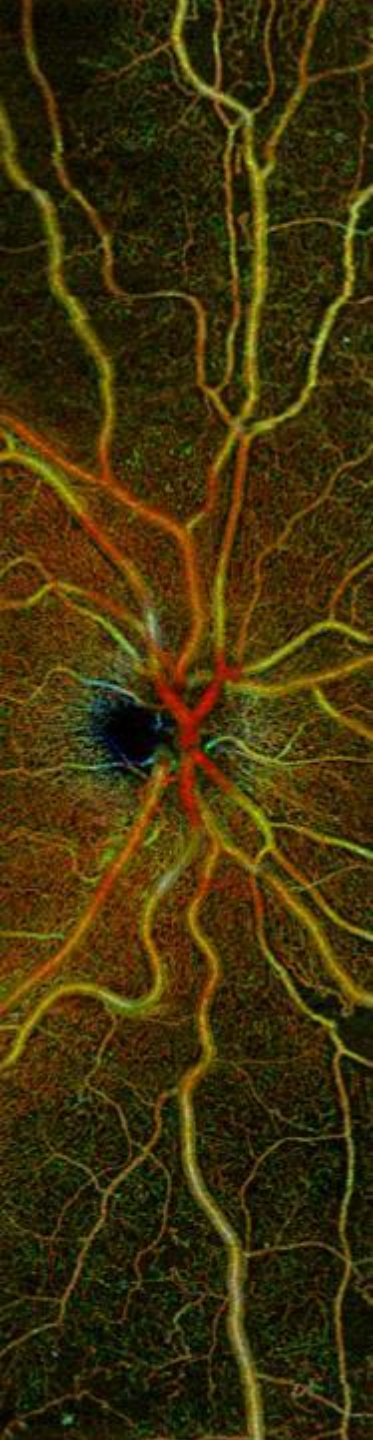
PMID 32826223



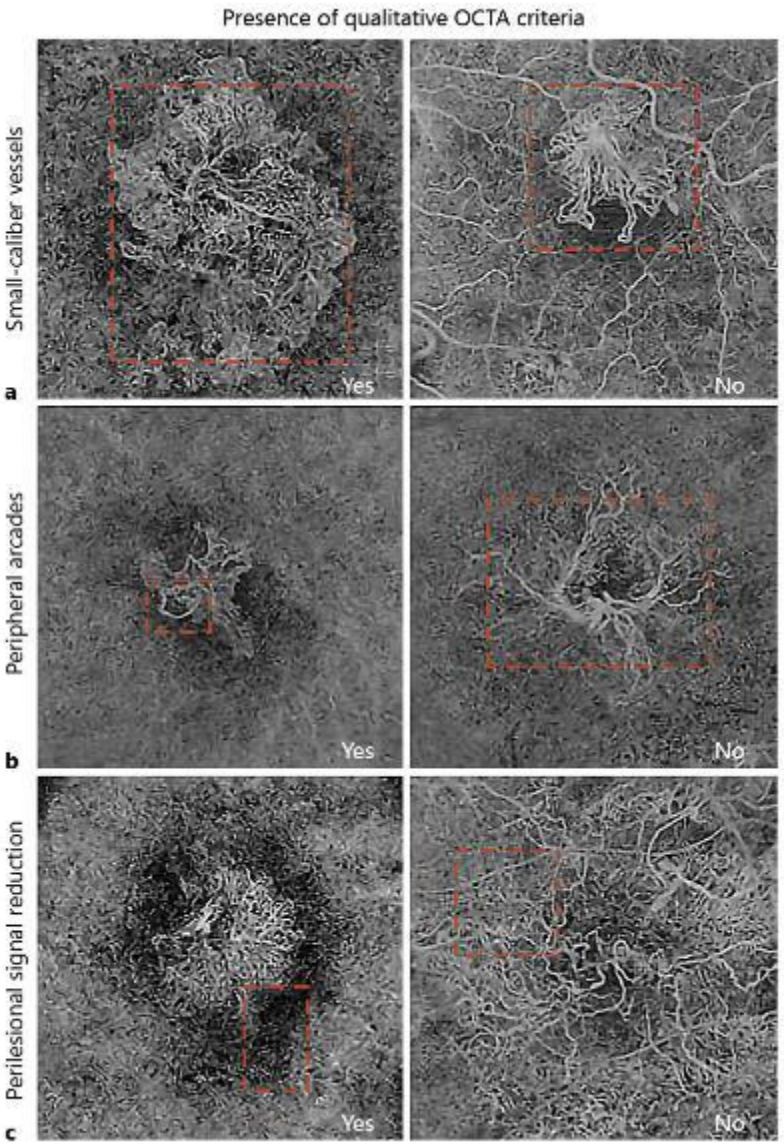
AMD- Exudative

THREE CLINICAL CNV VARIANTS

1. Active lesions: Symptomatic, signs of exudation on OCT (subretinal fluid)
2. Inactive lesions: Status following successful anti-VEGF therapy. No signs of exudation on OCT
3. Subclinical lesions: Asymptomatic, no signs of exudation on OCT. Often found in fellow eyes of active CNV. High risk of becoming active



AMD- Exudative



ACTIVE **INACTIVE**

OCTA SIGNS OF ACTIVE CNV

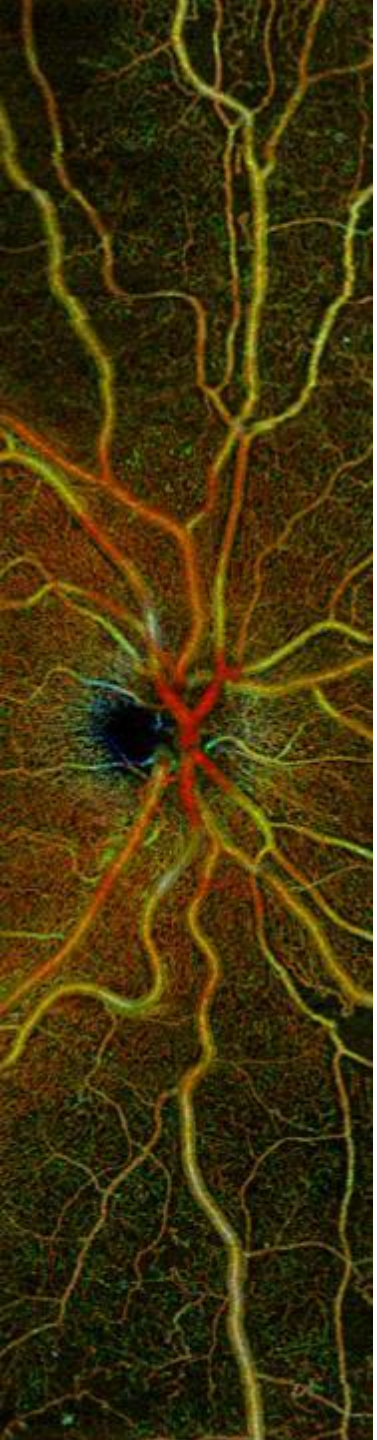
Active lesions contain smaller caliber vessels

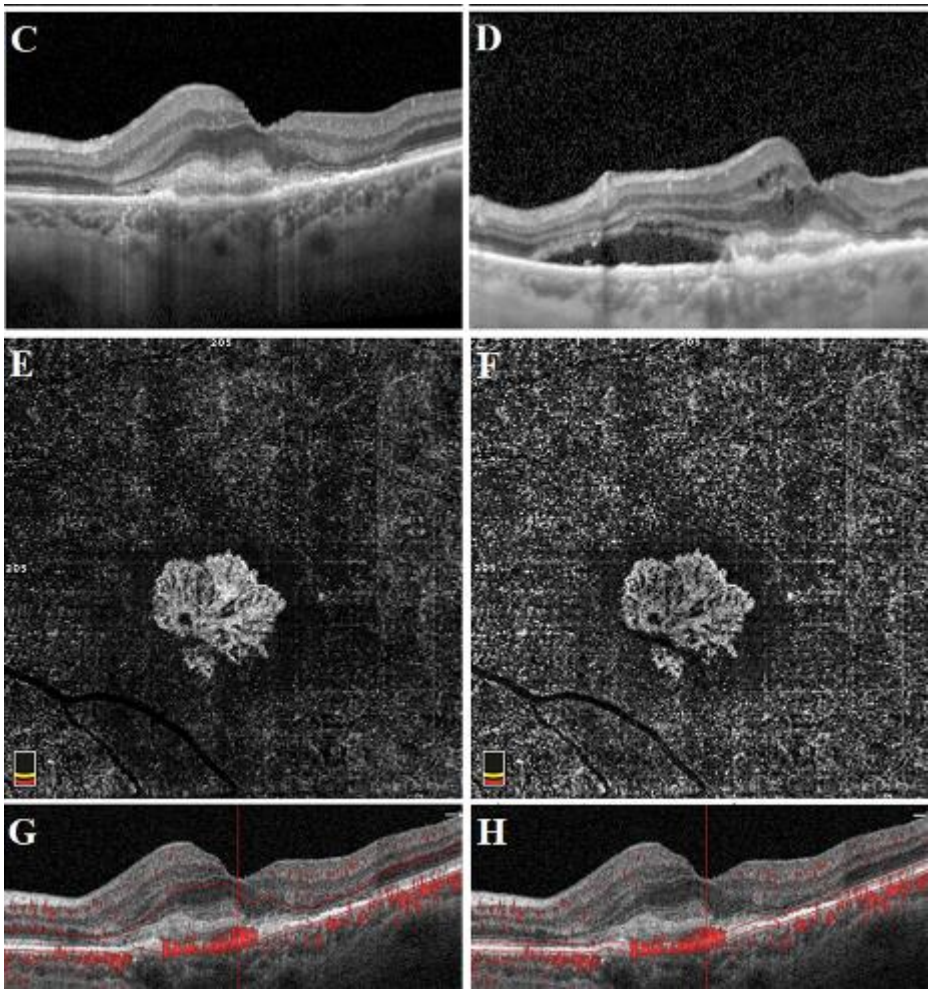
Active lesions have looping vessels at margins. Inactive lesions have a "dead tree" appearance

Active lesions are surrounded by a zone of decreased signal intensity ("halo sign")

PMID: 31665719

AMD- Exudative



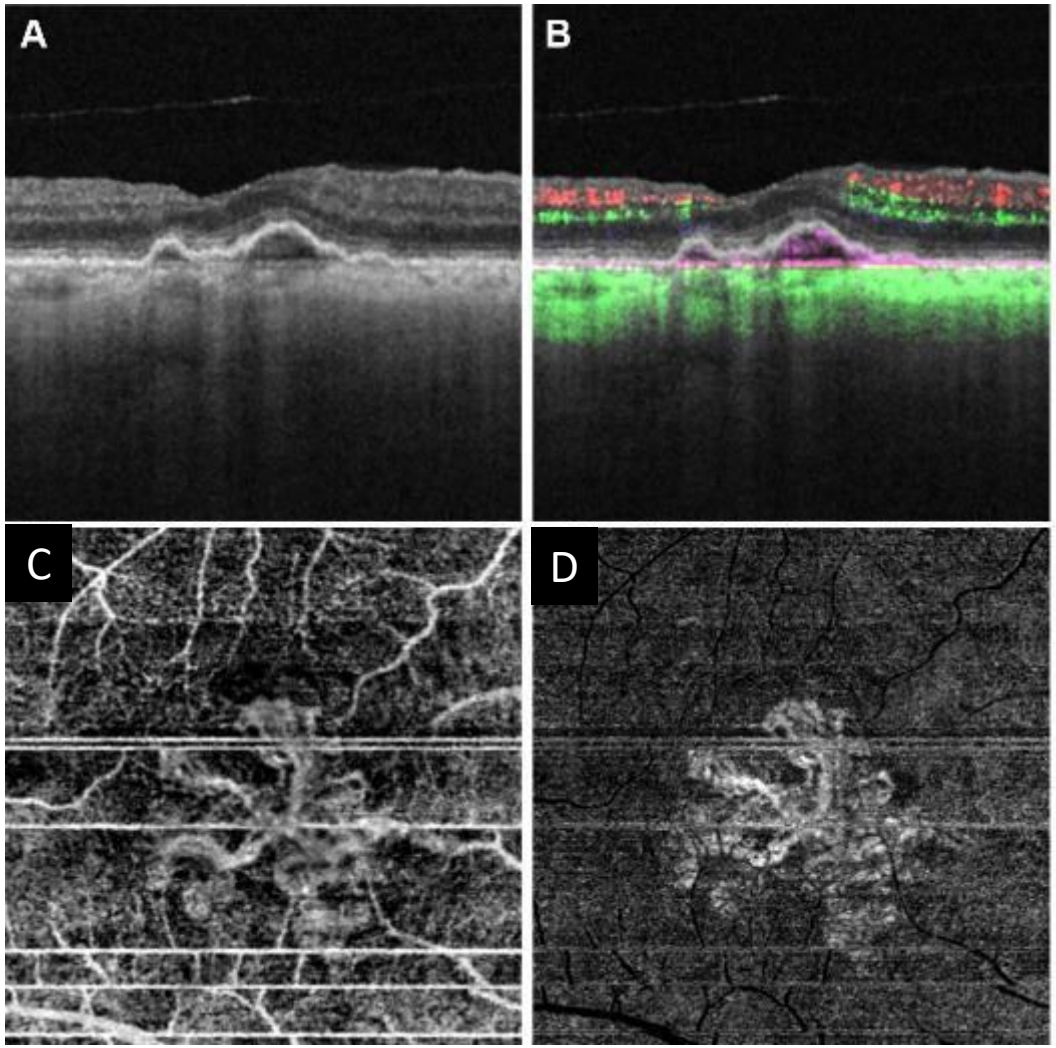


Subretinal lesion with fluid leakage

OCTA reveals sea-fan CNV with OCTA signs that it is active
Left: Outer retina
Right: Choroid

PMID: 30932032

AMD- Nonexudative (subclinical) CNV



A. OCT shows PED w/o SRF in right eye of 78yo asymptomatic man with dry AMD. VA 20/20

B. OCTA B-scan shows flow signal within PED

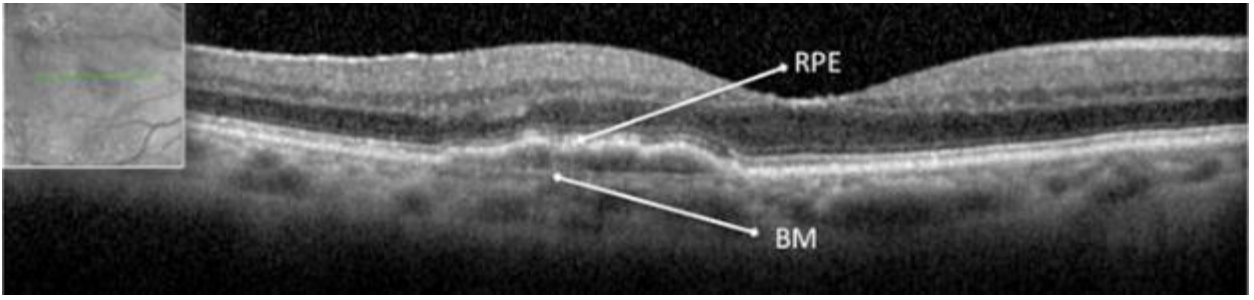
C. En-face OCTA reveals CNV within PED. Note projection artifact of retinal vascular tree

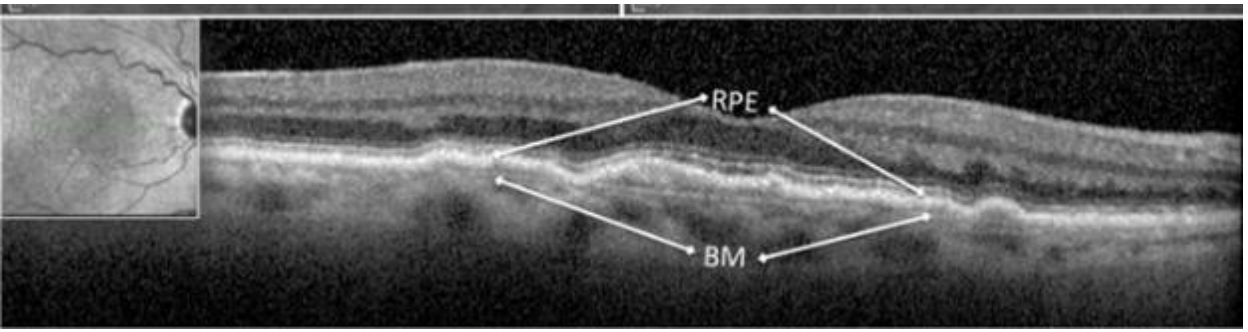
D. Same image with projection artifact removed

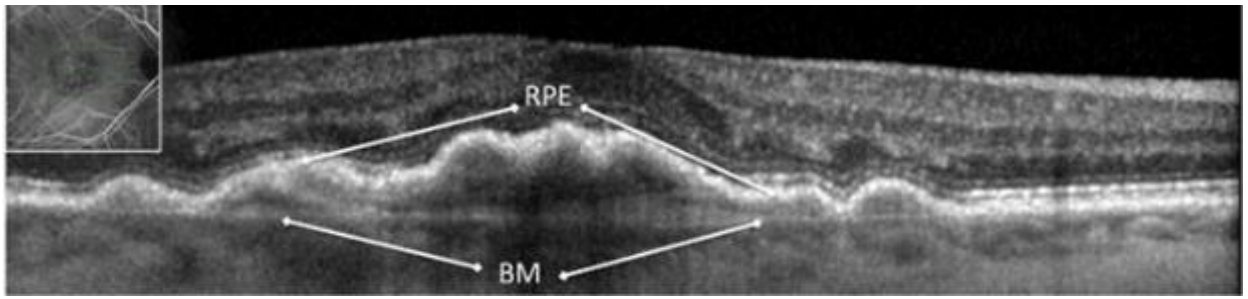
PMID 26876696

These lesions are asymptomatic but carry a high risk of exudation.
These lesions may remain stable for years but require close monitoring

AMD- Nonexudative (subclinical) CNV







“DOUBLE LAYER” SIGN TO IDENTIFY SUBCLINICAL CNV IN EYES WITH “DRY” AMD

Top layer = RPE

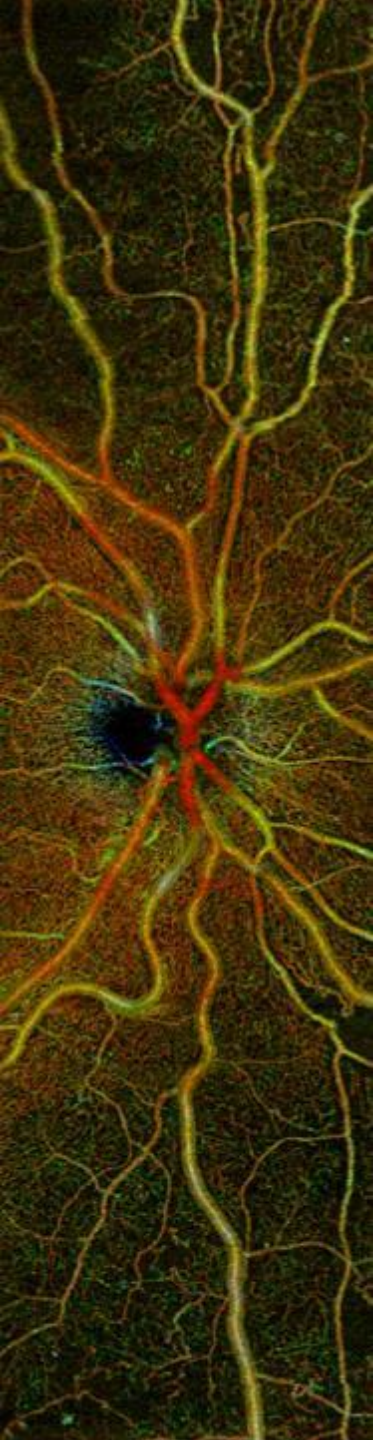
Bottom layer = Bruch’s

Absence of SRF, blood, and other signs of exudation indicates nonexudative nature of the lesion

Sensitivity: 88% **PPV: 76%**

Specificity: 87% **NPV: 94%**

PMID: 31014697



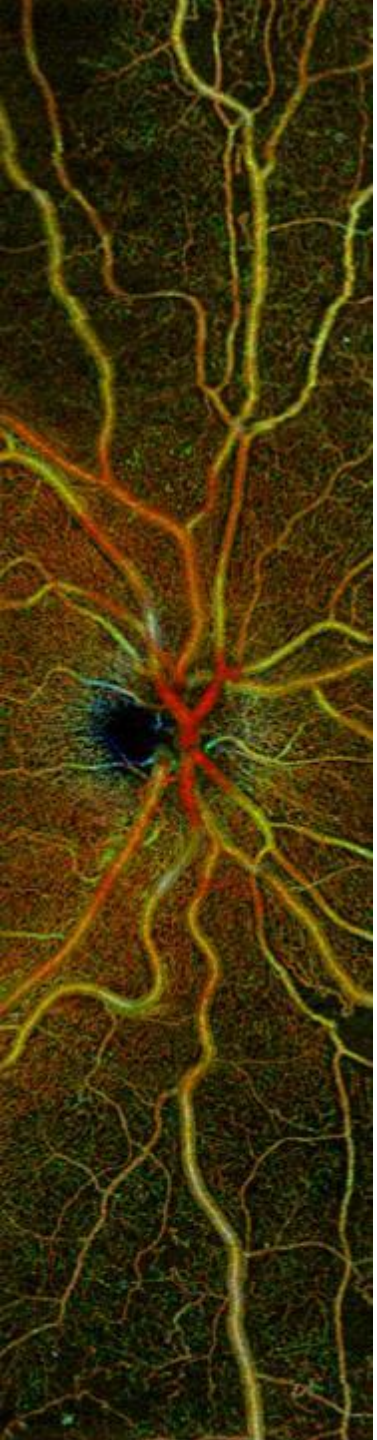
Macular Telangiectasia Type 2

WHAT IS IT?

MacTel type 2 is an idiopathic bilateral neurodegenerative disease with characteristic alterations of the macular capillary network and neurosensory atrophy

CLINICAL FEATURES INCLUDE:

- Loss of macular pigment
- Retinal hyporeflective cavities on OCT
- Telangiectatic capillaries (early)
- Retinal pigment plaques, foveal atrophy, and subretinal neovascularization (late)



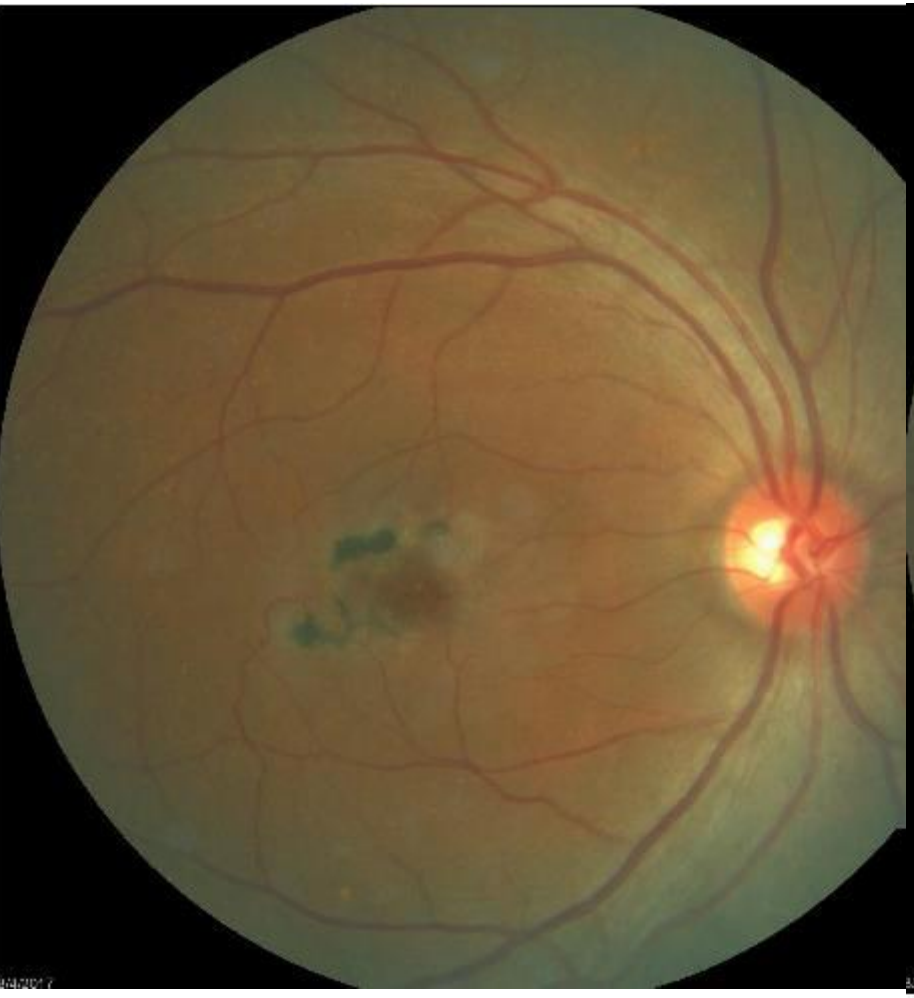
Macular Telangiectasia Type 2

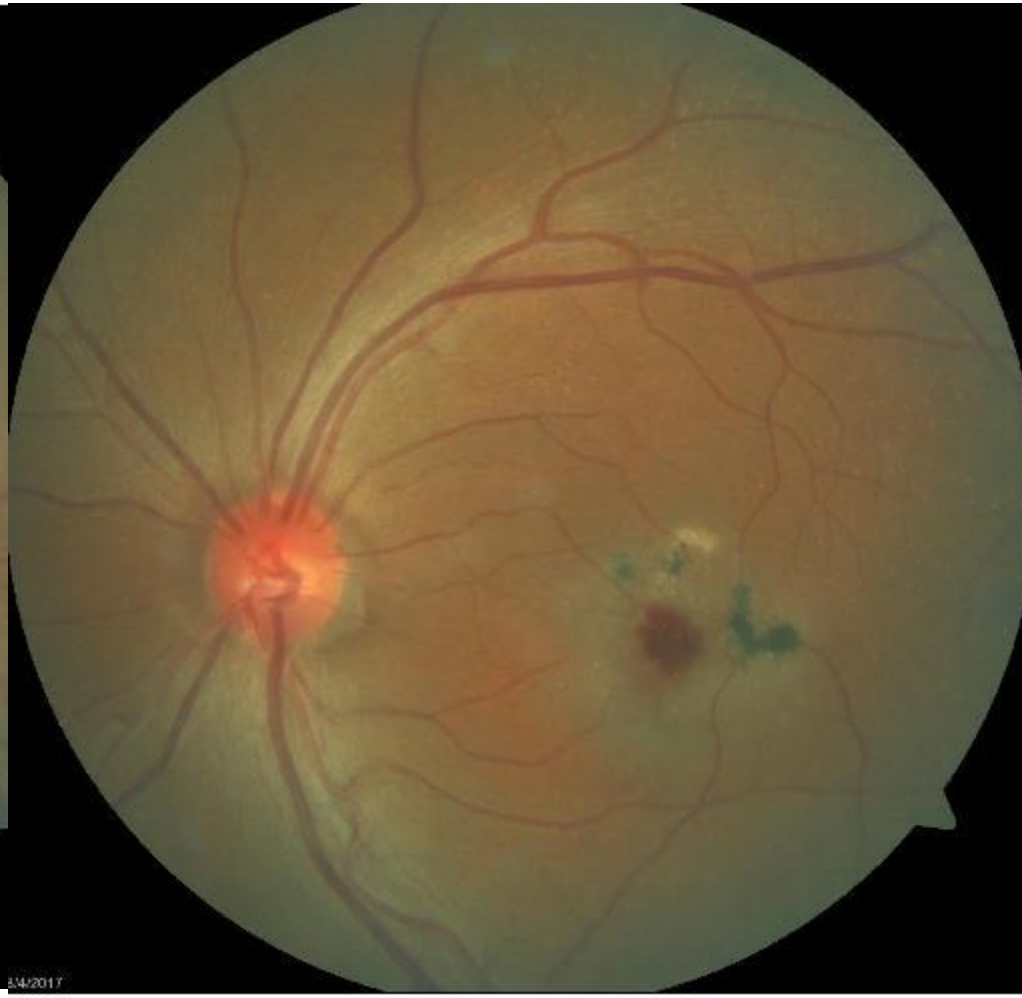
CASE REPORT

56yo HF

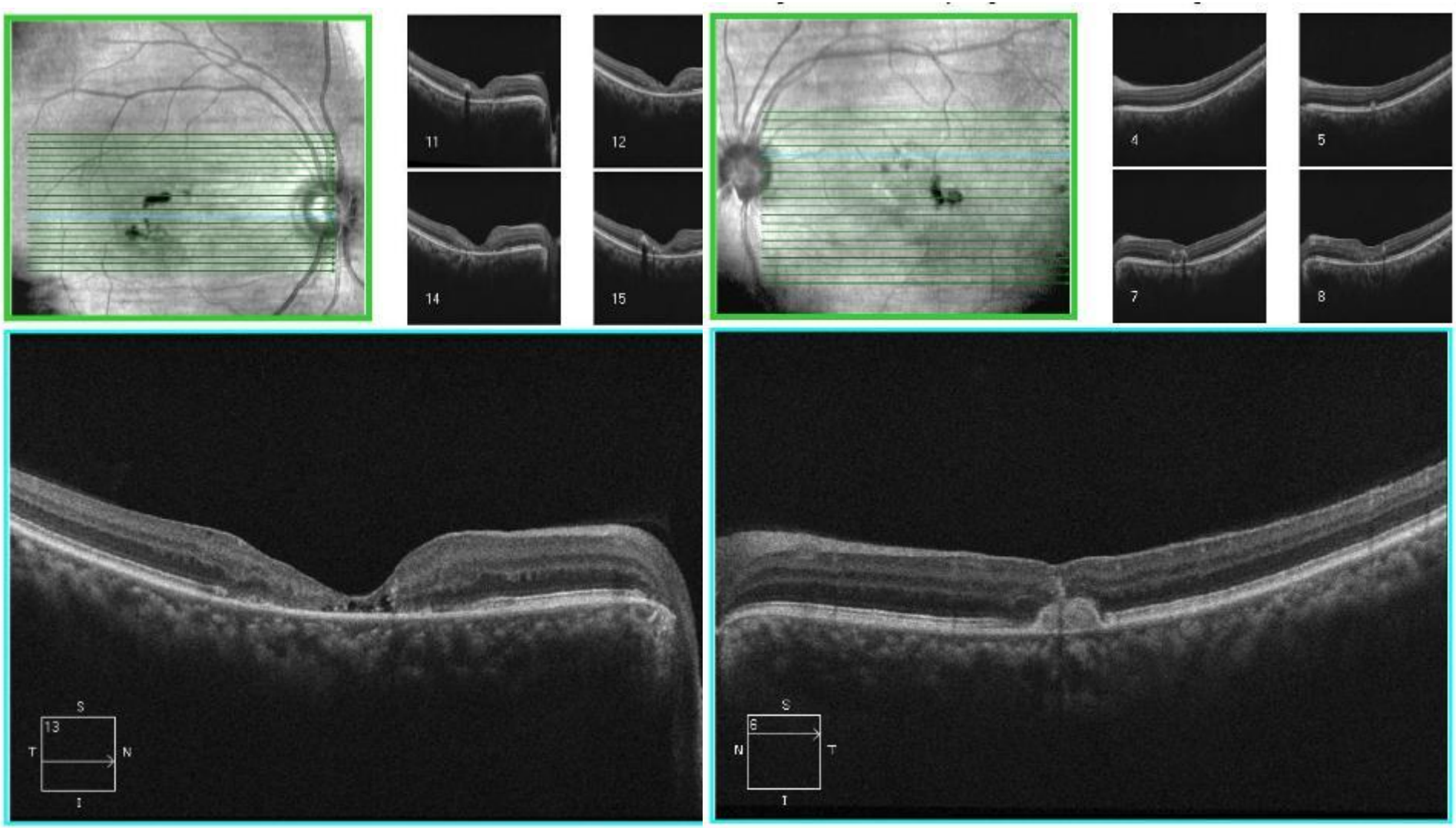
- Consultation for evaluation of maculopathy OU
- C/O bilateral progressive decrease in vision x 2 yrs
- MH: Good health. No meds
- POH: Unremarkable
- BCVA: 20/100 OD, 20/200 OS
- Ta 25/25 @ 2pm
- SLE: WNL OU

Macular Telangiectasia Type 2





Macular Telangiectasia Type 2

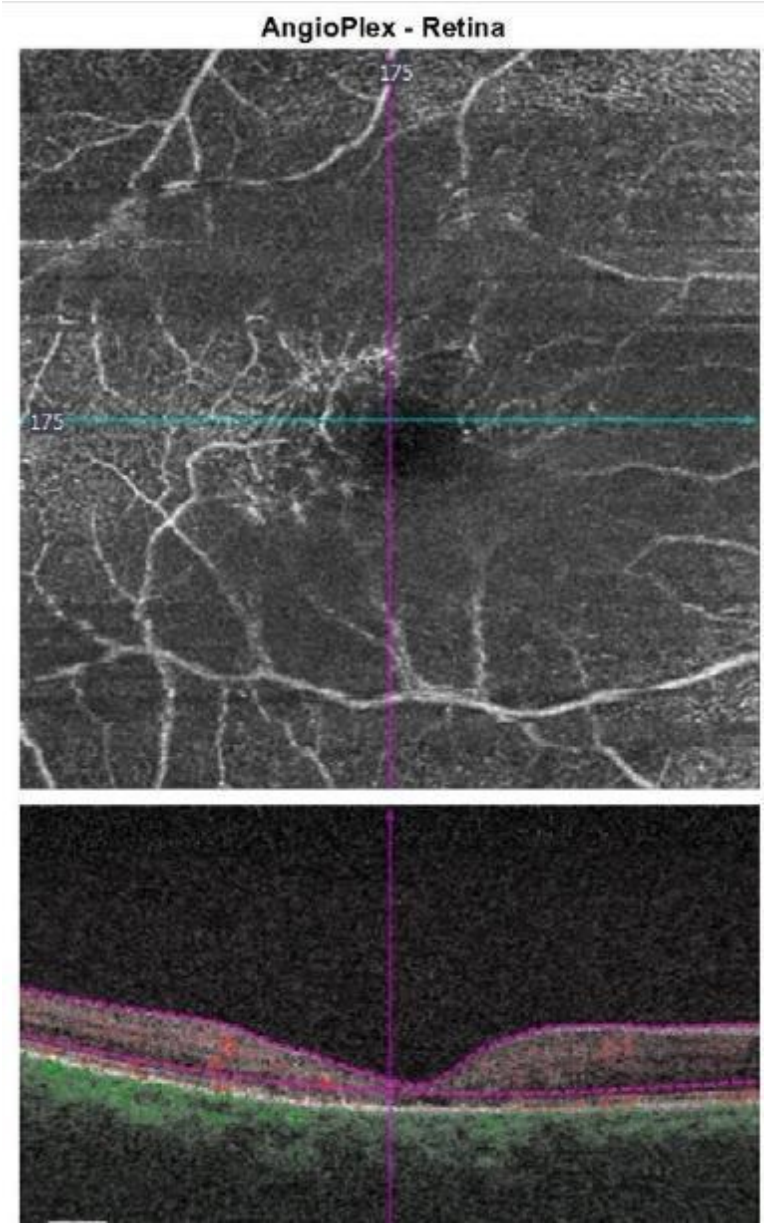


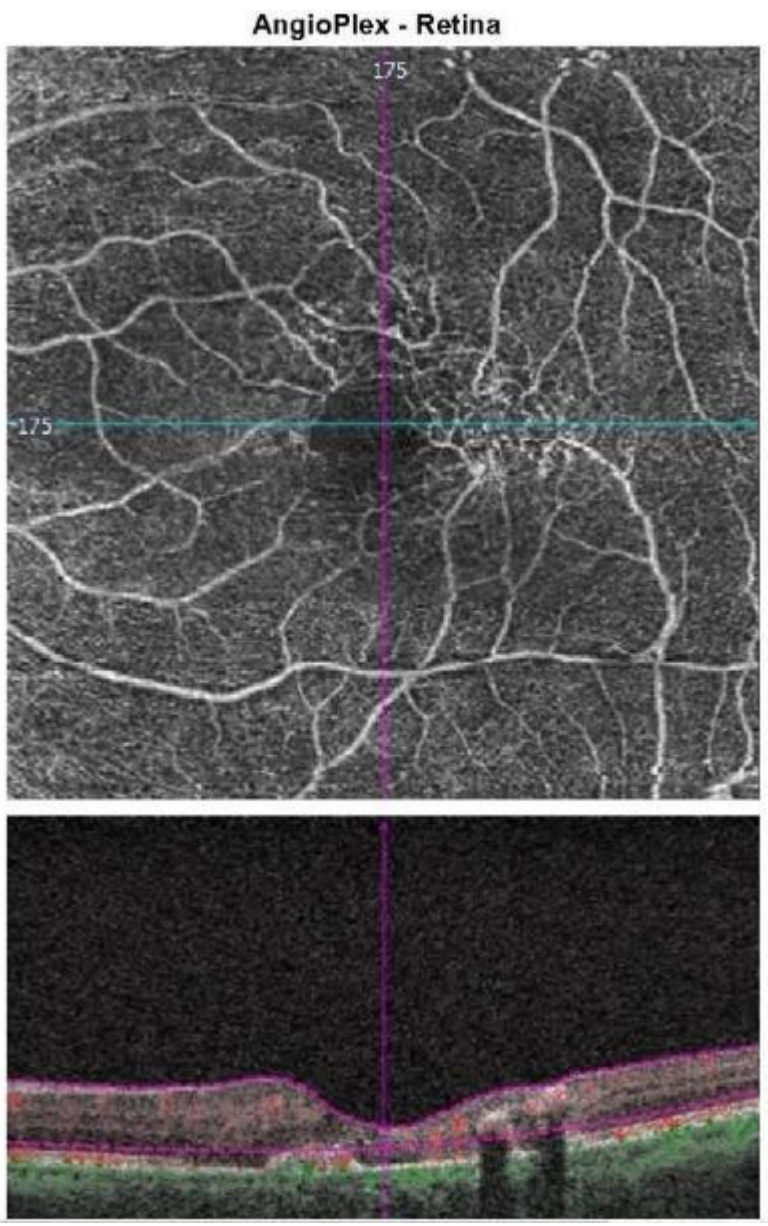
OD

OS

Macular Telangiectasia Type 2

OD

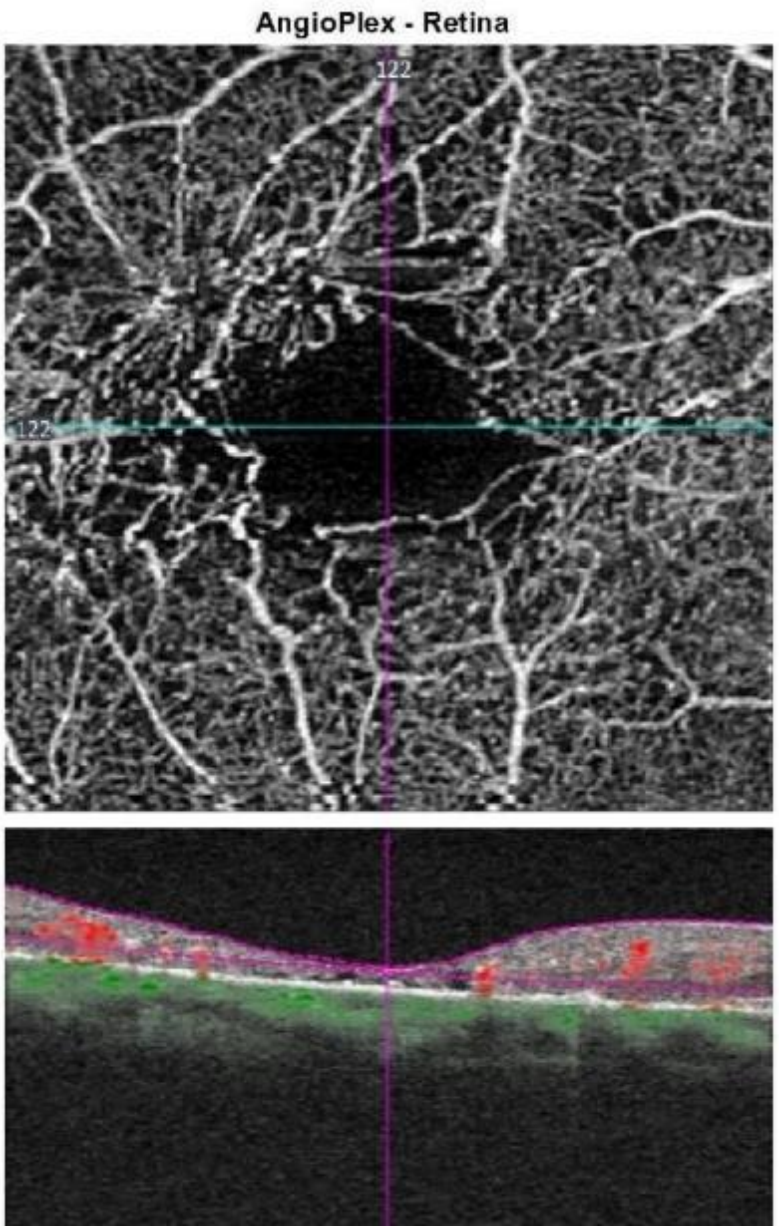


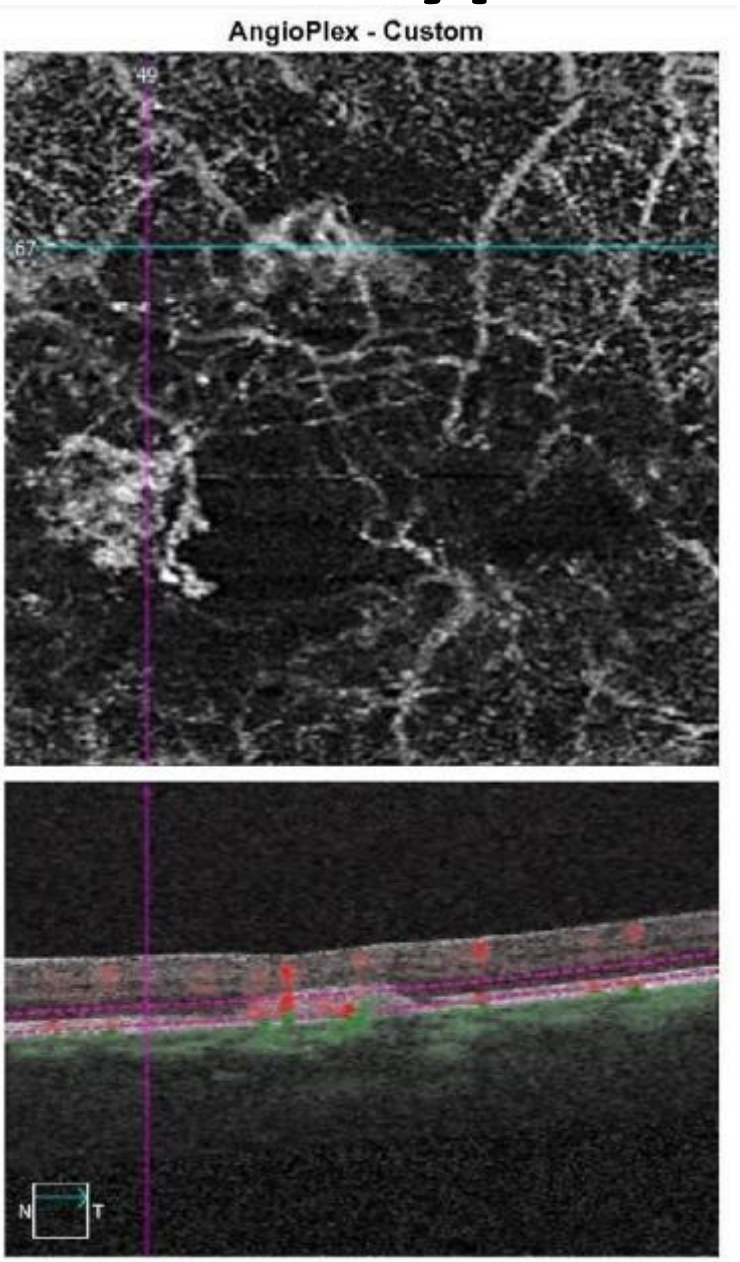


OS

Macular Telangiectasia Type 2

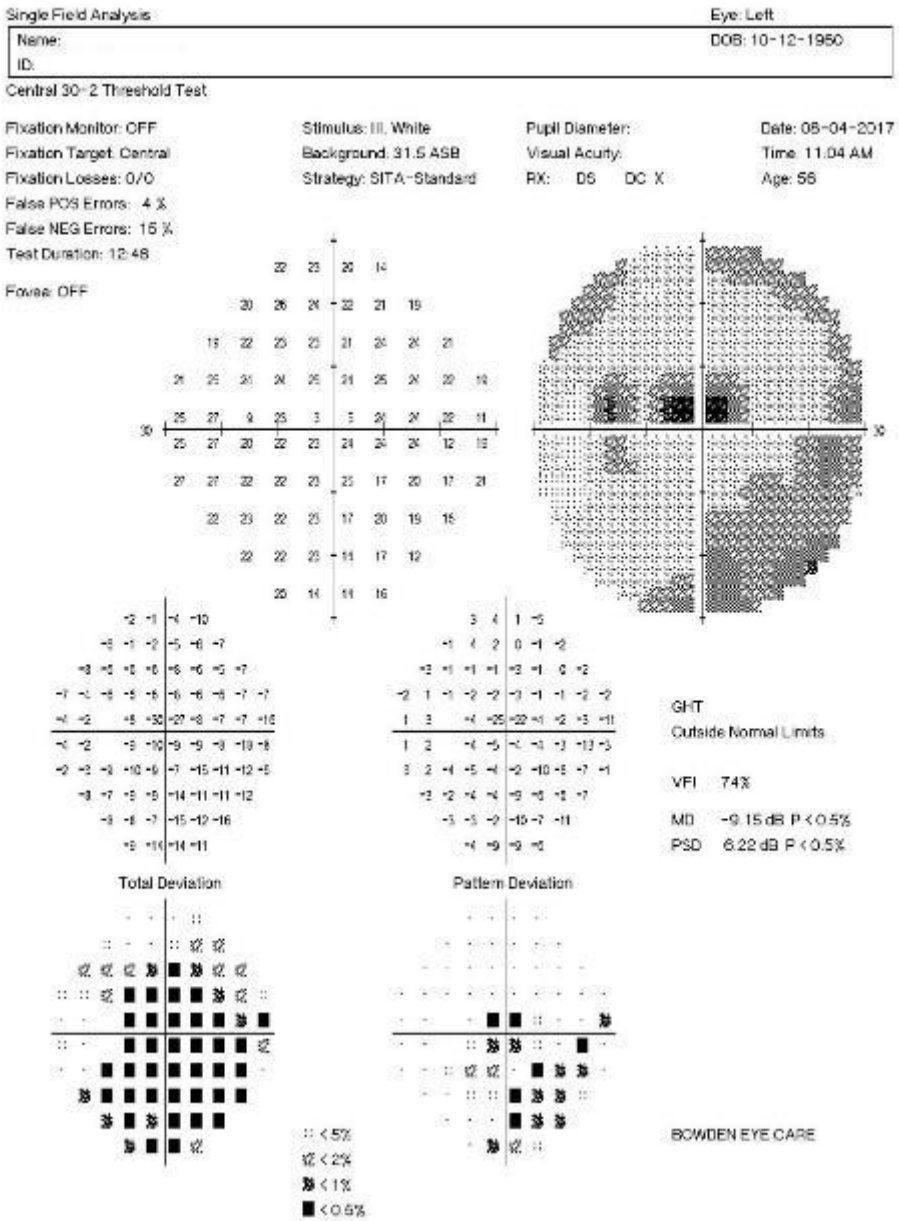
OD

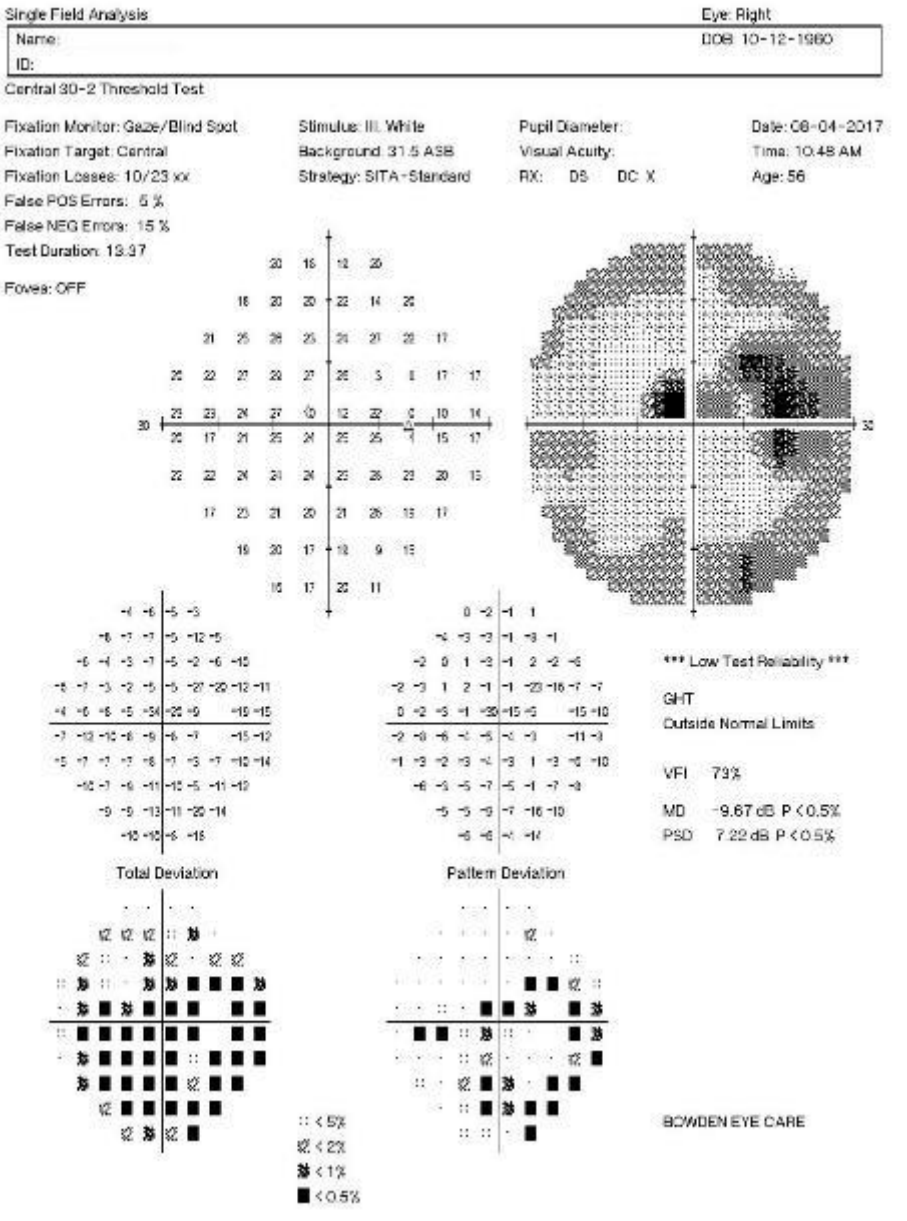




OS

Macular Telangiectasia Type 2





Macular Telangiectasia Type 2

OUR PLAN:

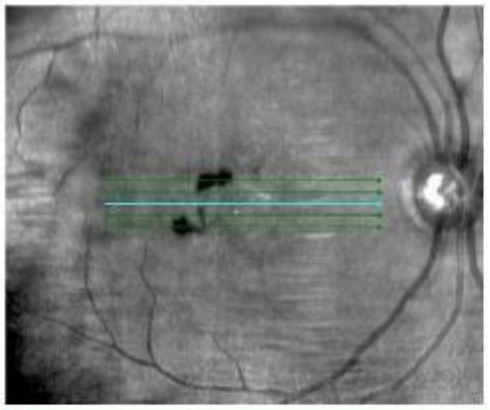
(1) IVB OS, (2) Glaucoma eval, (3) Low vision

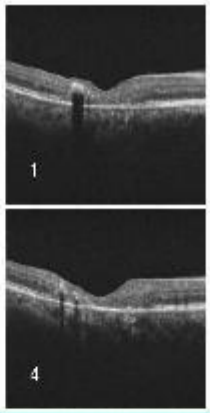
PATIENT'S PLAN:

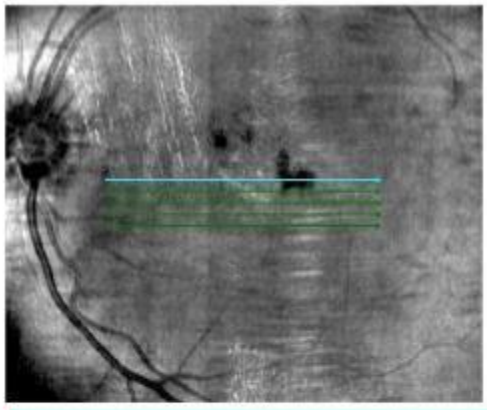
- Return 8 mos later

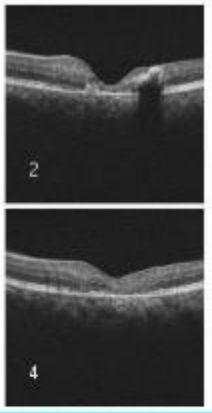
- C/O vision getting worse OS.
- BCVA: 20/100 OU
- Ta 24/24 @ 4pm
- SLE: WNL OU

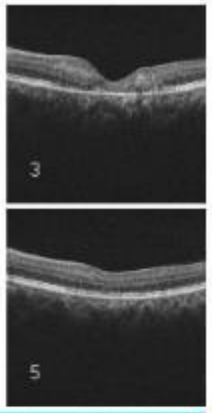
Macular Telangiectasia Type 2

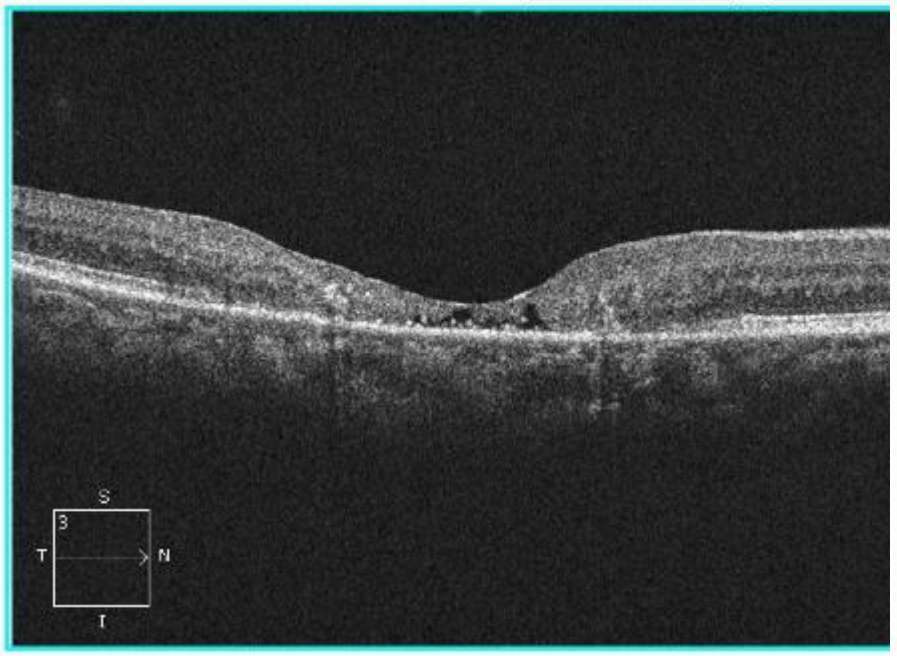


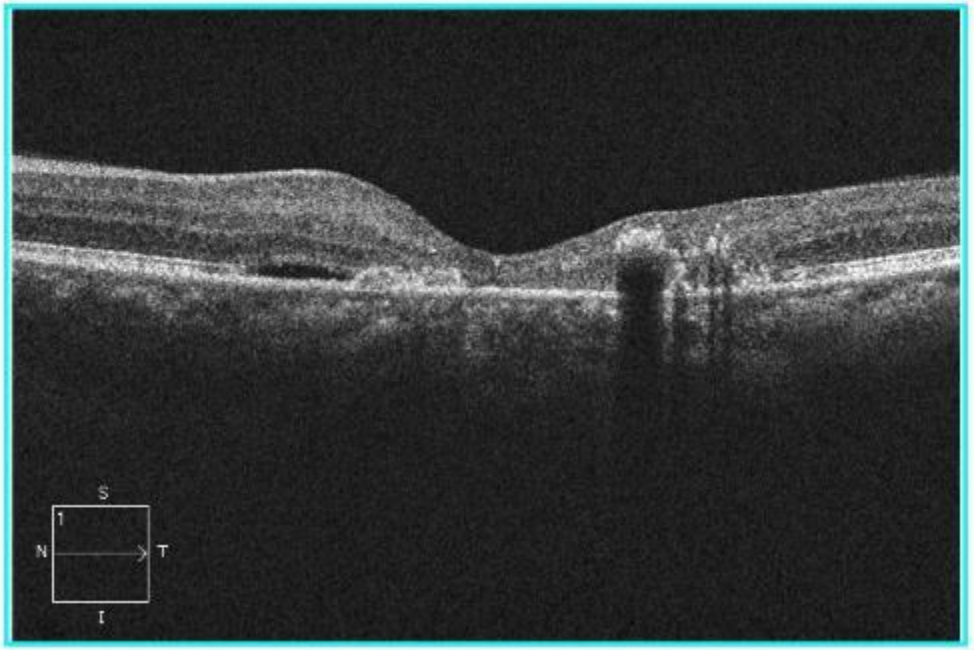








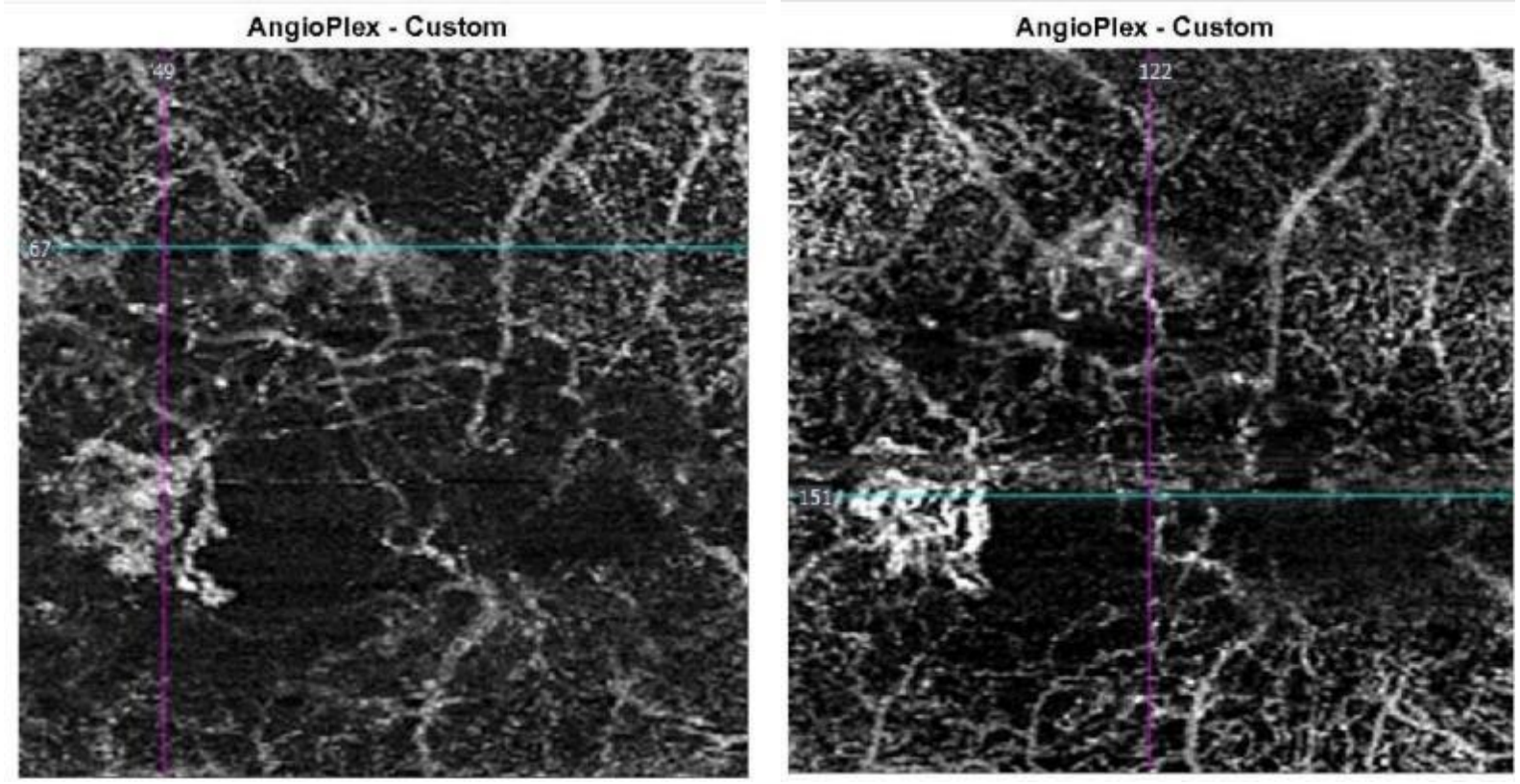




OD

OS

Macular Telangiectasia Type 2

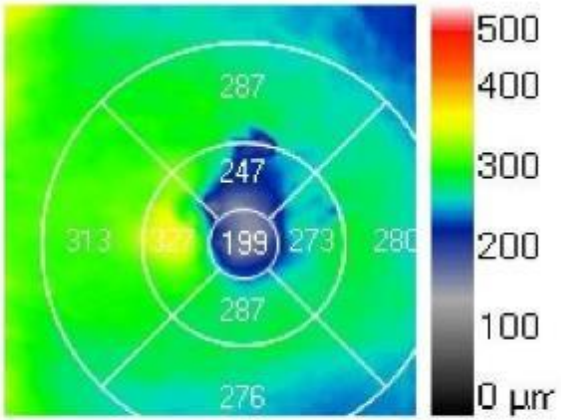


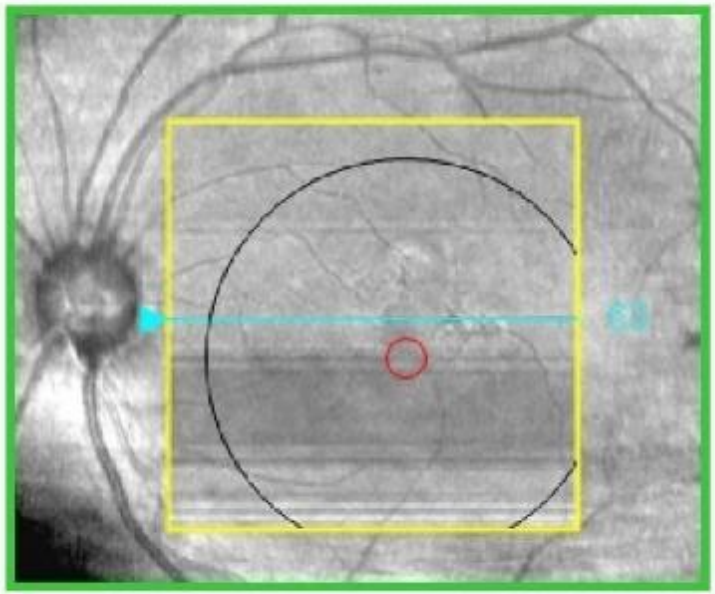
2017 2018

Registration : Automatic Registration succeeded

Exam from 8/4/2017 1:02:18 PM

Fovea: 297, 75

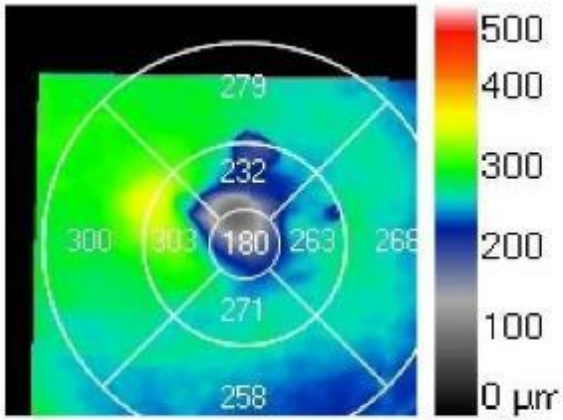


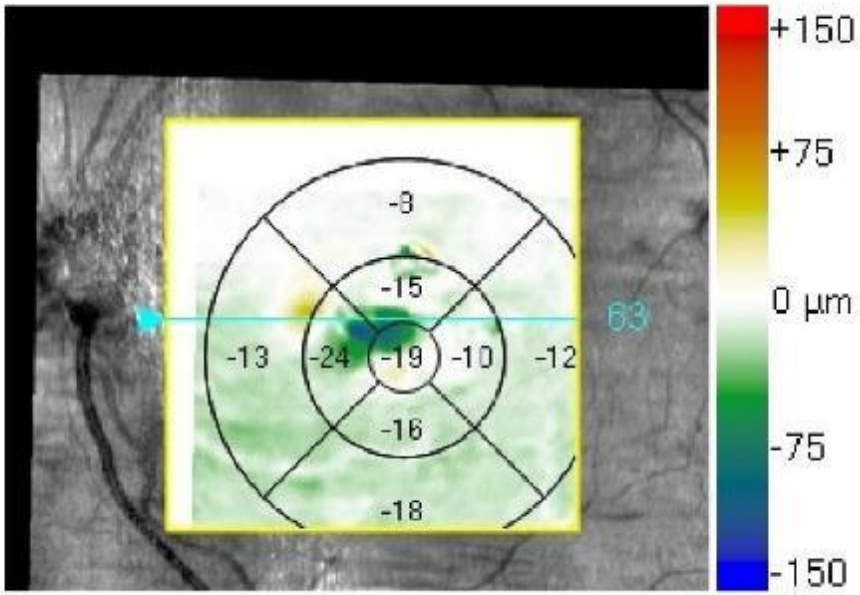


Overlay: OCT Fundus Transparency: 0 %

Exam from 4/13/2018 4:21:07 PM

Fovea: 297, 75



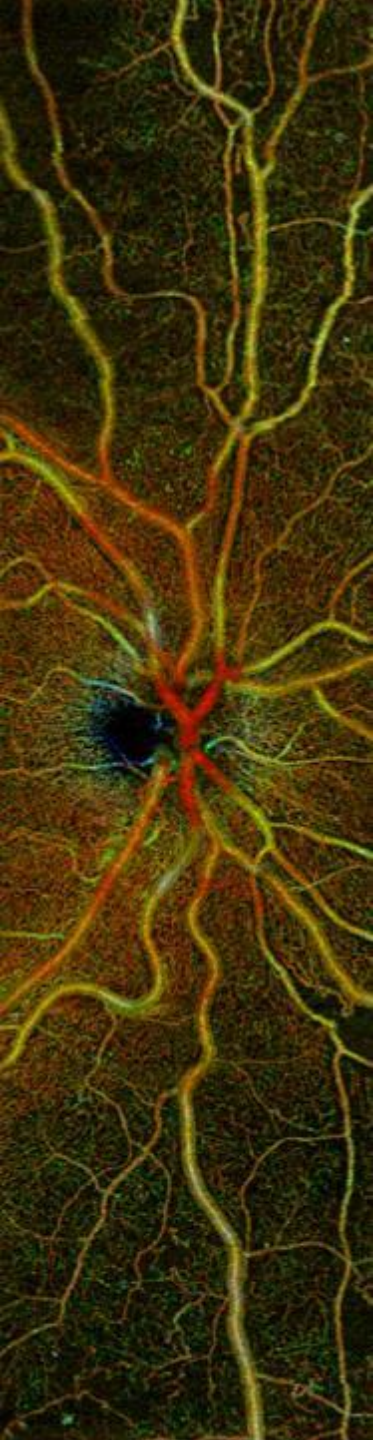


Overlay: ILM-RPE Difference Transparency: 0 %

Macular Telangiectasia Type 2

KEY POINTS

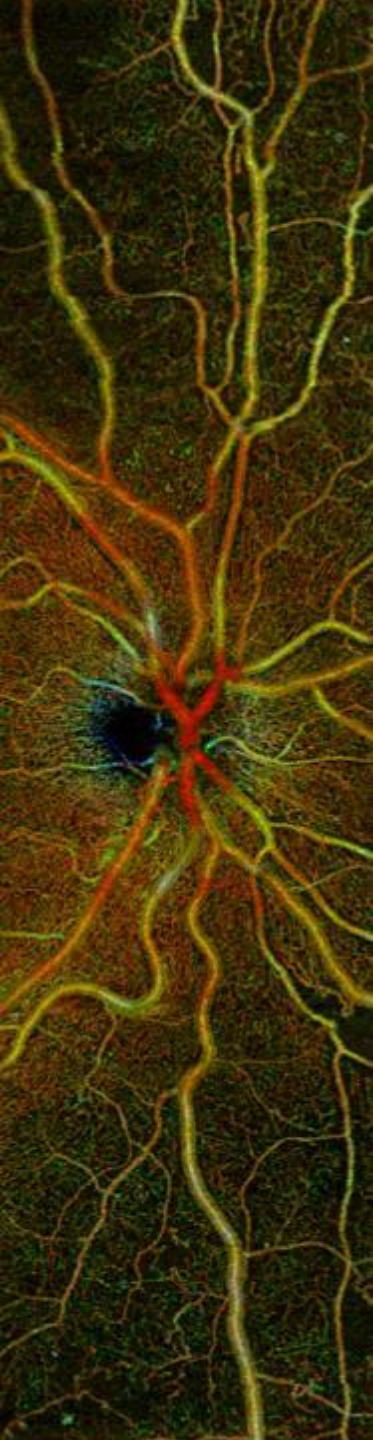
- No effective treatment for nonproliferative disease (macular atrophy)
- Treatment of subretinal neovascularization can prevent vision loss
- OCTA is well suited to visualizing the retinal vascular abnormalities associated with MacTel2, particularly with monitoring subretinal neovascularization



GLAUCOMA

OCTA Clinical Applications

- Screening/diagnosing
- Staging
- Monitoring progression
  - High myopia



GLAUCOMA

AMERICAN ACADEMY OF OPHTHALMOLOGY®

Ophthalmic Technology Assessment

OCT Angiography for the Diagnosis of Glaucoma

A Report by the American Academy of Ophthalmology

Darrell WuDunn, MD, PhD,[1] Hana L. Takusagawa, MD,[2] Arthur J. Sit, MD,[3] Julia A. Rosdahl, MD, PhD,[4] Sunita Radhakrishnan, MD,[5] Ambika Hoguet, MD,[6] Ying Han, MD, PhD,[7] Teresa C. Chen, MD[8]

Purpose: To review the current published literature on the use of OCT angiography (OCTA) to help detect changes associated with the diagnosis of primary open-angle glaucoma.

Methods: Searches of the peer-reviewed literature were conducted in March 2018, June 2018, April 2019, December 2019, and June 2020 in the PubMed and Cochrane Library databases. Abstracts of 459 articles were examined to exclude reviews and non-English articles. After inclusion and exclusion criteria were applied, 75 articles were selected and the panel methodologist rated them for strength of evidence. Three articles were rated level I and 57 articles were rated level II. The 15 level III articles were excluded.

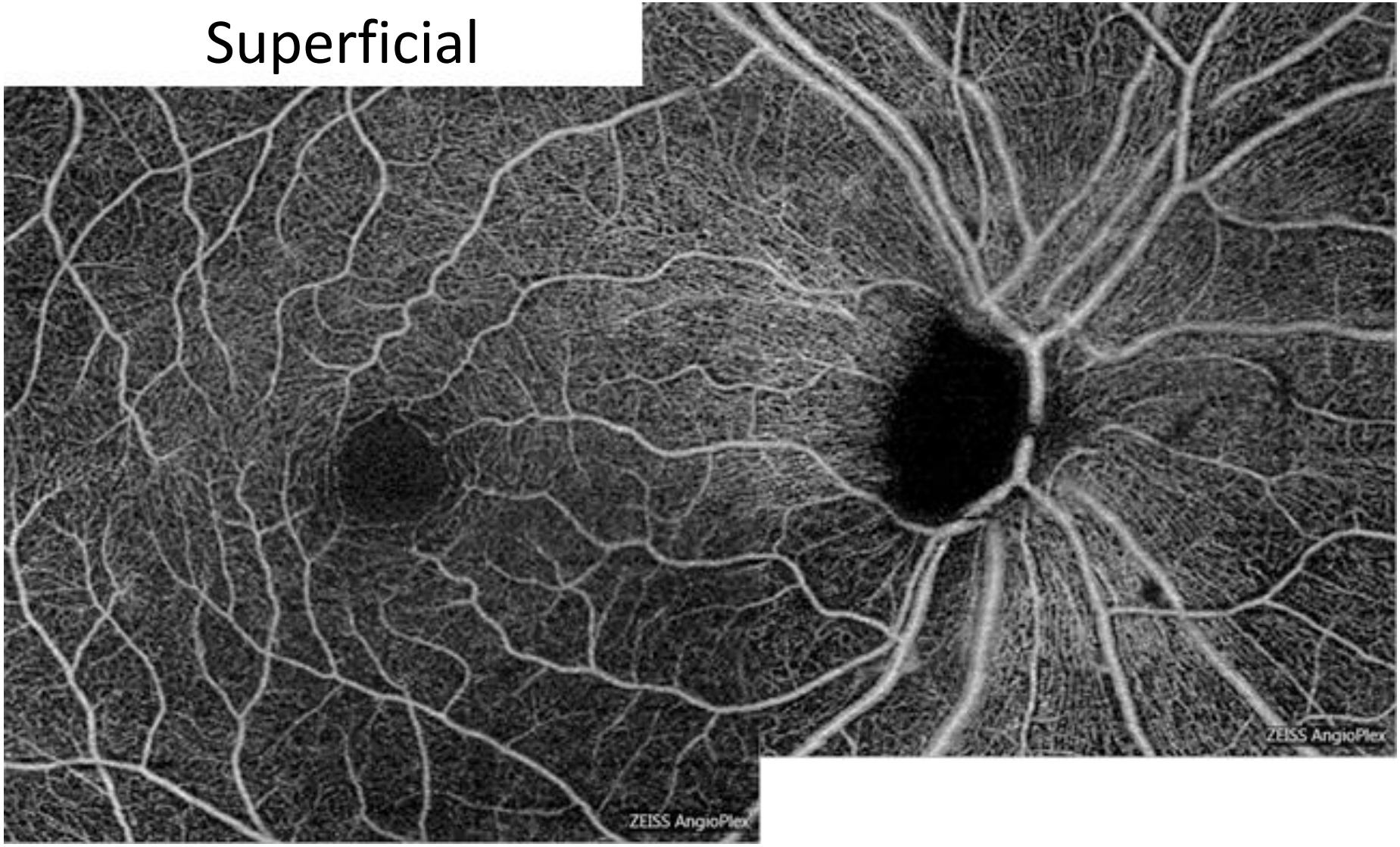
Results: OCT angiography can detect decreased capillary vessel density within the peripapillary nerve fiber layer (level II) and macula (level I and II) in patients with suspected glaucoma, preperimetric glaucoma, and perimetric glaucoma. The degree of vessel density loss correlates significantly with glaucoma severity both overall and topographically (level II) as well as longitudinally (level I). For differentiating glaucomatous from healthy

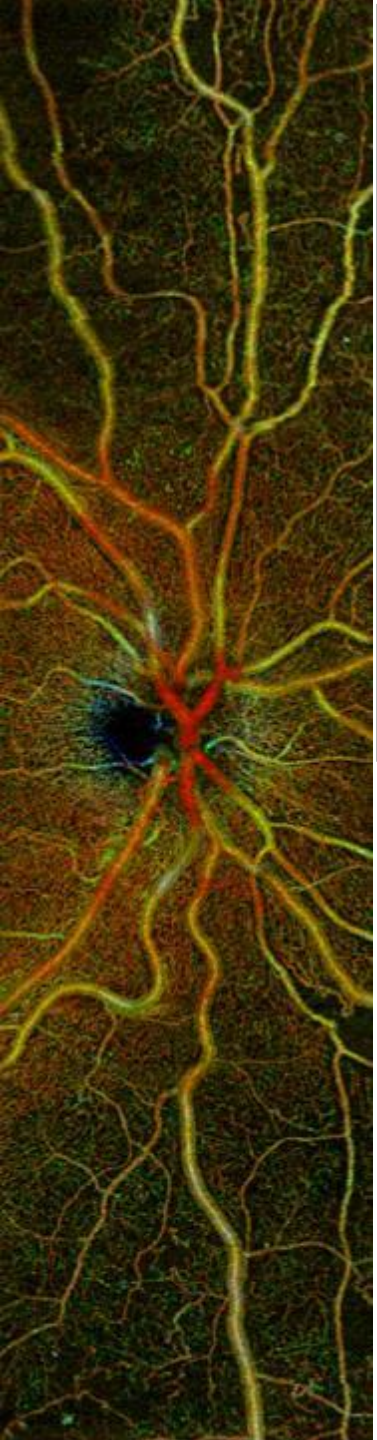
"Vessel density loss associated with glaucoma can be detected by OCTA."

PMID 33632585

Glaucoma

Superficial





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A Review of OCT Angiography in Glaucoma

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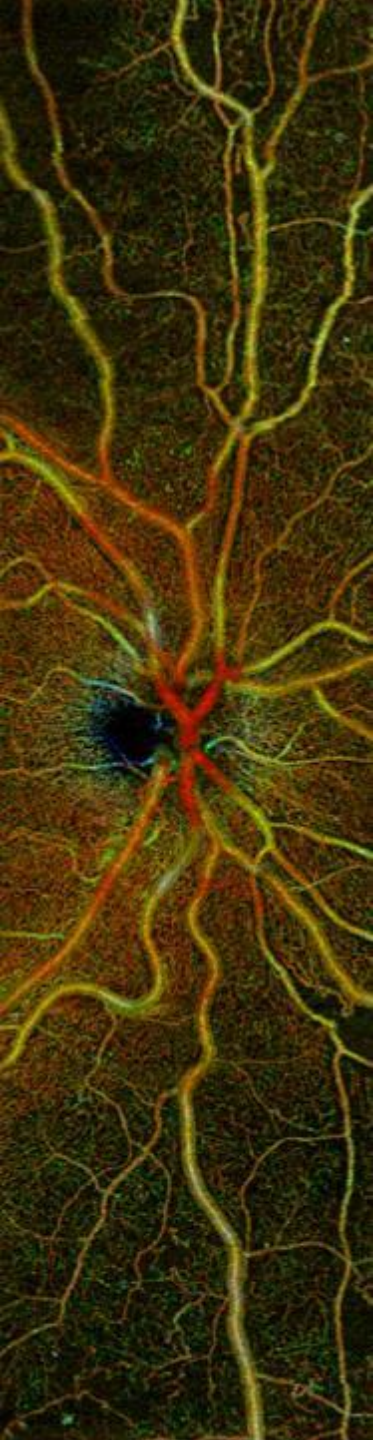
ABSTRACT

There is growing evidence that vascular dysfunction plays a role in the pathogenesis of glaucoma. The details of this relationship have remained elusive partially due to limitations in our ability to assess blood flow in the optic nerve. Optical coherence tomography angiography (OCTA) has emerged as a promising new technology well positioned to become the first clinically suitable test of optic nerve perfusion. OCTA uses the motion of red

"There is early evidence that OCTA may be of particular use in very early or very late stage disease where our current functional or structural diagnostic modalities fall short, however, its superiority to existing technology has not been confirmed."

PMID 31158045



CONCLUSION

- Many advantages over IVFA
- Better detection of non-perfusion in diabetes and vein occlusion
- Earlier detection of pre-retinal neovascularization
- Improved visualization of CNV and precursors
- Potential for early glaucoma detection and end-stage management