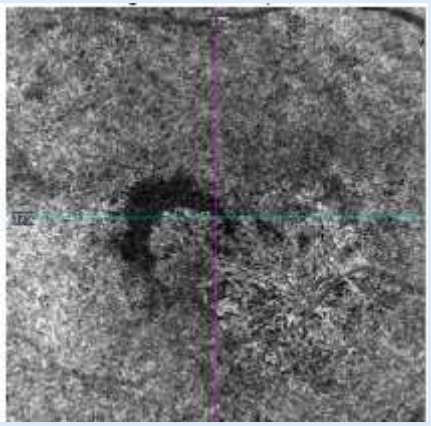


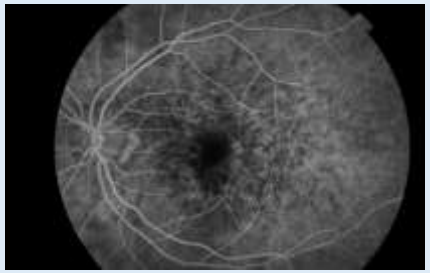
OCT Fundal Angiography Initial Experience

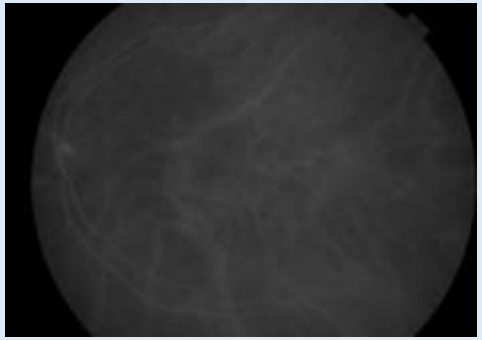
The new era in Medical Retina Imaging

Based on Cirrus 5000 AngioPlex 2016 Model

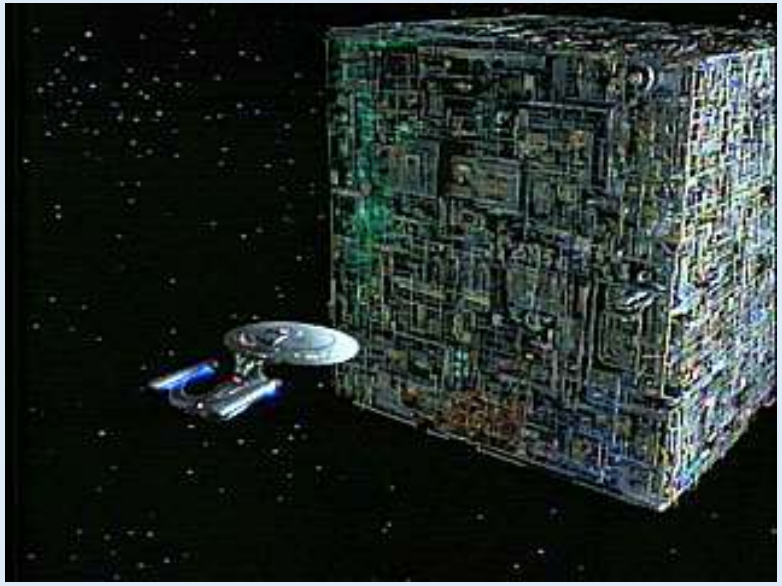
Sheena George & Nicholas Lee

Consultants Ophthalmologist at The Hillingdon Hospital and The Western Eye Hospital in London UK





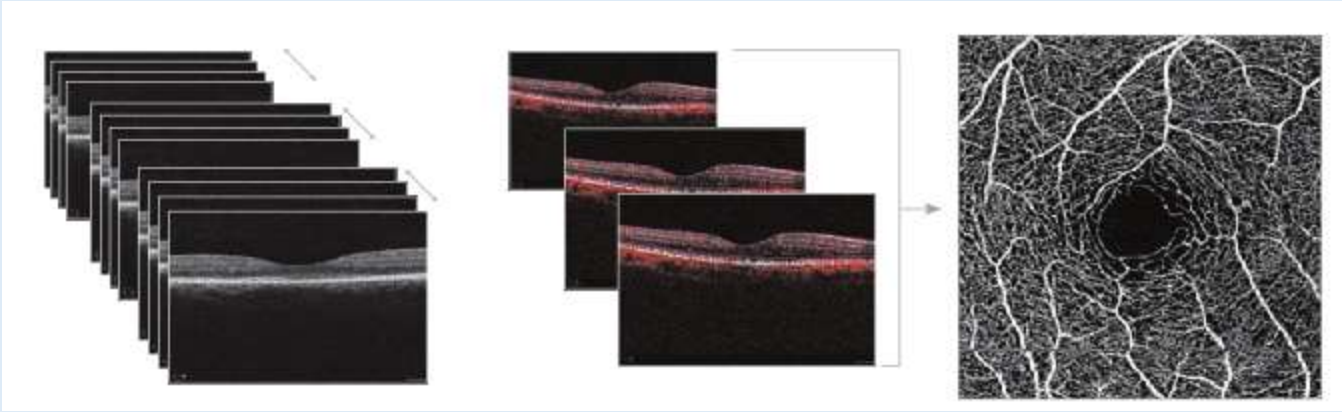
OCT – Angiography
New Era of Dye Less Angiography

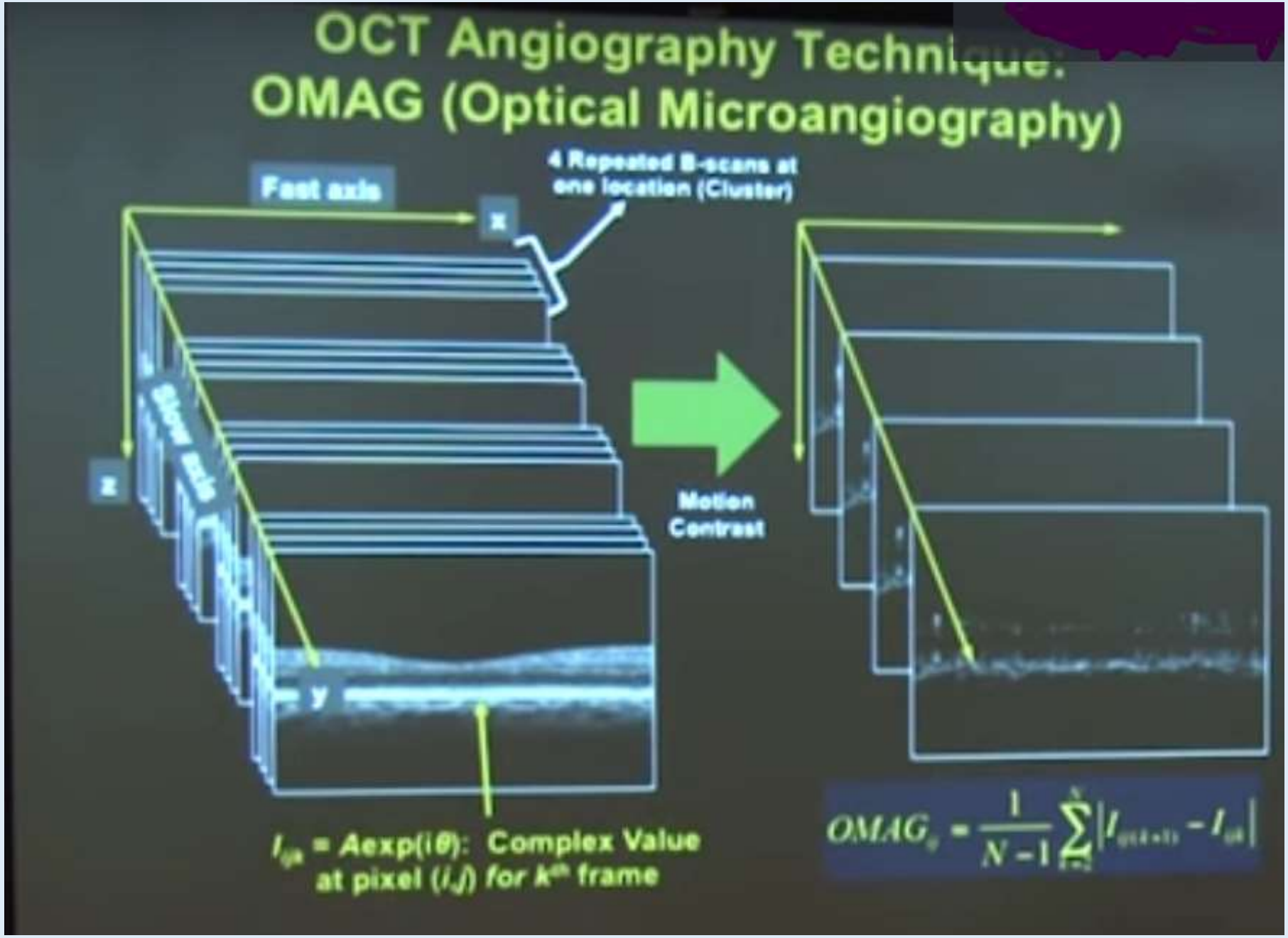


- Key is OCT Laser scanners increased from 27,000 to 68,000+ Hz
    - Time to do scans is shorter
      2.6 for 512 image, 1.8 for 200 image and 0.8 for Raster
- 840um Wavelength for resolution
    - Shorter wavelength = higher resolution
    - Longer wavelength = greater depth penetration – eg swept Source
- 5um and 15um Axial/horizontal resolution
    - Limited by wavelength
- 36 x 30 degree view
    - Limited by optics designs
    - Typically 3 to 6 to 8mm squares
- >67 Million data cube points for Cube data analysis
    - Fast i7 chips allow for rapid processing – Near instant now.

Blood Moves!

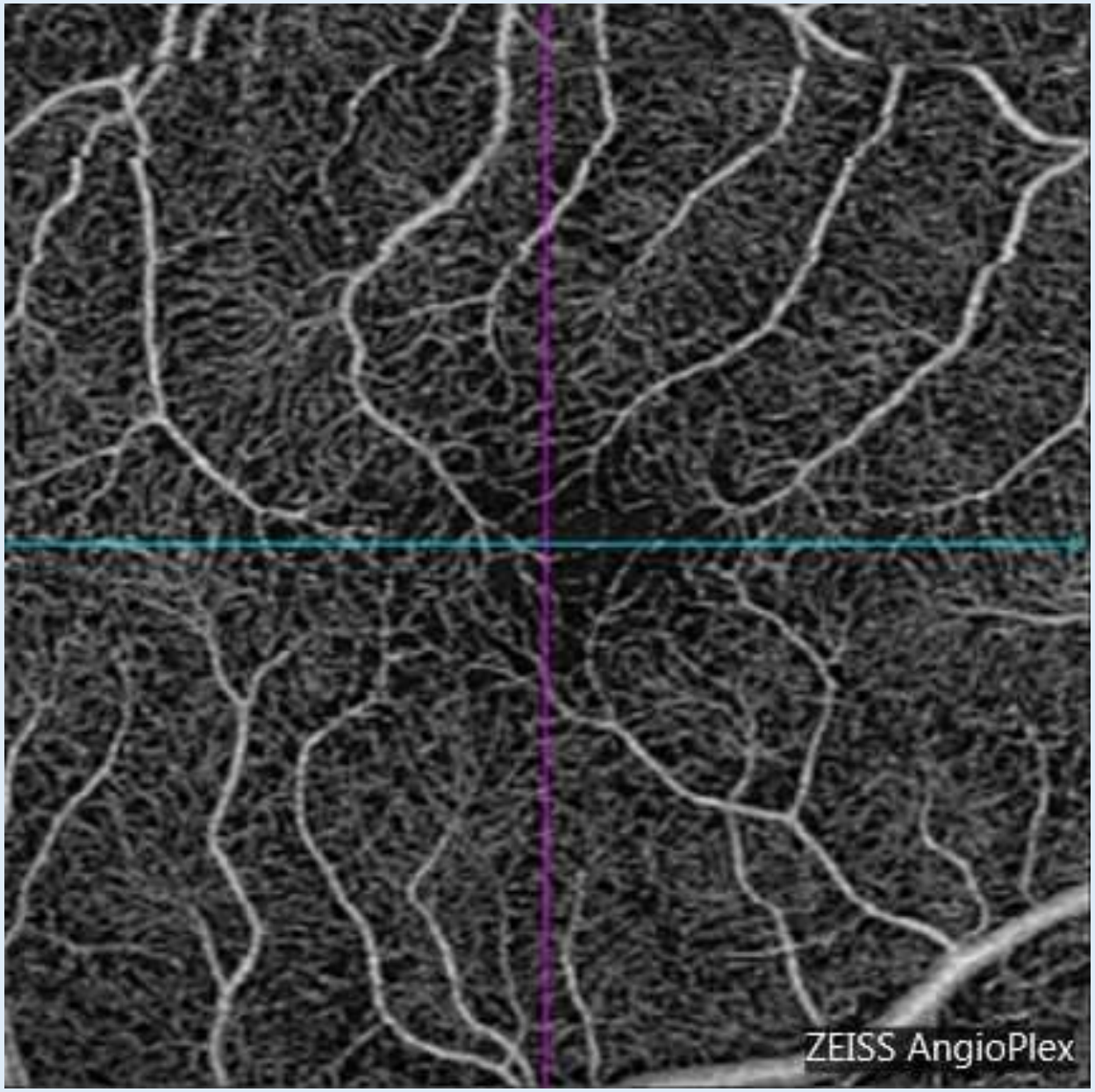
- Blood flows in veins and arteries
- Detect moving blood highly reflective
- Imaging the vessels where blood moves
- Ultrafast scanners can look for changes = blood flow
- 4 scans taken per slice
- Accurate Live eye tracking is key
- Computers calculate and render the data into images of the blood vessels




OCT Angiography Technique:
OMAG (Optical Microangiography)
Fast axis
4 Repeated B-scans at one location (Cluster)
x
z
y
Slow axis
Motion Contrast
I_{ijk} = Aexp(iθ): Complex Value at pixel (i,j) for k^th frame
$OMAG_{ij} = \frac{1}{N-1}\sum_{k=1}^{N-1}\left|I_{ij(k+1)} - I_{ijk}\right|$

Normal OCT-A Enface Blood flow

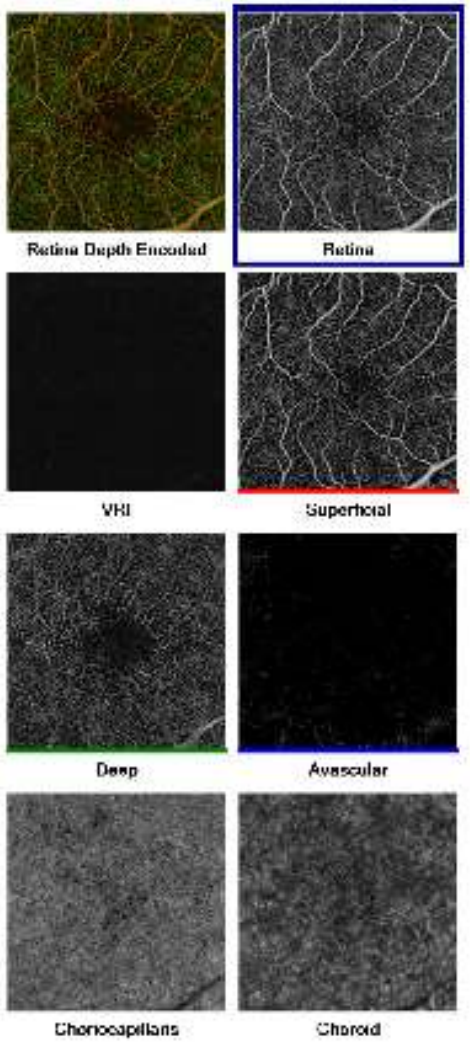
- As useful as abnormal
- Vitreous – New vessels
- Retinal circulation – Diabetes, Vein occlusions
  - Better resolution than FFA
- Mid retina – Aneurysm, RAP
- Choriocapillaris - AMD, PED
- Choroid – Naevi, Melanoma



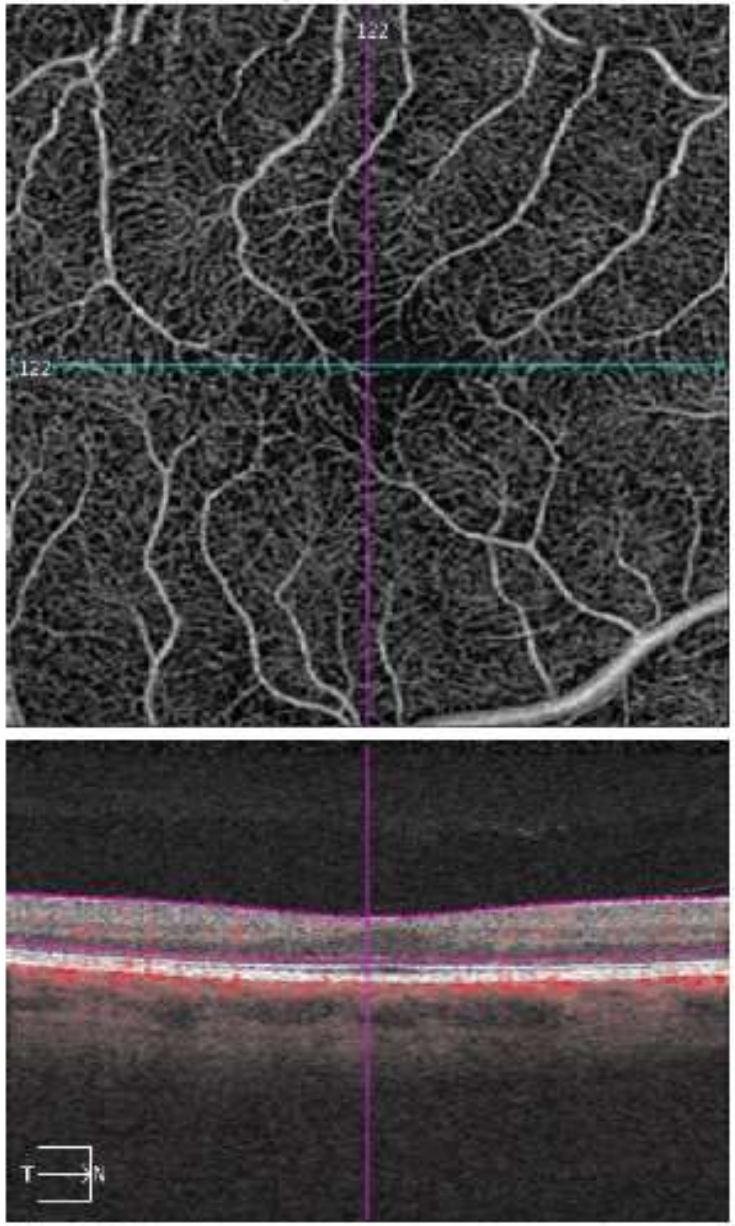
Zeiss OCT-A Standard Screen/Printed Report

Angiography Analysis : Angiography 3x3 mm

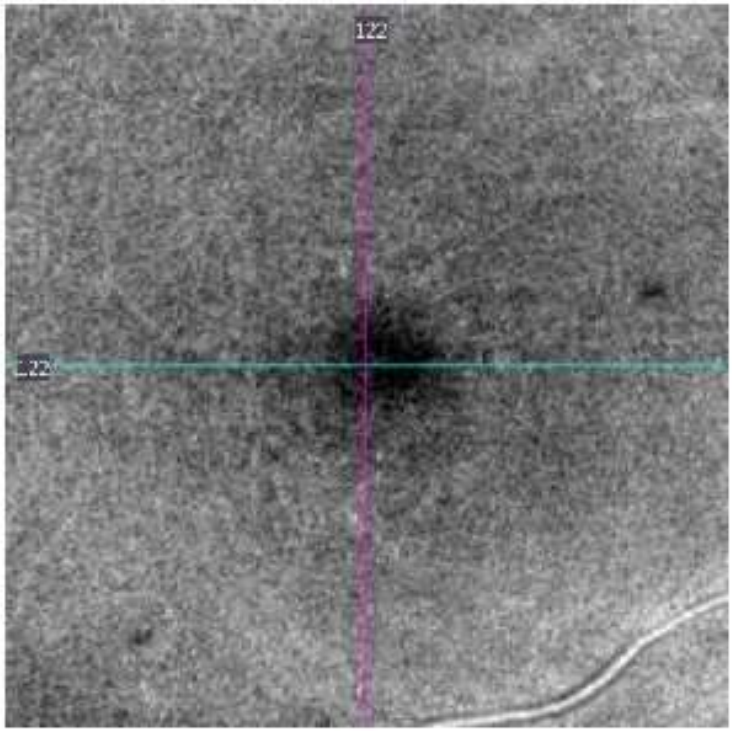
OD ● | ○ OS



AngioPlex - Retina



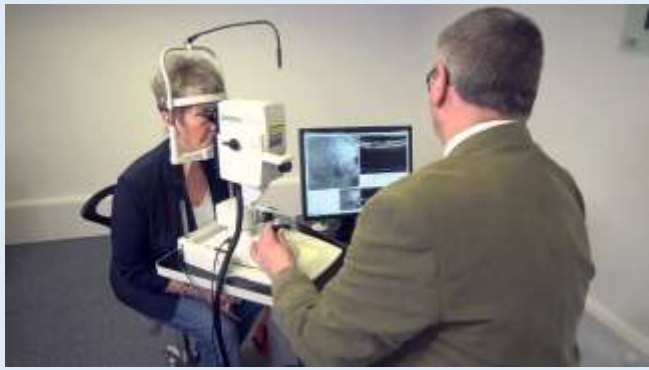
Structure - Retina



Current View:Retina

Reference	Offset
Top: ILM	0
Bottom: RPEFit	-70

What OCT-A Machines are out there



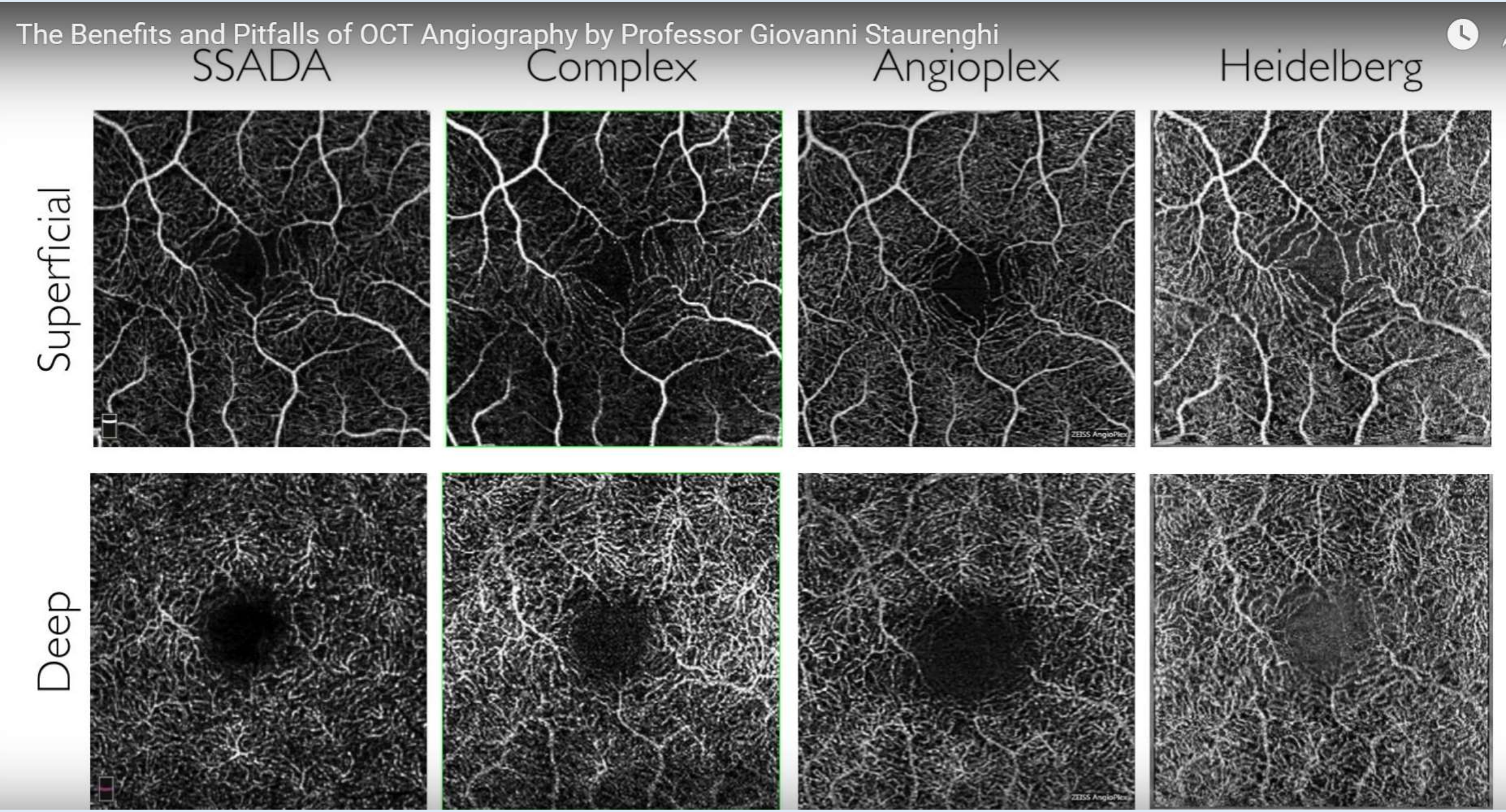
- March 2016 Zeiss 5000 - Solely OCT 78Khz
- 2017 Heidelberg Spectablis – OCT 85Khz
- December 2015 Topcon Triton – Swept source 100Khz + Fundal Camera
- Nidek Rs-3000 Advance (53Khz)
- OptoVue – Haag-Streit, AngioMontage, Angio Anlaysis 70Khz

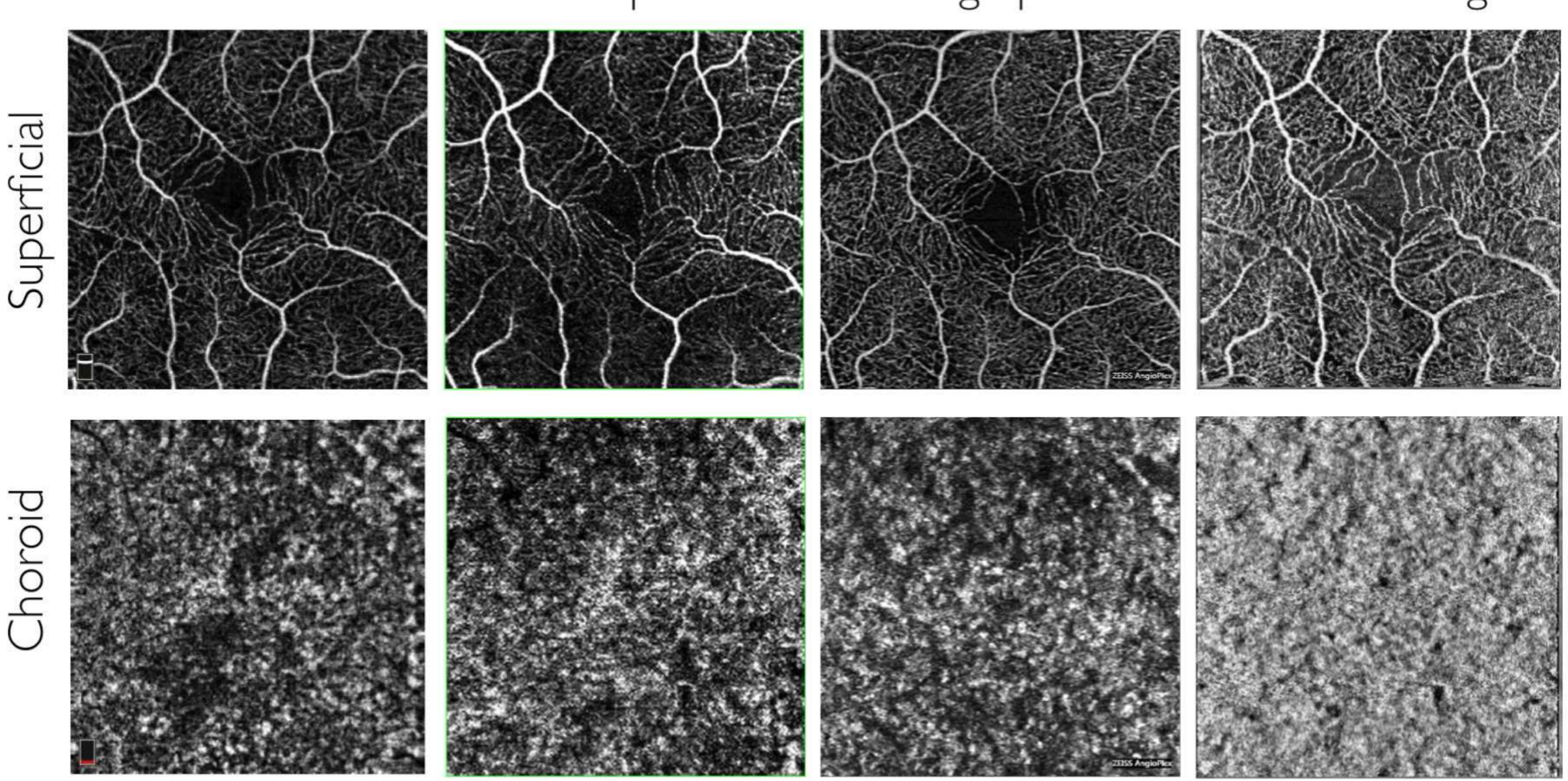
Different types of algorithms

- Zeiss
  - OMAG Optical Microangiography
- Heidelberg
  - Full spectrum-Decorrelation angiography
- Topcon
  - Full spectrum Ratio Based-amplitude ratio analsysi
- Optovue
  - Split spectrum amplitude decorrelation angiography

- Four OCTA Methods
  - Speckle Variance SV OCTA
  - Amplitude decorrelation
  - Phase Variance
  - Combination of Amplitude and Phase variance
- Two Averaging
  - Split spectrum
  - Volume averaging

The Benefits and Pitfalls of OCT Angiography by Professor Giovanni Staurenghi

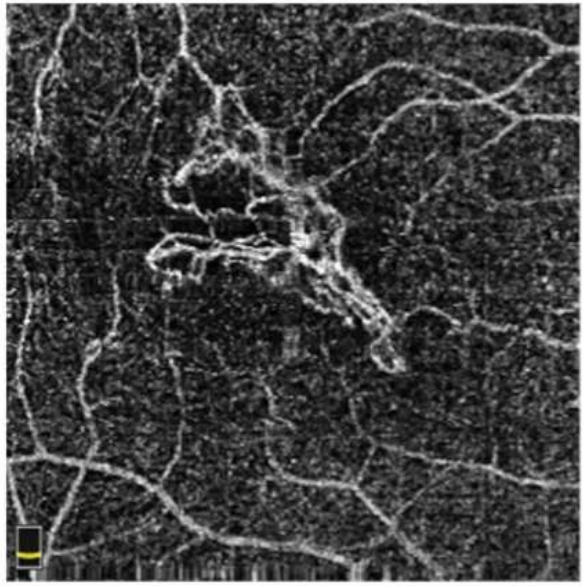



SSADA
Complex
Angioplex
Heidelberg
Superficial
Choroid
ZEISS AngioPlex
ZEISS AngioPlex

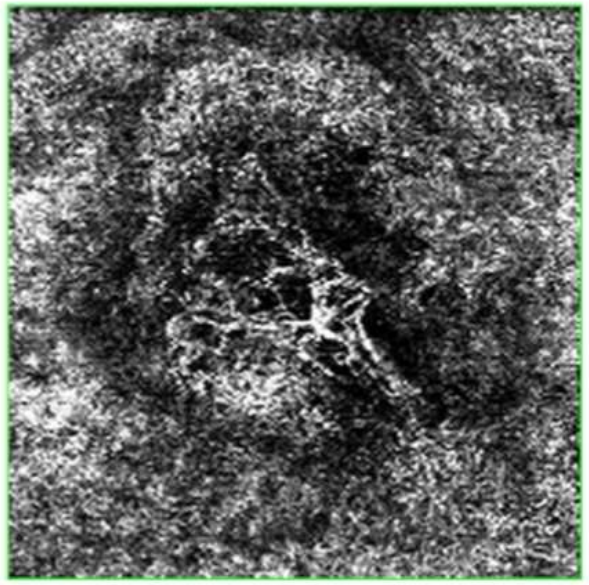
The Benefits and Pitfalls of OCT Angiography by Professor Giovanni Staurenghi

Choroidal Neovascularization

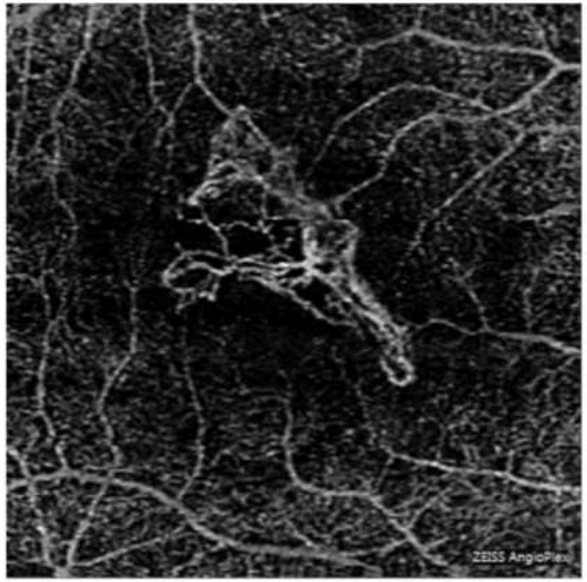
SSADA



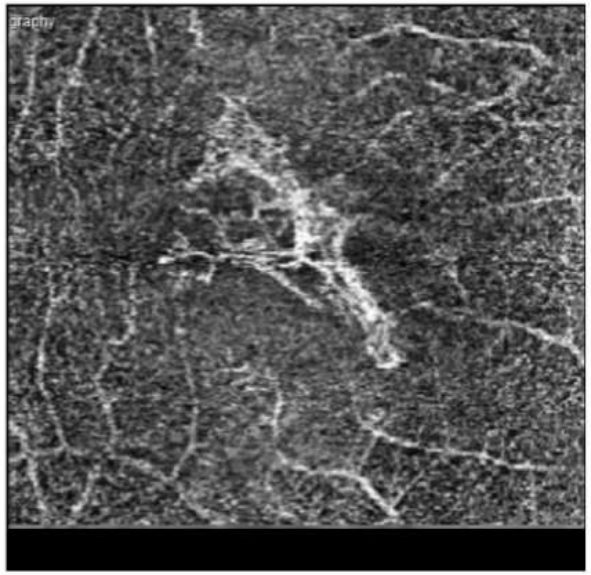
Complex



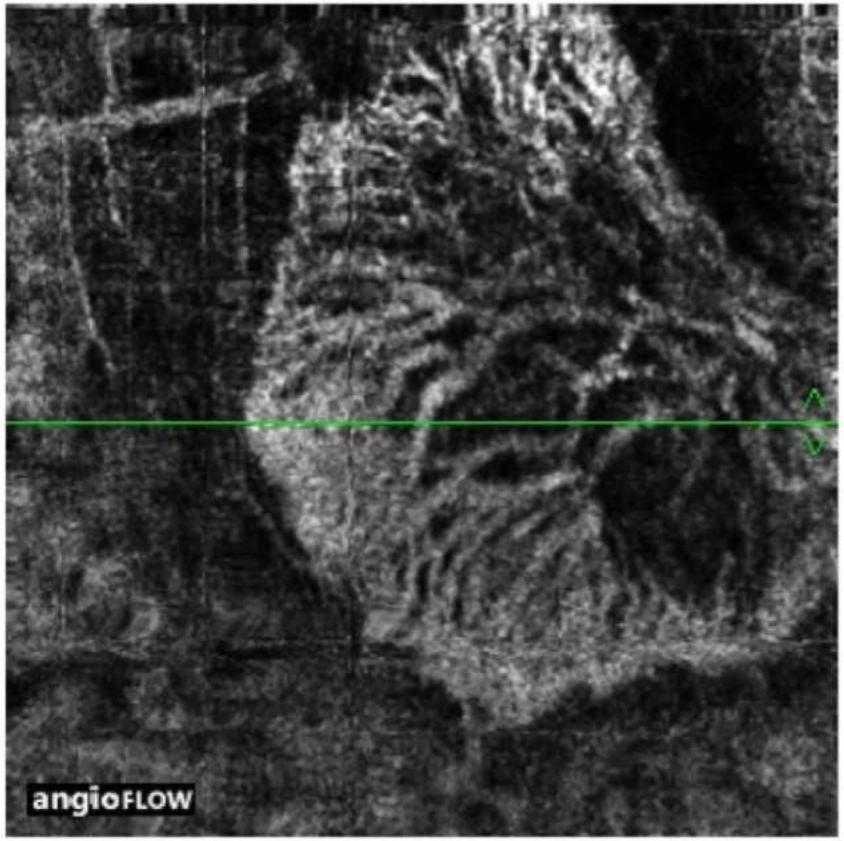
Angioplex

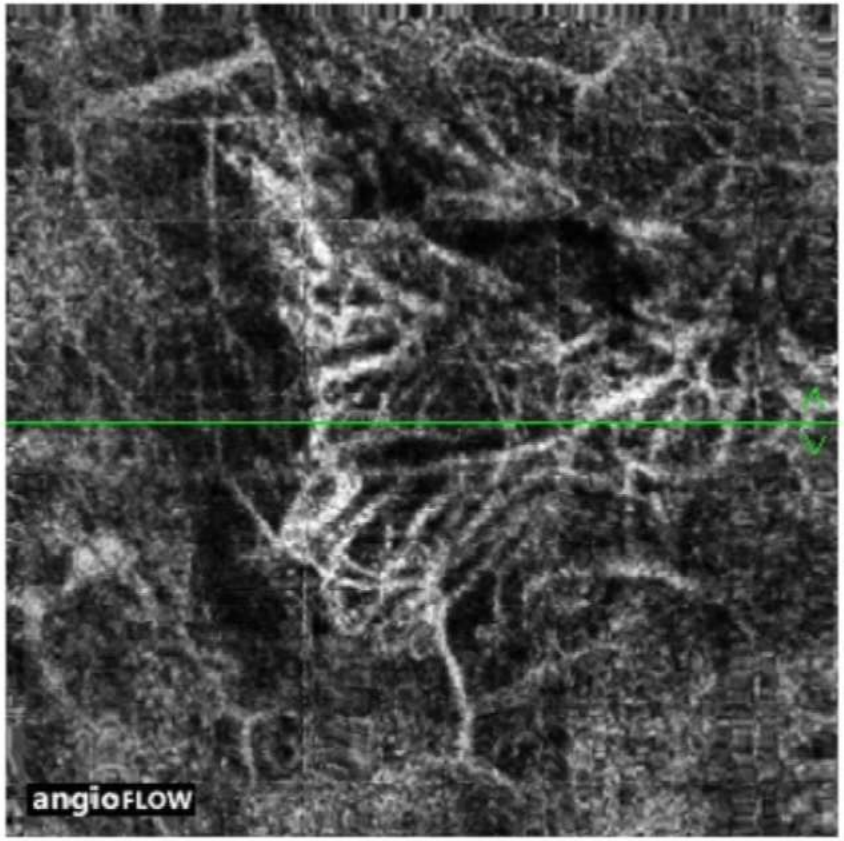


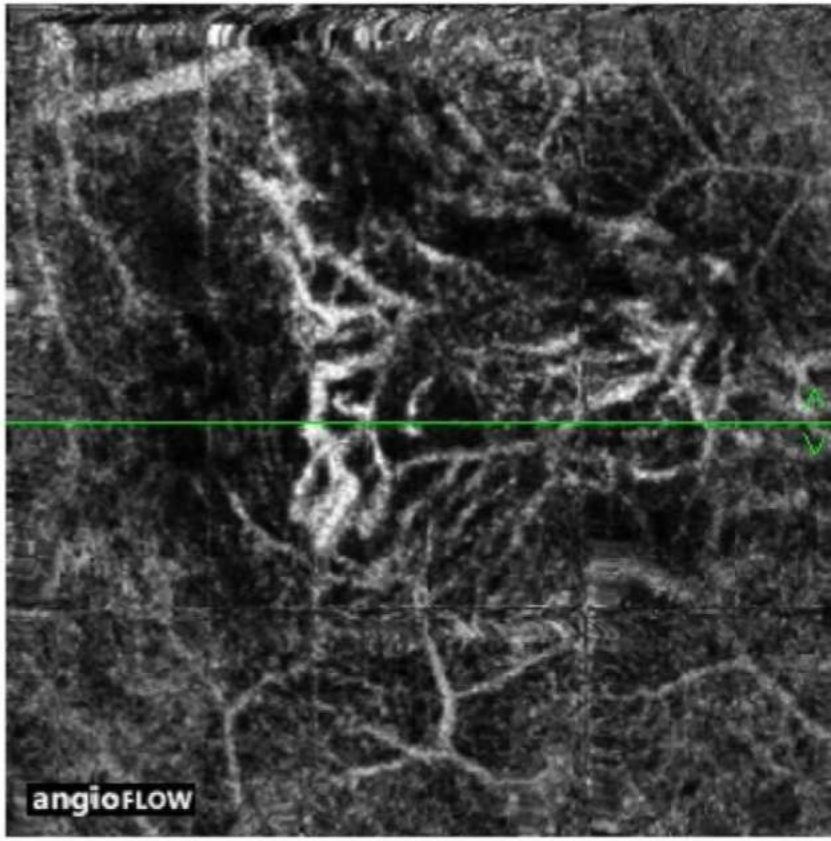
FSADA

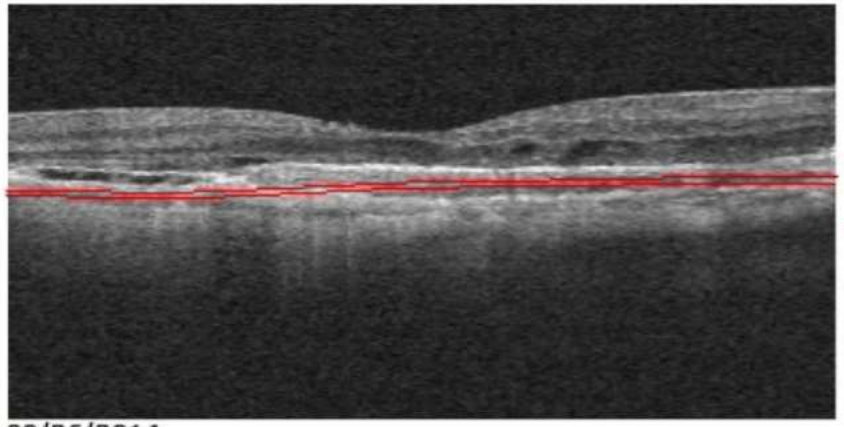


Angio Retina Change Analysis

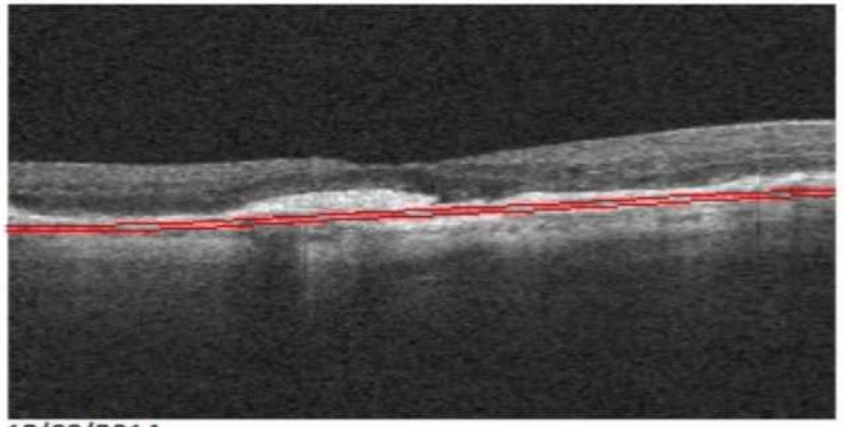




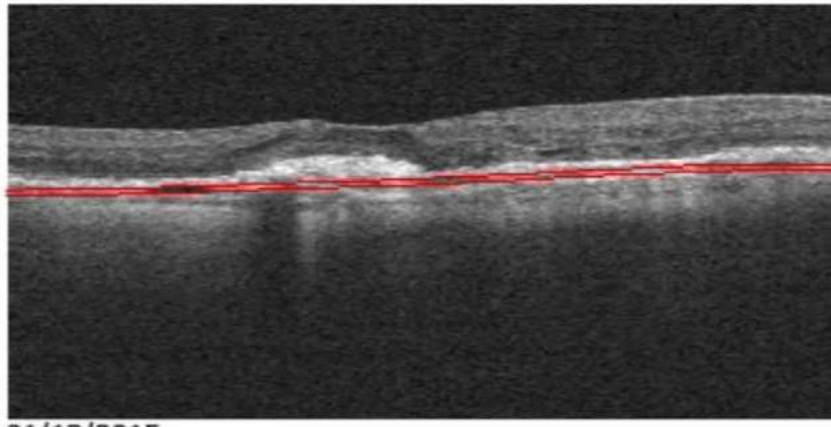




09/26/2014

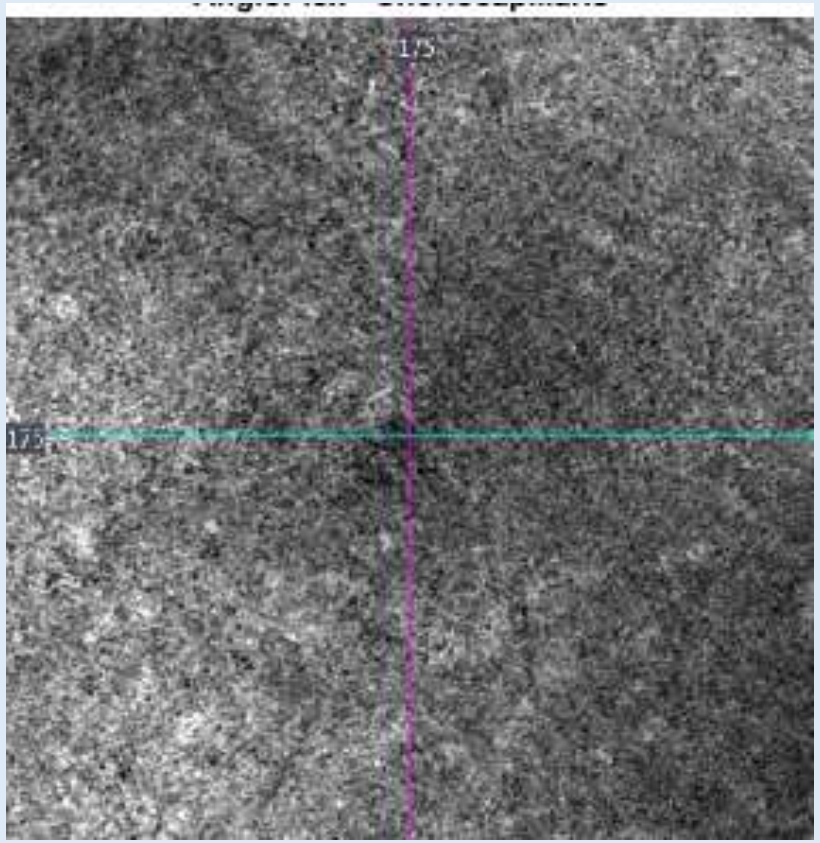


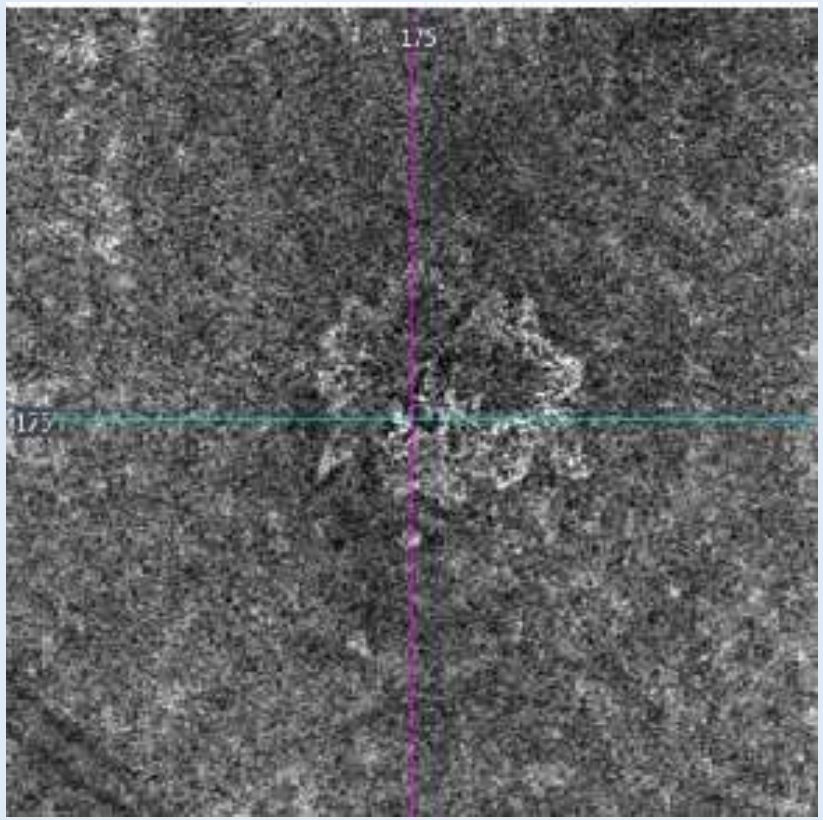
12/09/2014

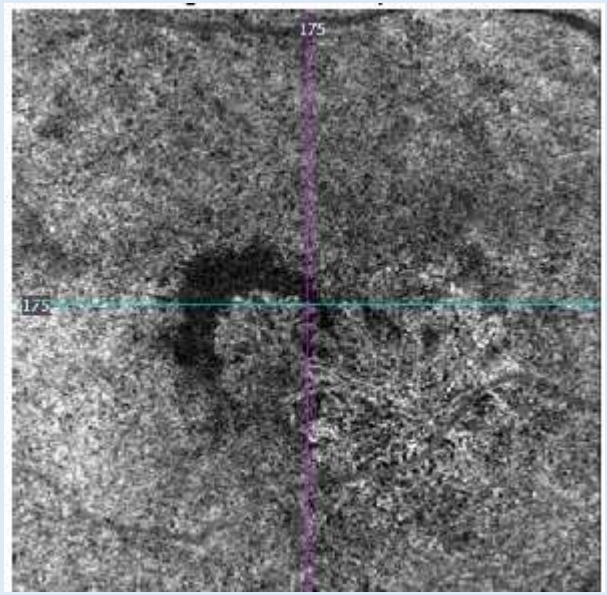


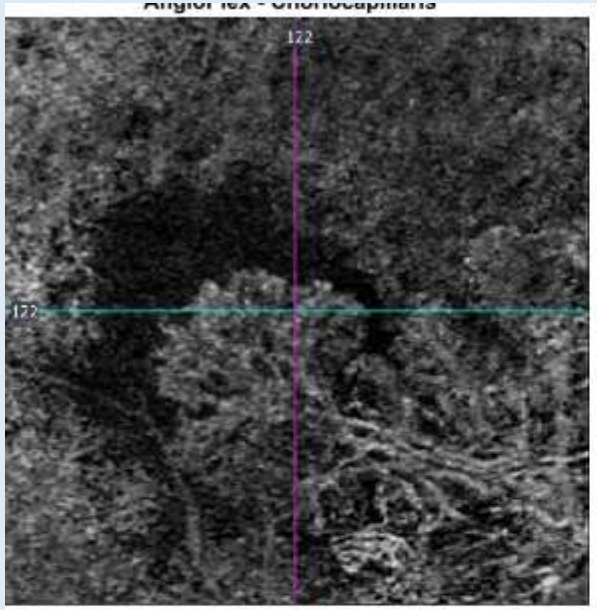
01/13/2015

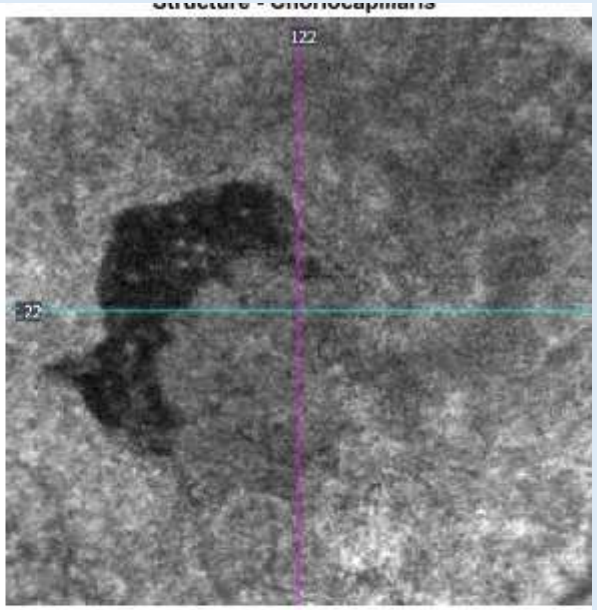
Normal Choriocapillaris vs abnormal inactive

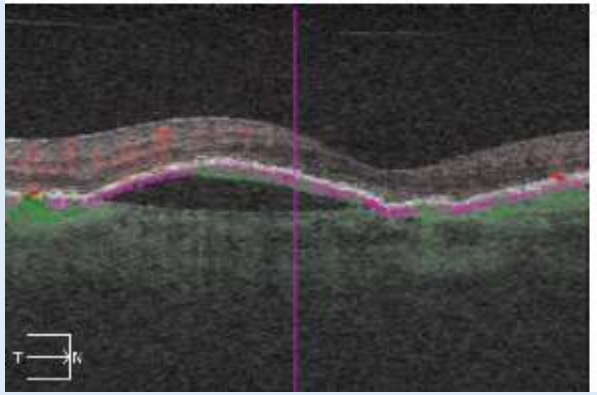










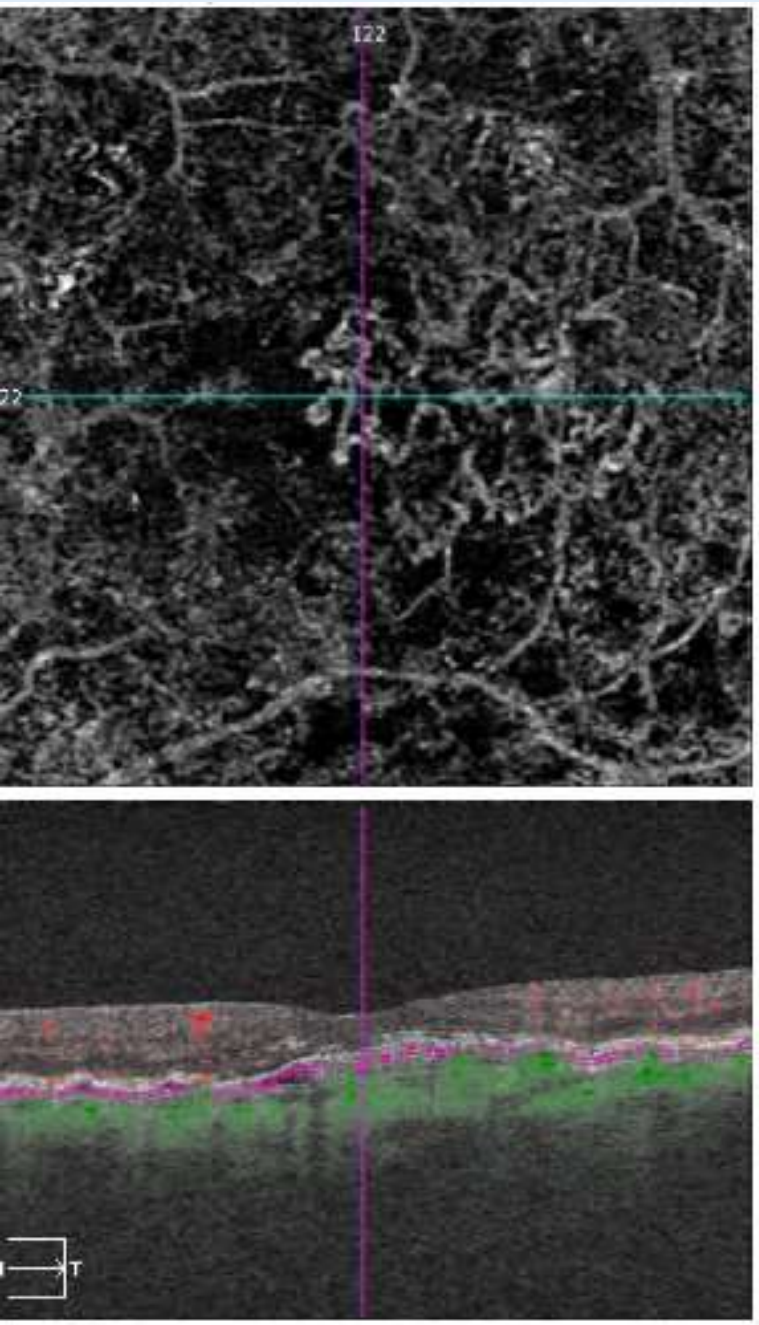


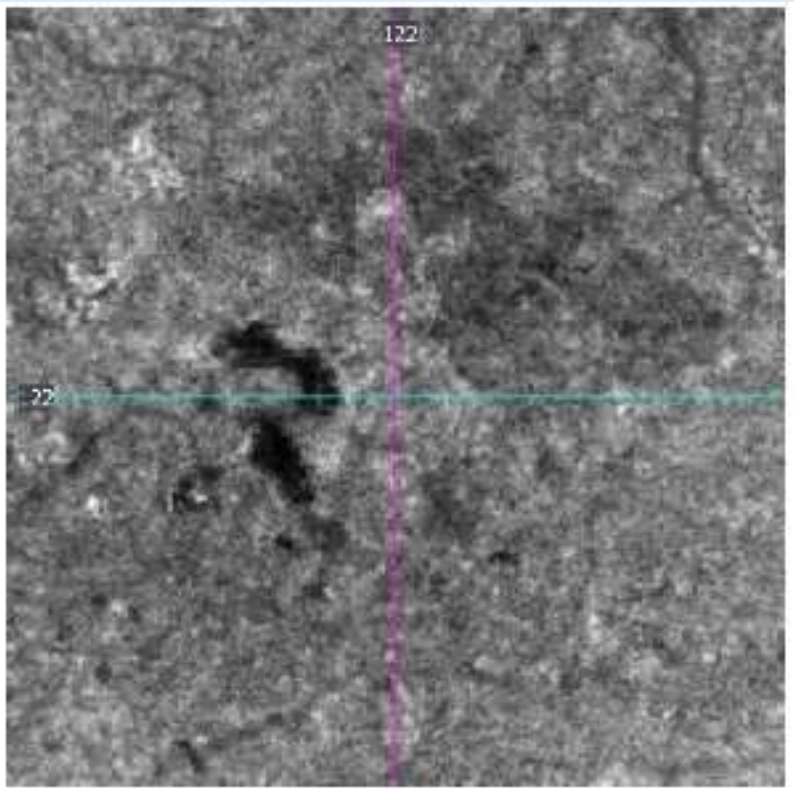
Current View:Choriocapillaris

Reference	Offset
Top: RPE	29
Bottom: RPE	49

Classical SRNVM that has been treated and a new recurrence has fanned out from the edge of the old lesion

These originate from one central vessel growth and spread like petals of a flower



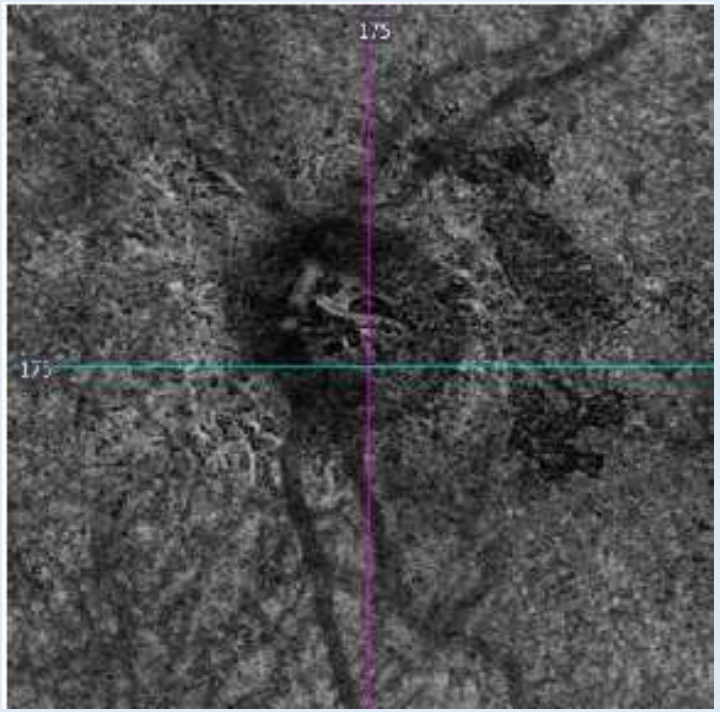


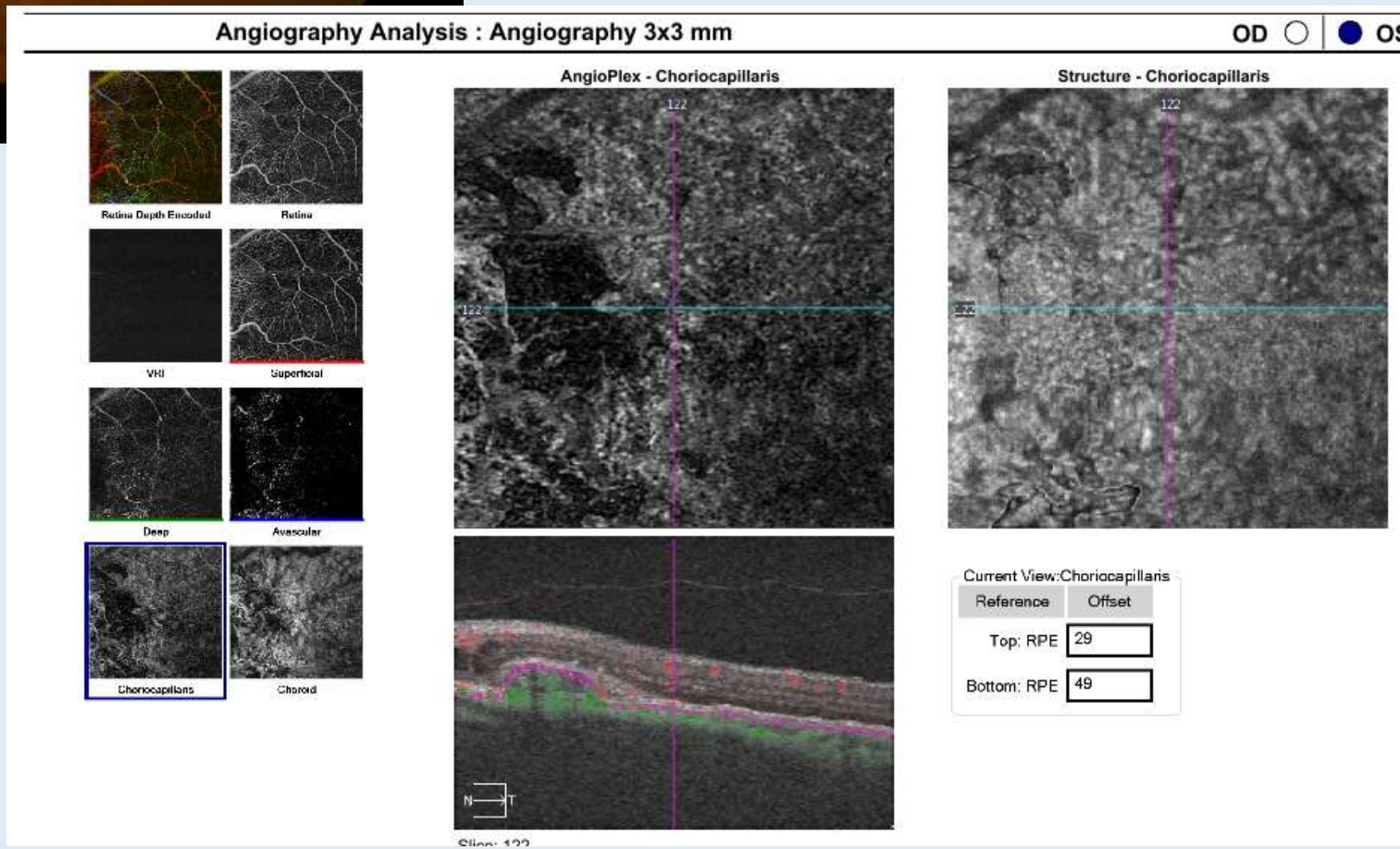
Current View:Choriocapillaris

Reference	Offset
Top: RPE	29
Bottom: RPE	49

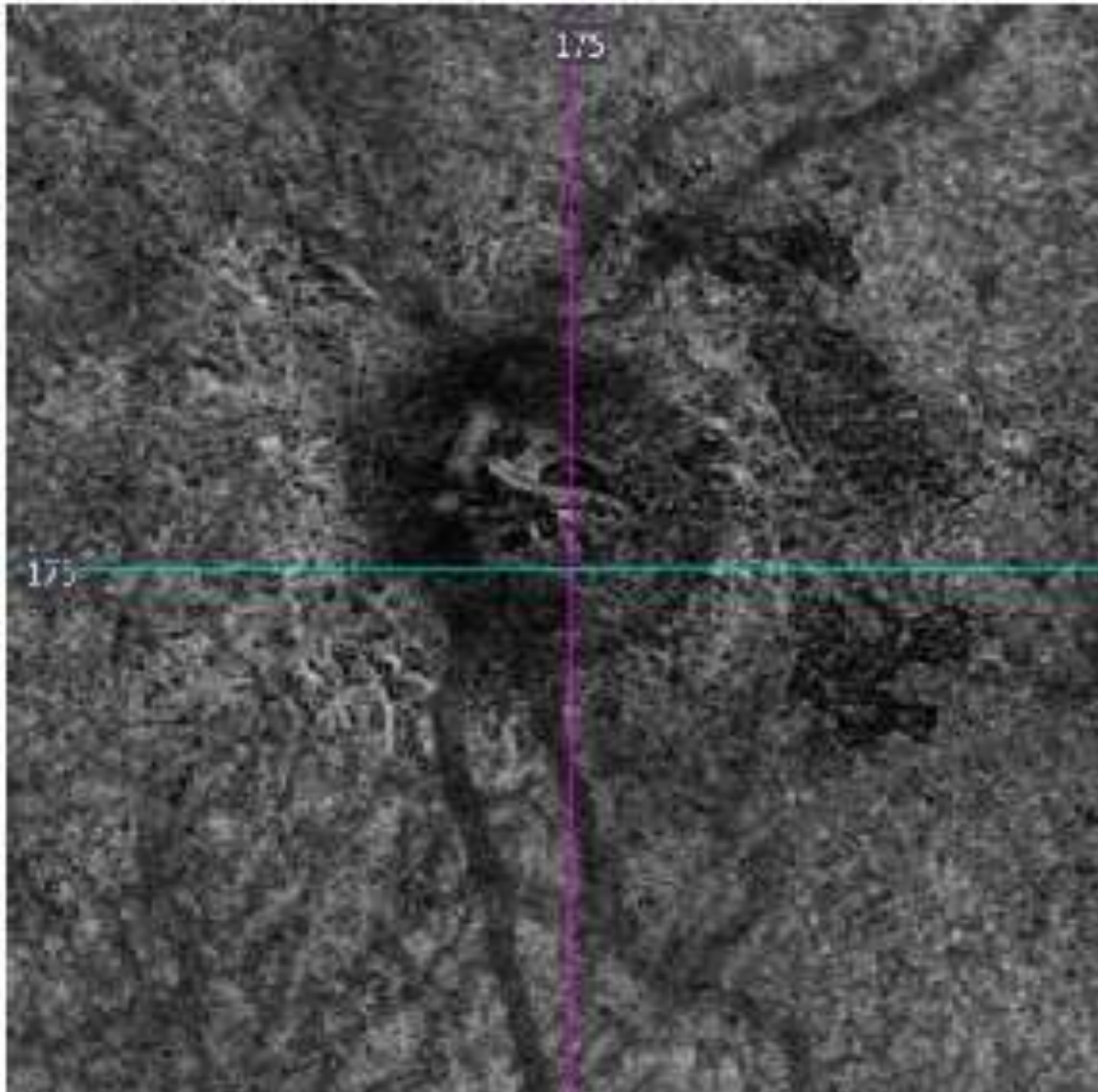
Tracked during scan

High quality Definition of SRNVM in AMD


175
175

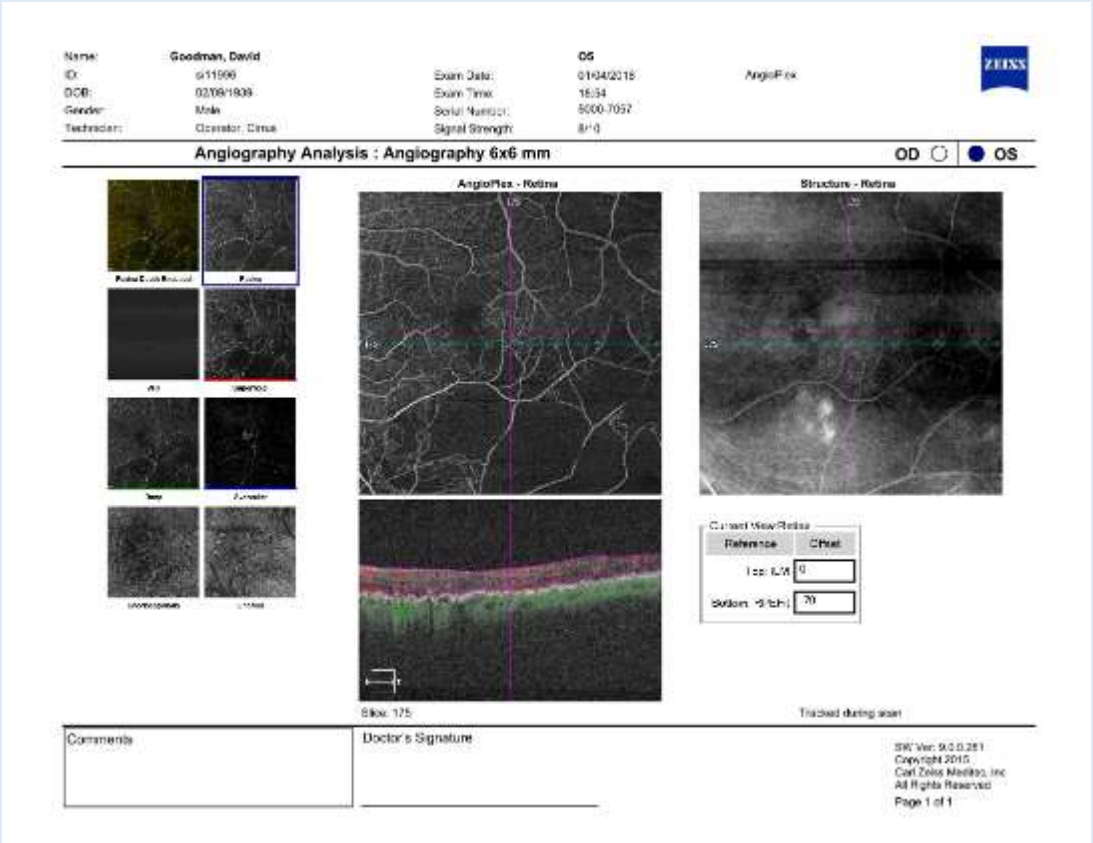

Angiography Analysis : Angiography 3x3 mm
OD
OS
Retina Depth Encoded
Retina
VRI
Superficial
Deep
Avascular
Choriocapillaris
Choroid
AngioPlex - Choriocapillaris
Structure - Choriocapillaris
122
122
122
122
Current View:Choriocapillaris
Reference
Offset
Top: RPE
29
Bottom: RPE
49
N
T

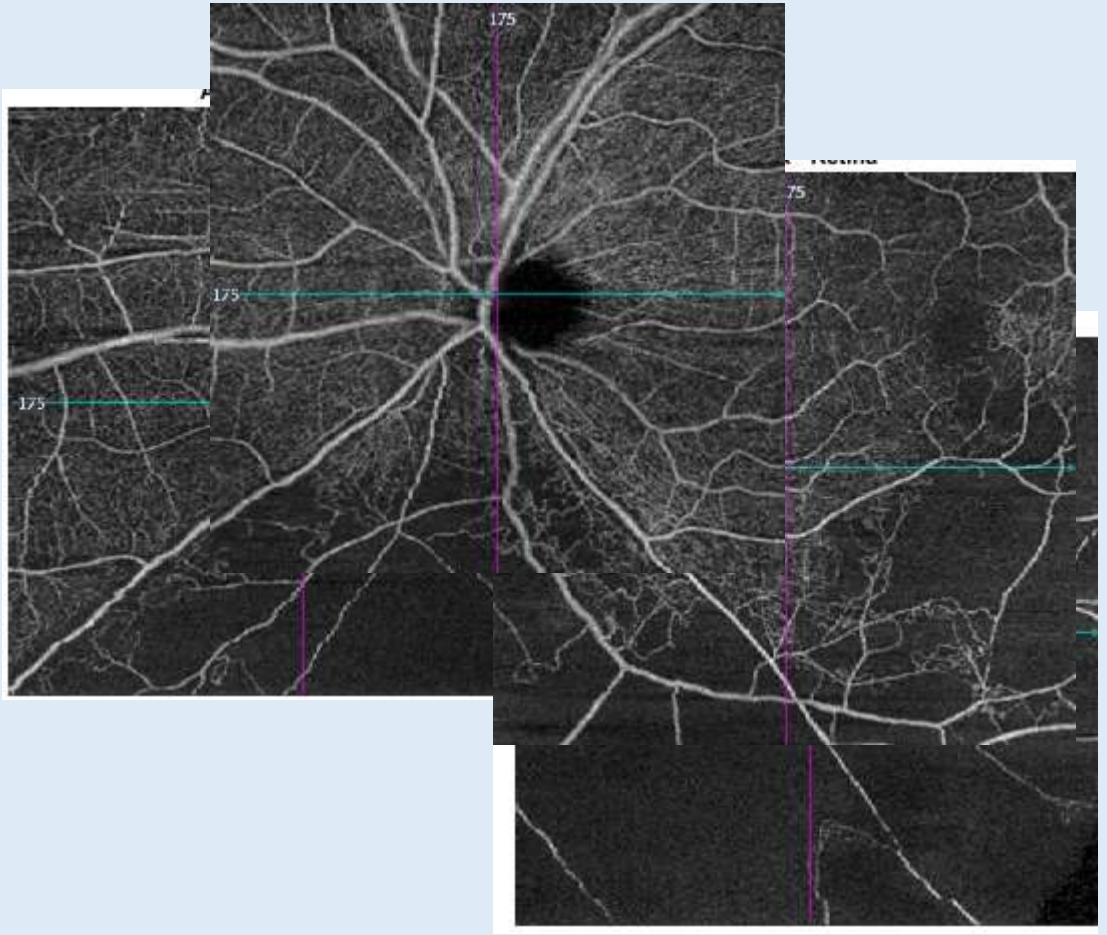
- Enhanced detail
- ConFocal Image
- Helpful to compare the two FFA and OCT-A at times
- Segmentation adjustments
- Still need Colour Photo



Making a Collage

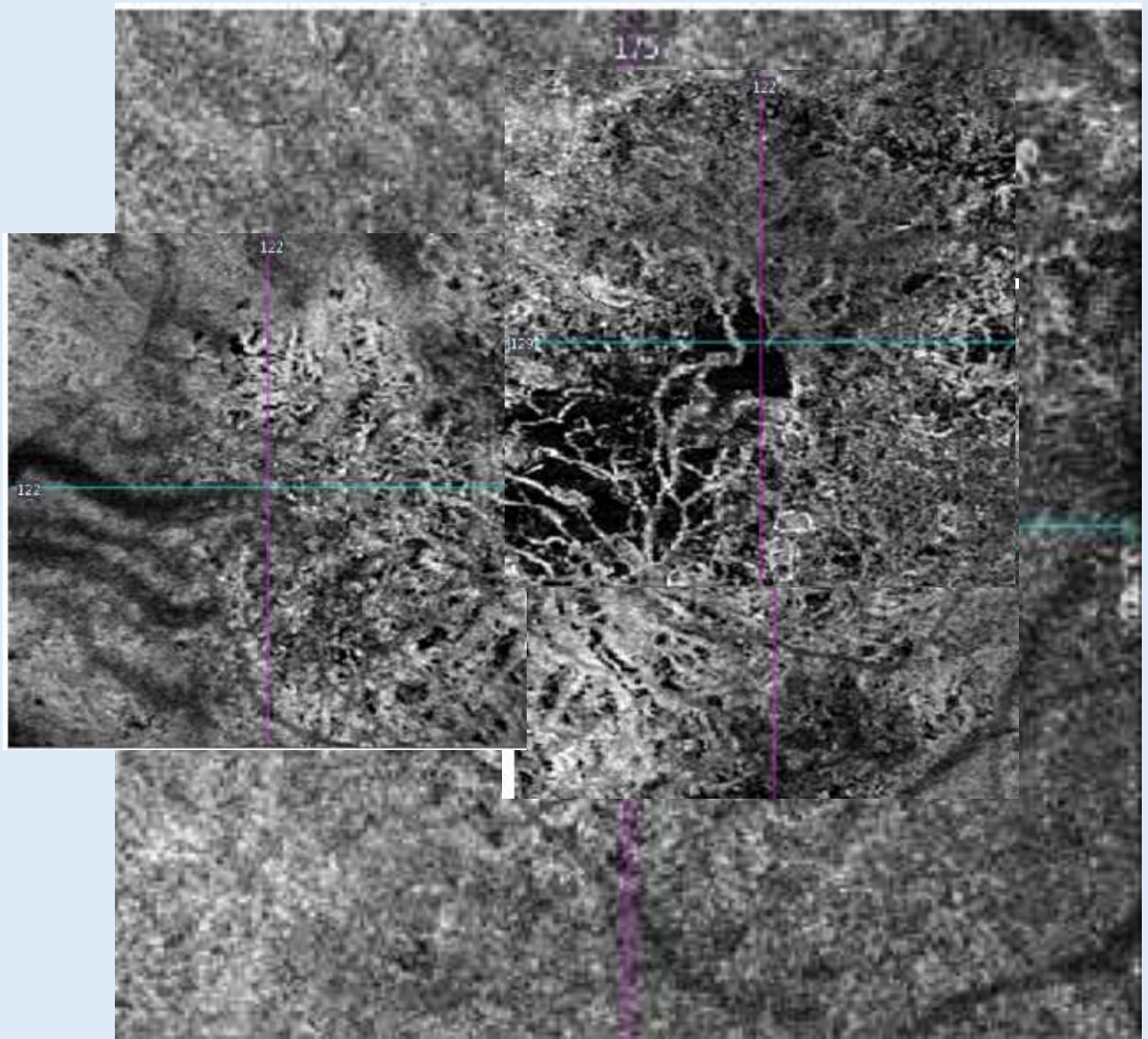
- Capture Multiple images 6x6 or 3x3 or combination
- Use “Irfanview” Free image software to Crop image
- Use Power point to Collage the images
- Use Group function to lock all the images together





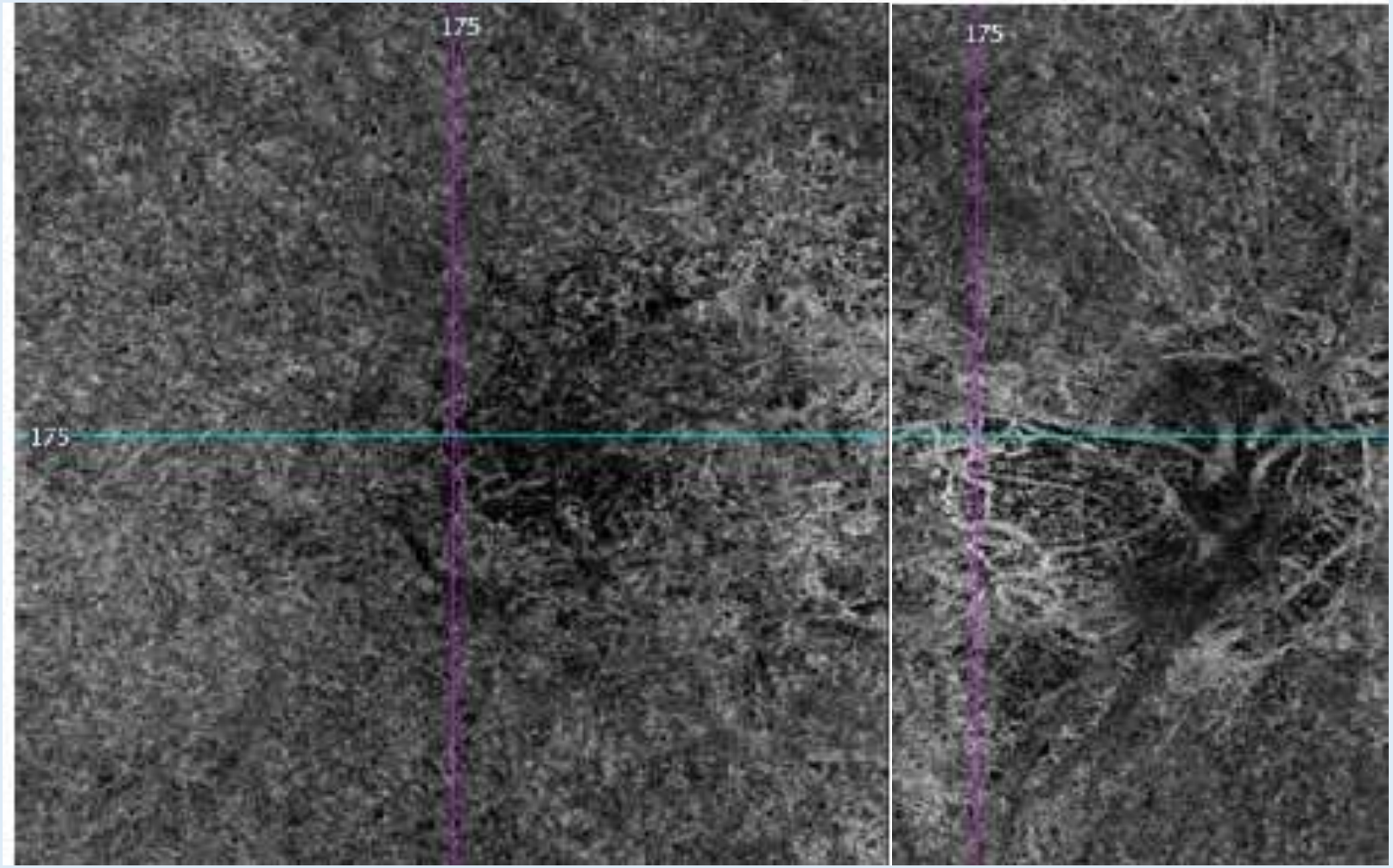
Collage images with Power point

Overlay 3x3 on to 6x6 to enhance the detail

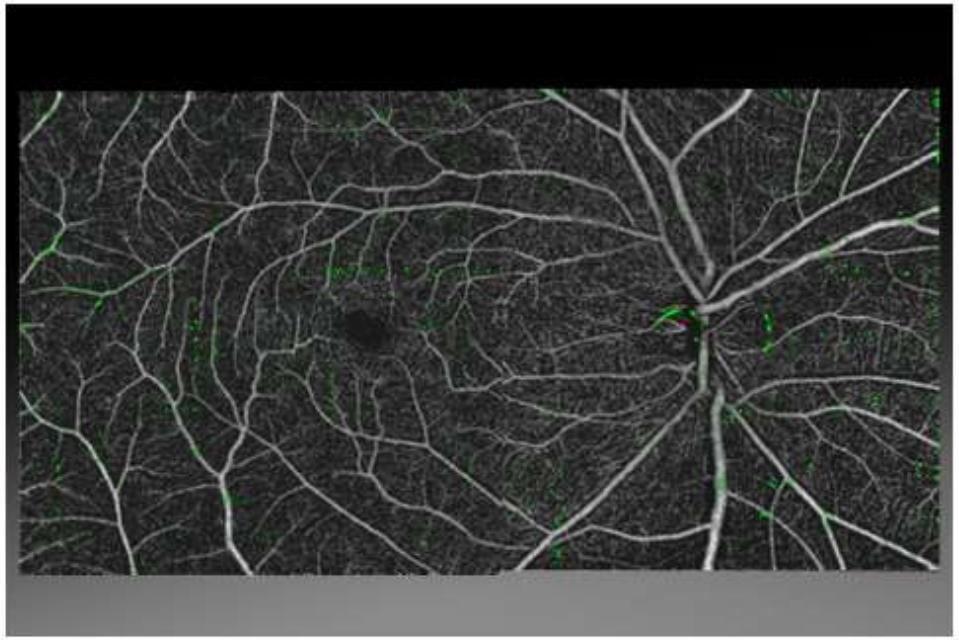


SRVM Spreading from the disc to

the macular



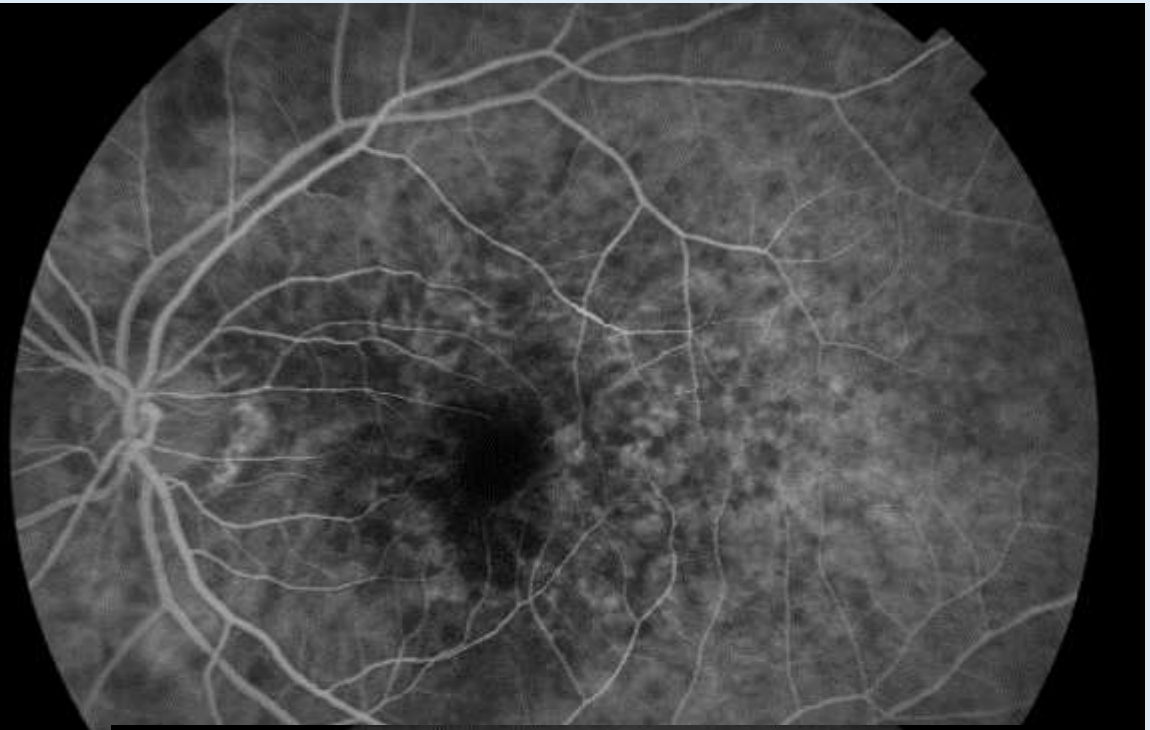
AngioVue

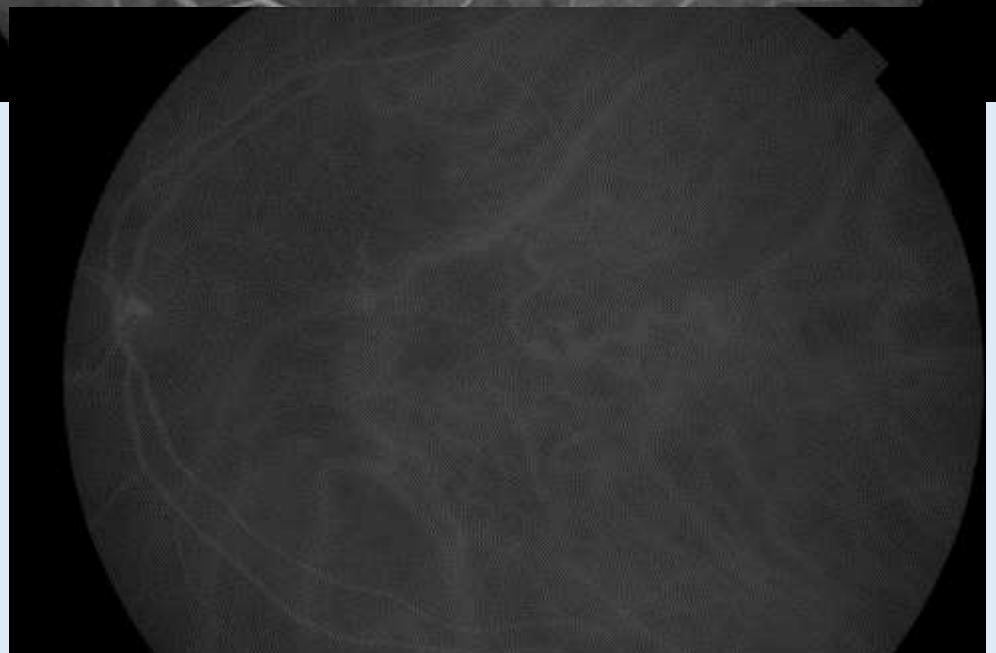


WIDER FIELD OF VIEW

Improves visualisation of abnormalities

AngioMontage combines two 6x6mm scan images to create a wider field of view that improves visualisation of abnormalities in the retinal vasculature. This unprecedented display of microvasculature enables assessment of the essential part of the retina to aid in the early diagnosis and management of sight-threatening diseases.





43 LUCENTIS (ranibizumab) to the Left eye,
Since 2011

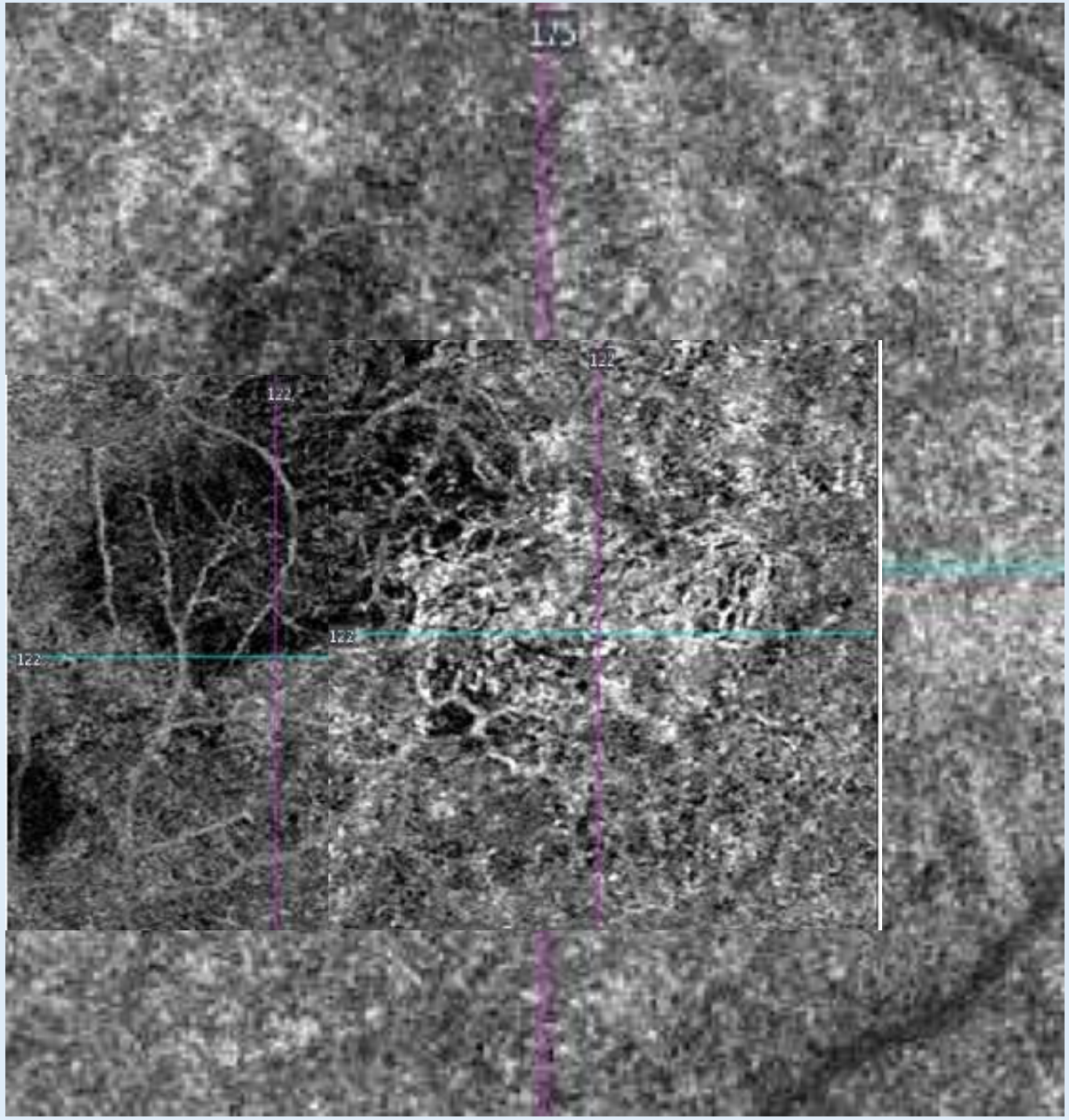
Undertook OCT-A

OCT-A shows good definition
This is 6x6 with inserted/over layered 3x3 images

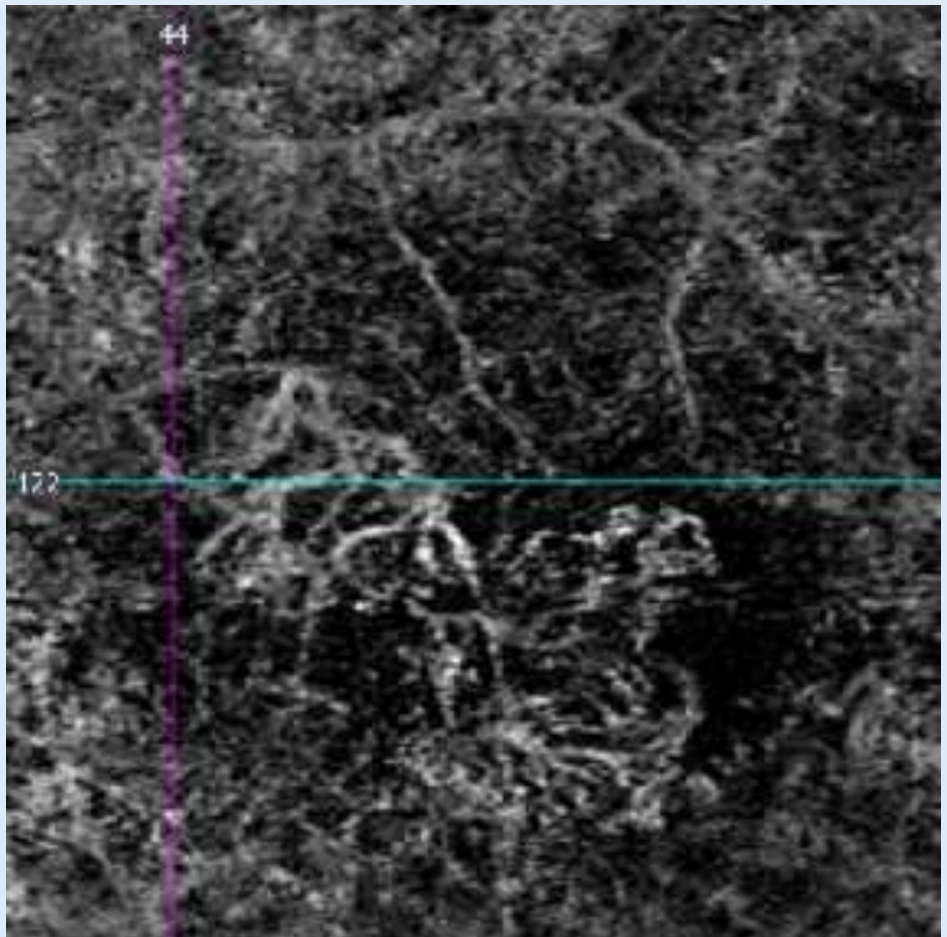
3x3 give higher definition than 6x6

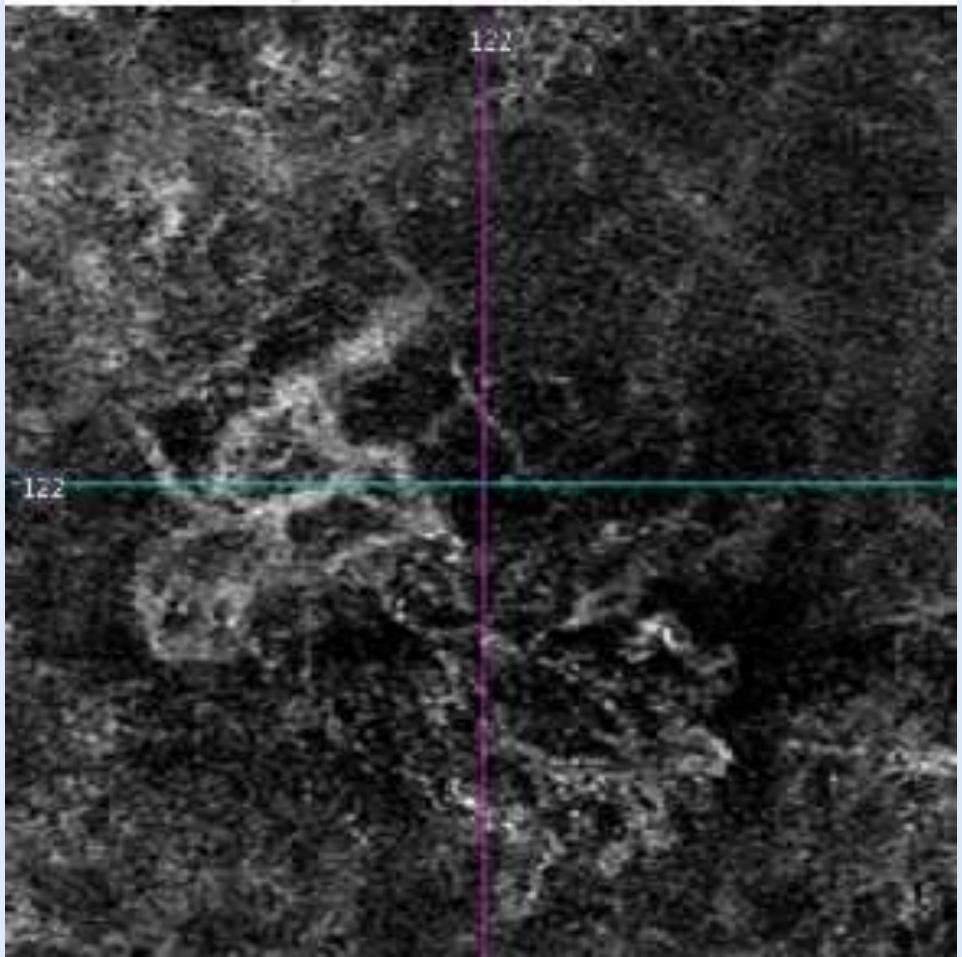
However by Collaging 3x3 or 6x6 wider fields of view can be achieved

Currently manually done using Power point - easy



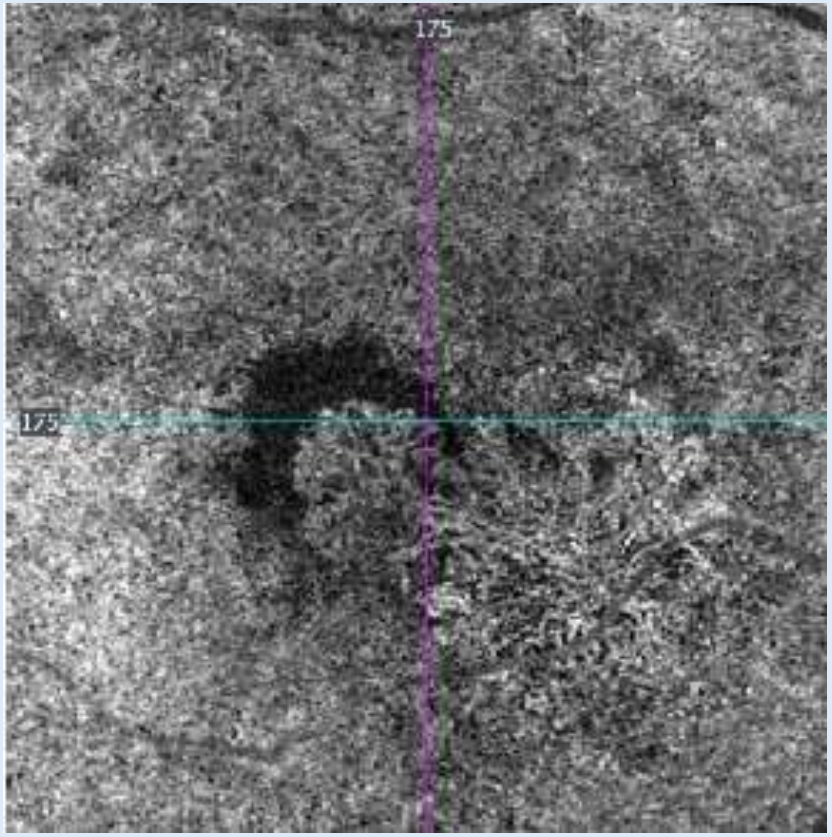
One Month apart – Dilation of the blood vessels
Possibility to monitor change/growth



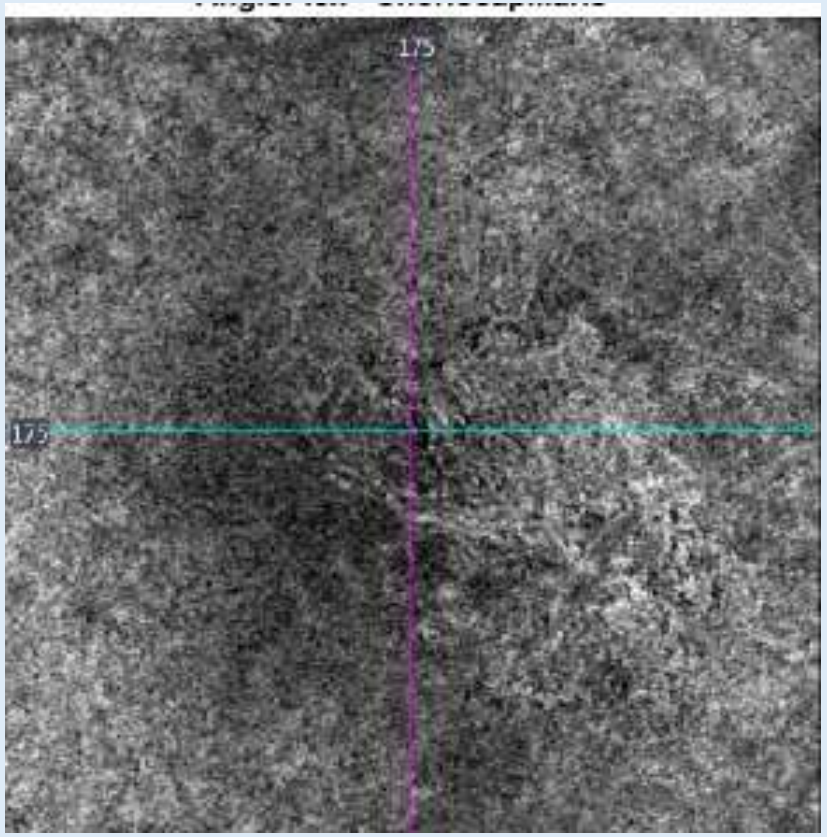


9 months OCT-A change Recurrence s/12754

April 16

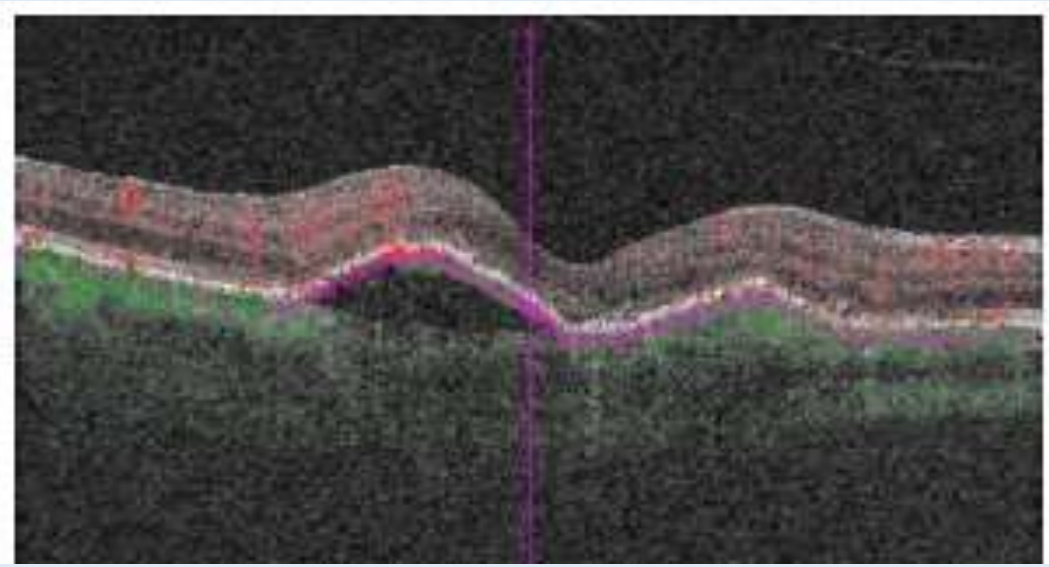


Jan 17 6/9 vision

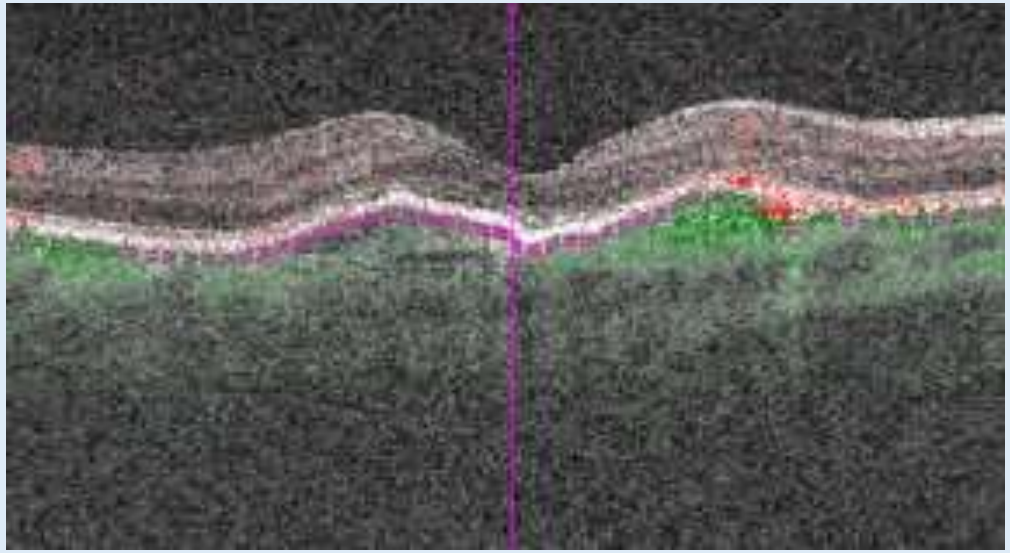


Equivalent OCT Scans, with Blood flow

Macular OCT

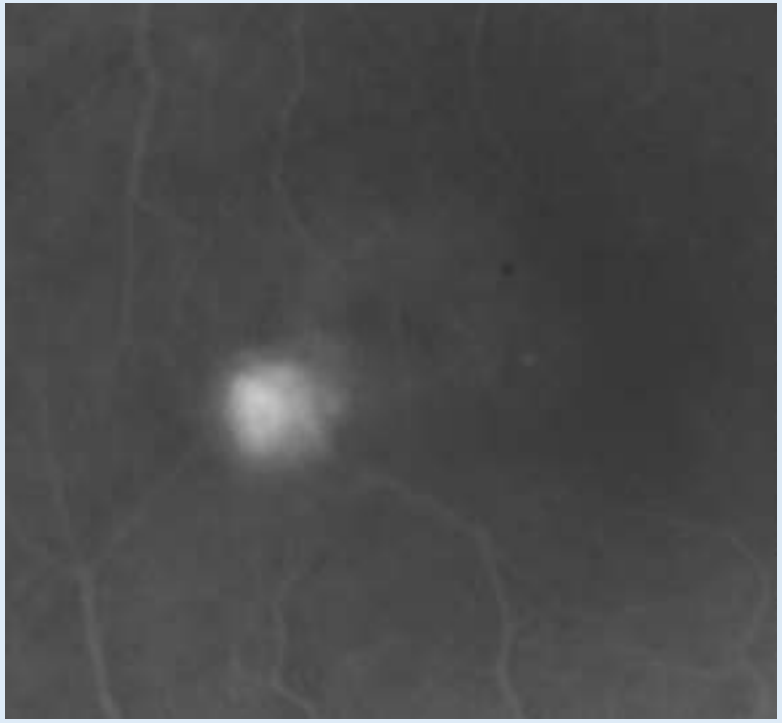


Macular Scan

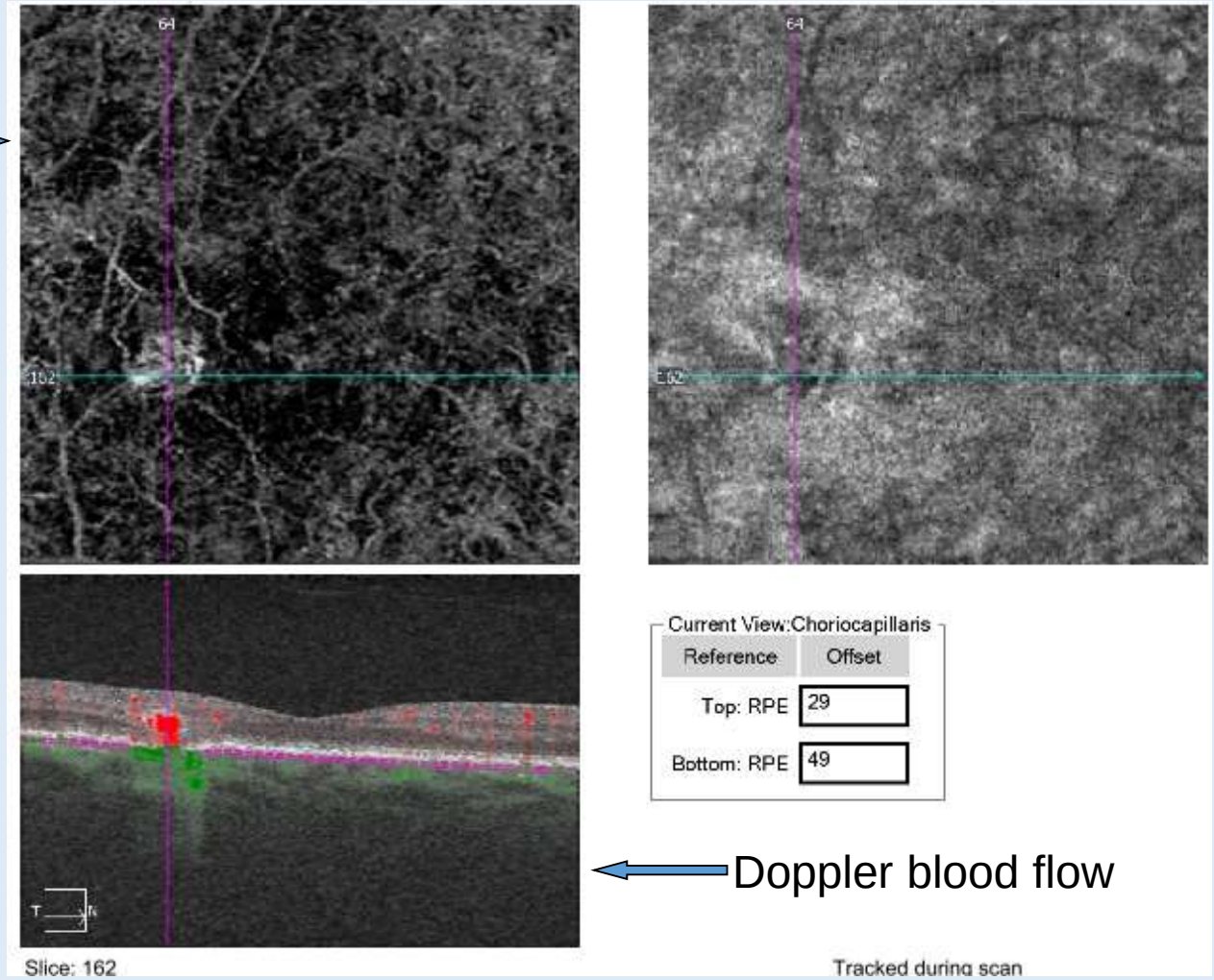


OCT-A shows this is Retinal to Choroidal Anastomosis - RAP

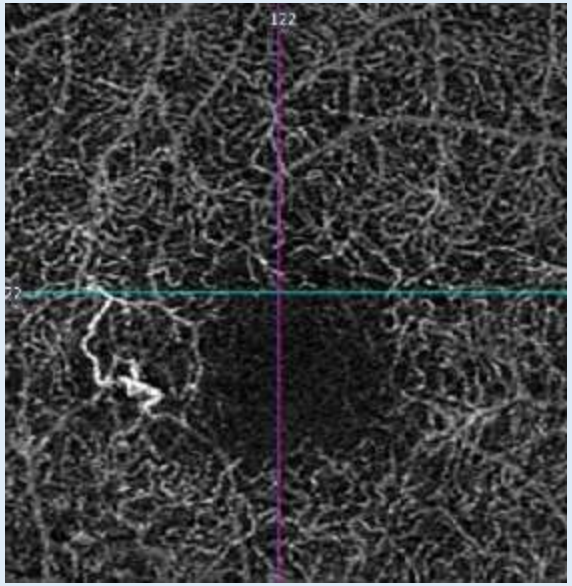
FFA

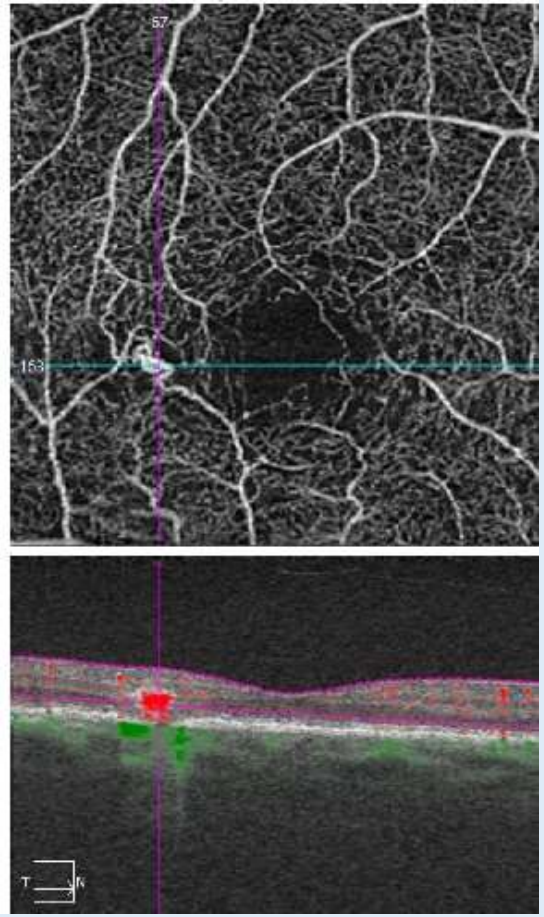


OCT-A

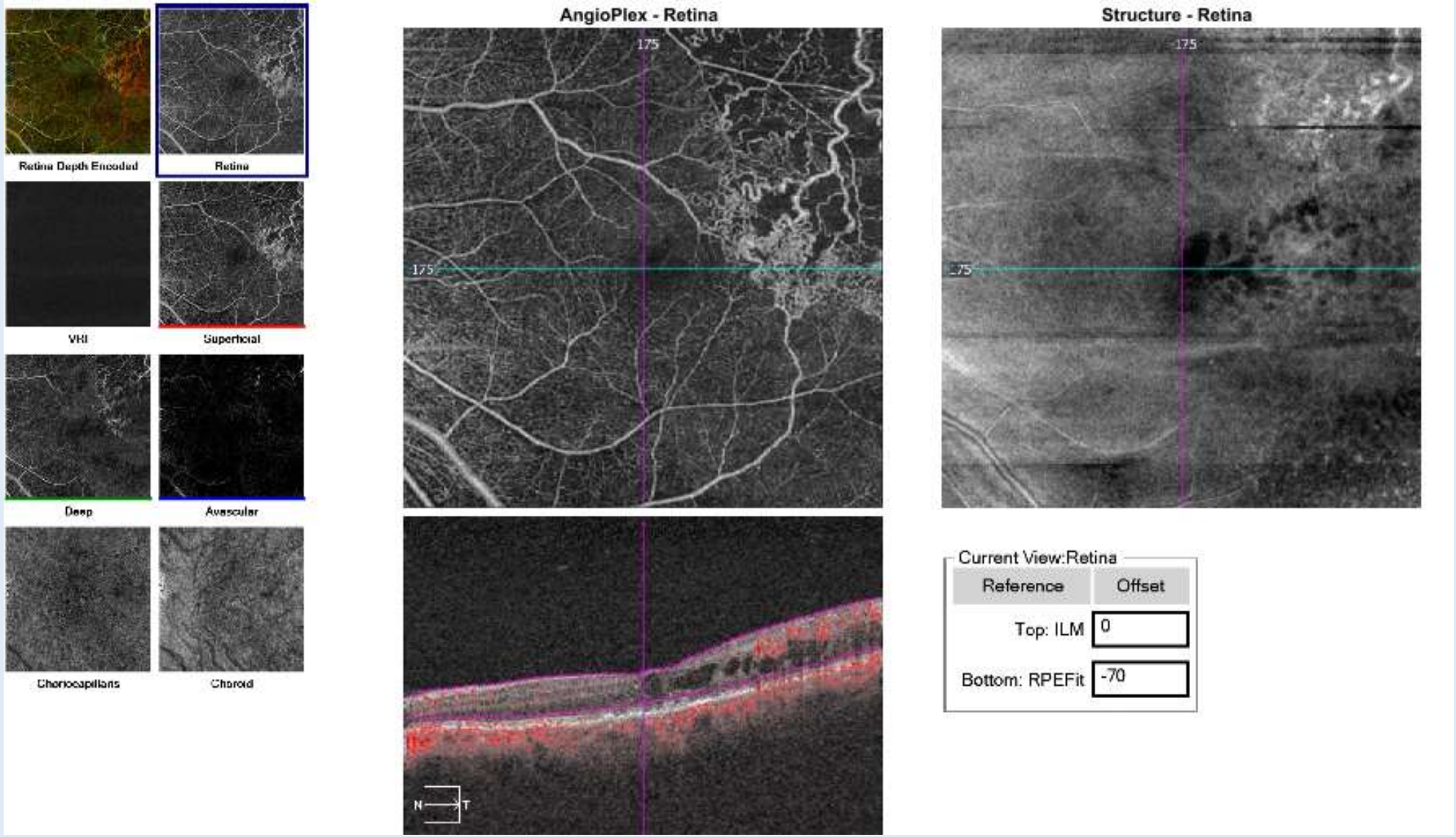


Move cursor to look at blood flow
Angiography – linked to OCT scan
Precise retinal alignment is essential in all OCT-A’s





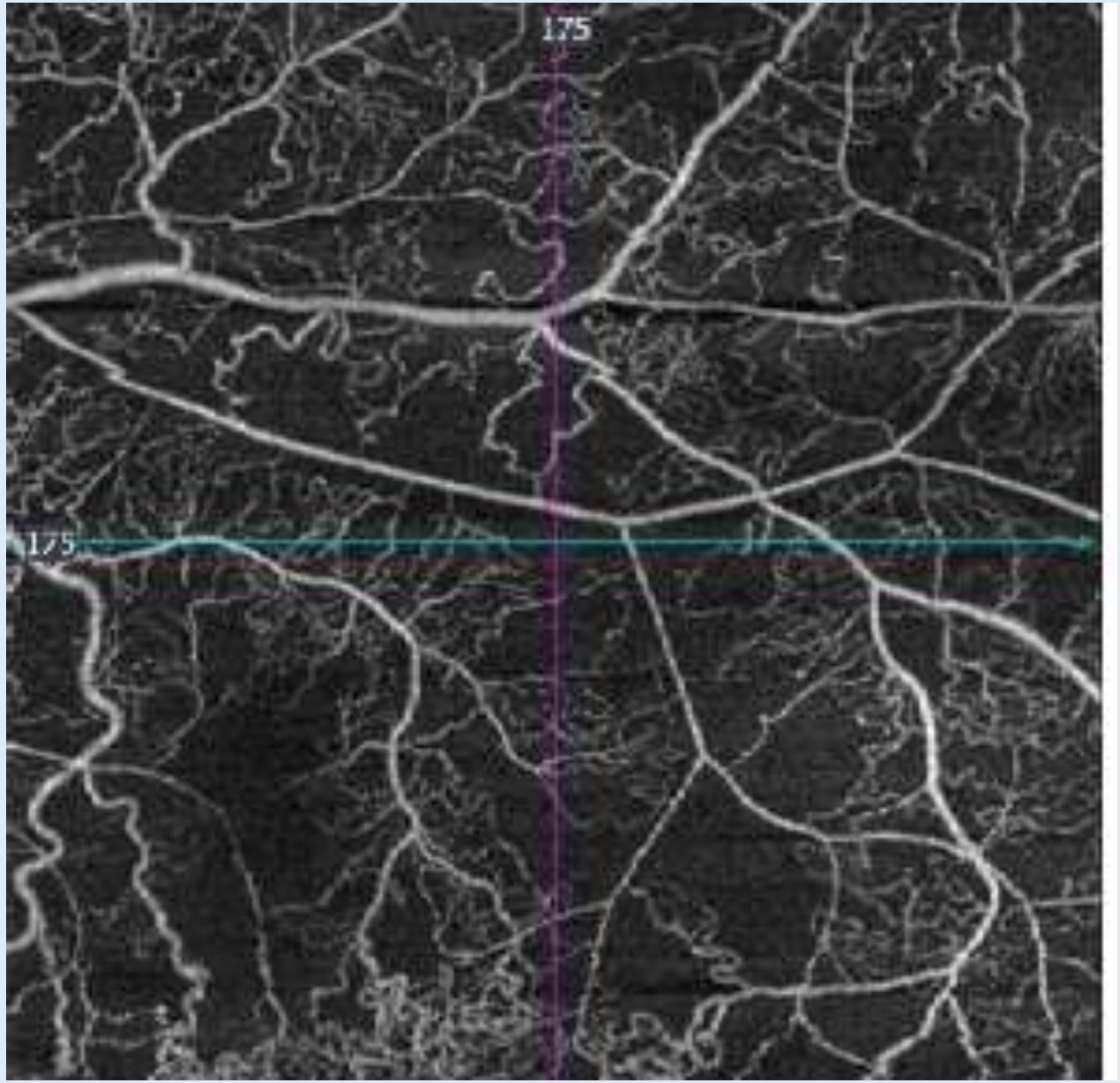
Branch retinal vein occlusion - Collaterals



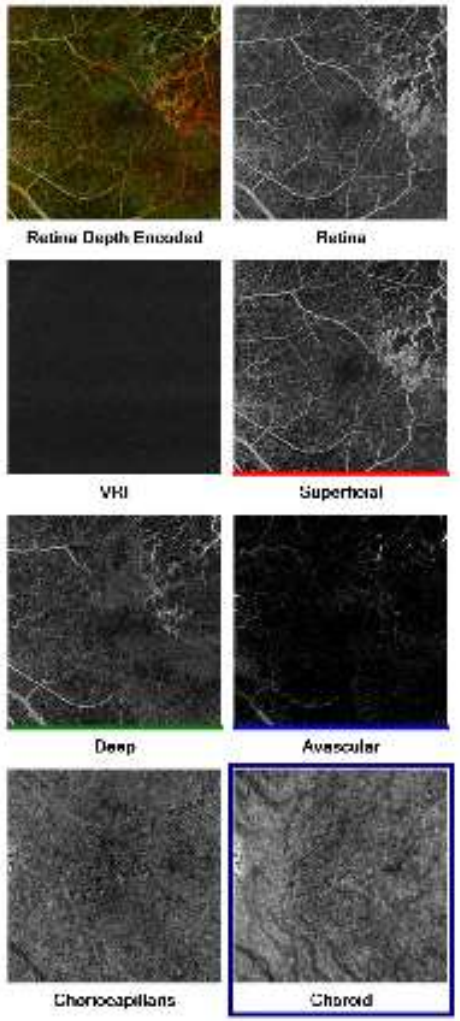
HD

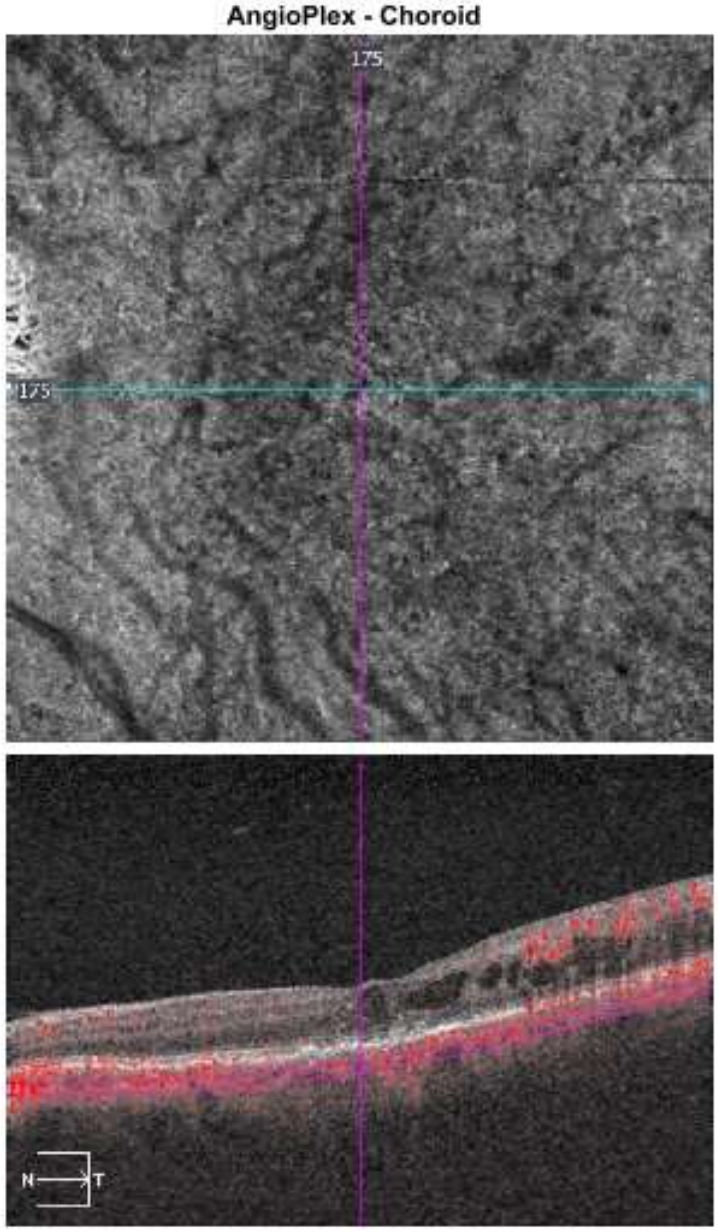
Detail Better than

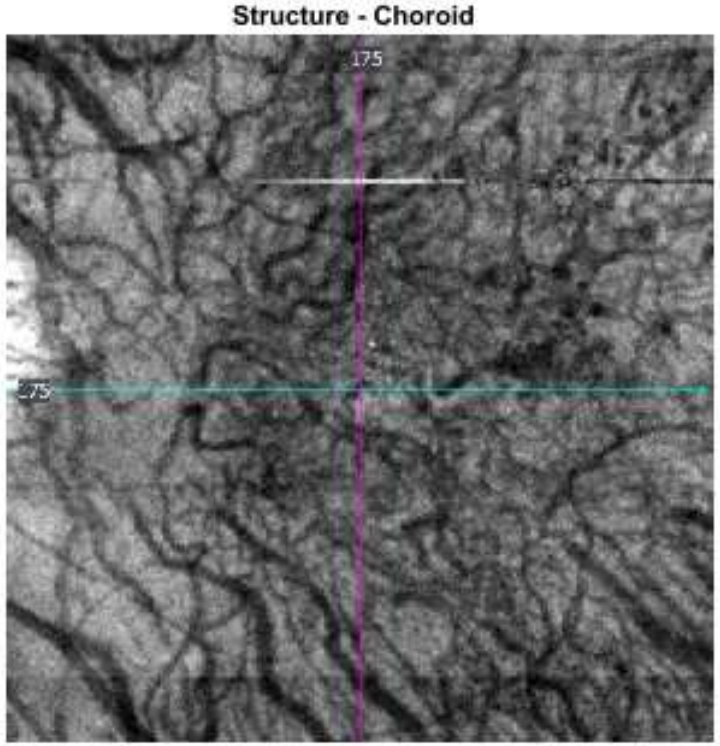
Fundus fluorescein angiography

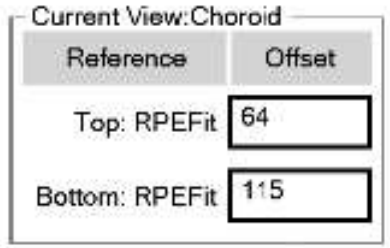


BRVO Choroidal views - Normal



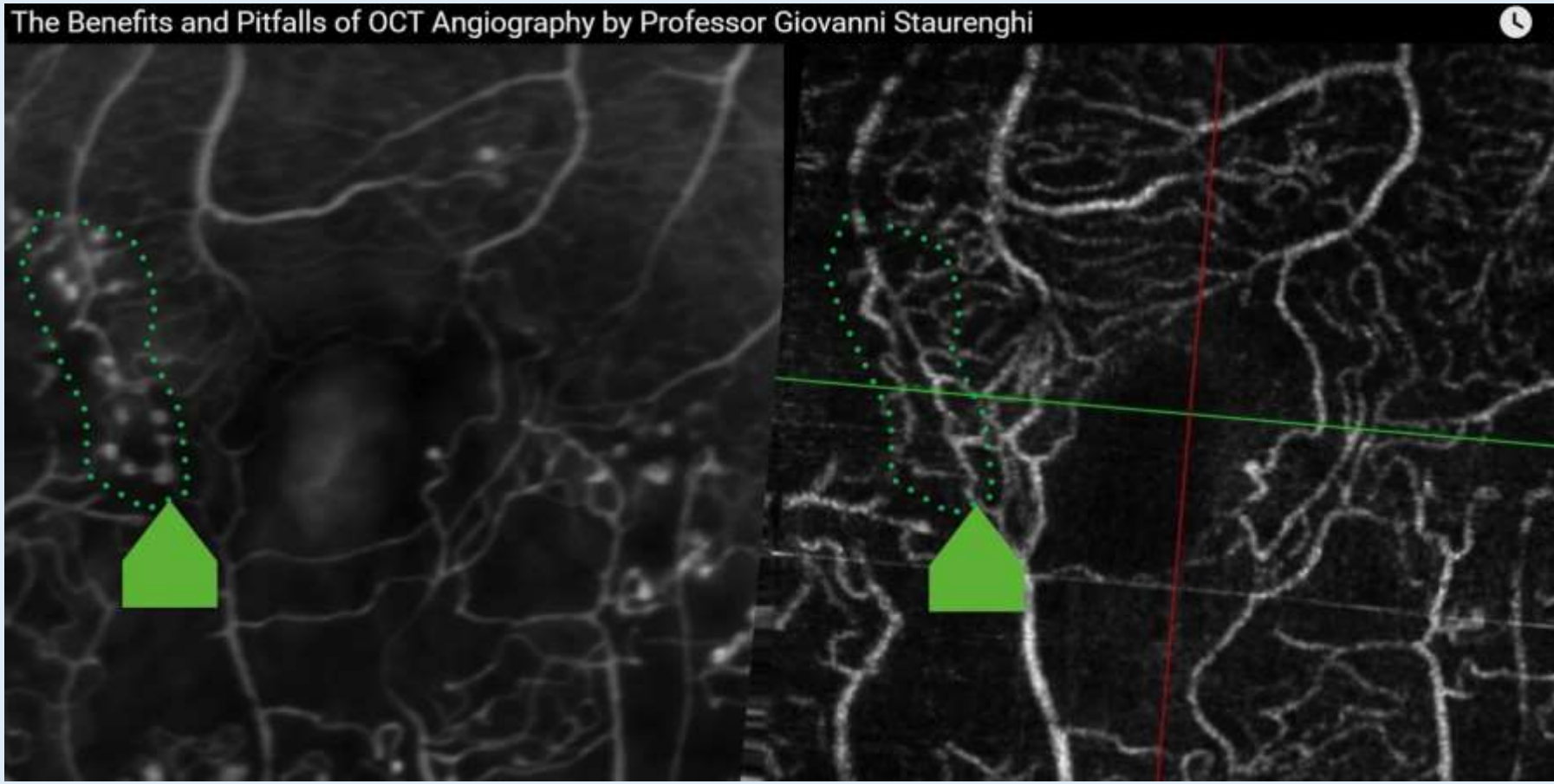




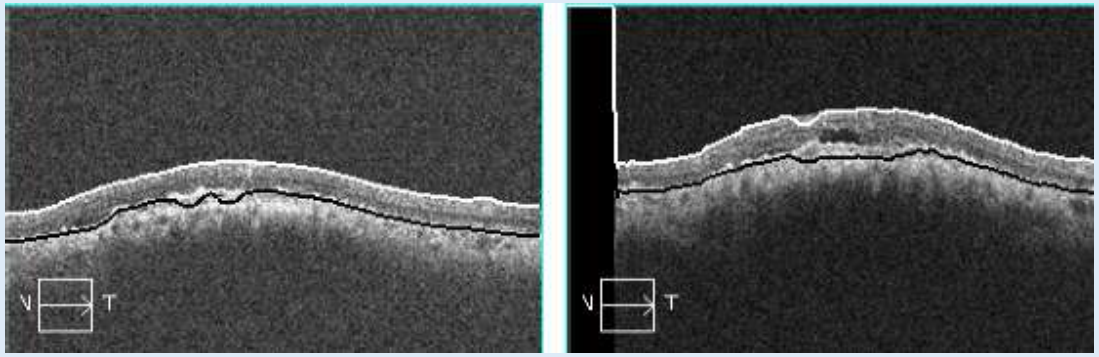


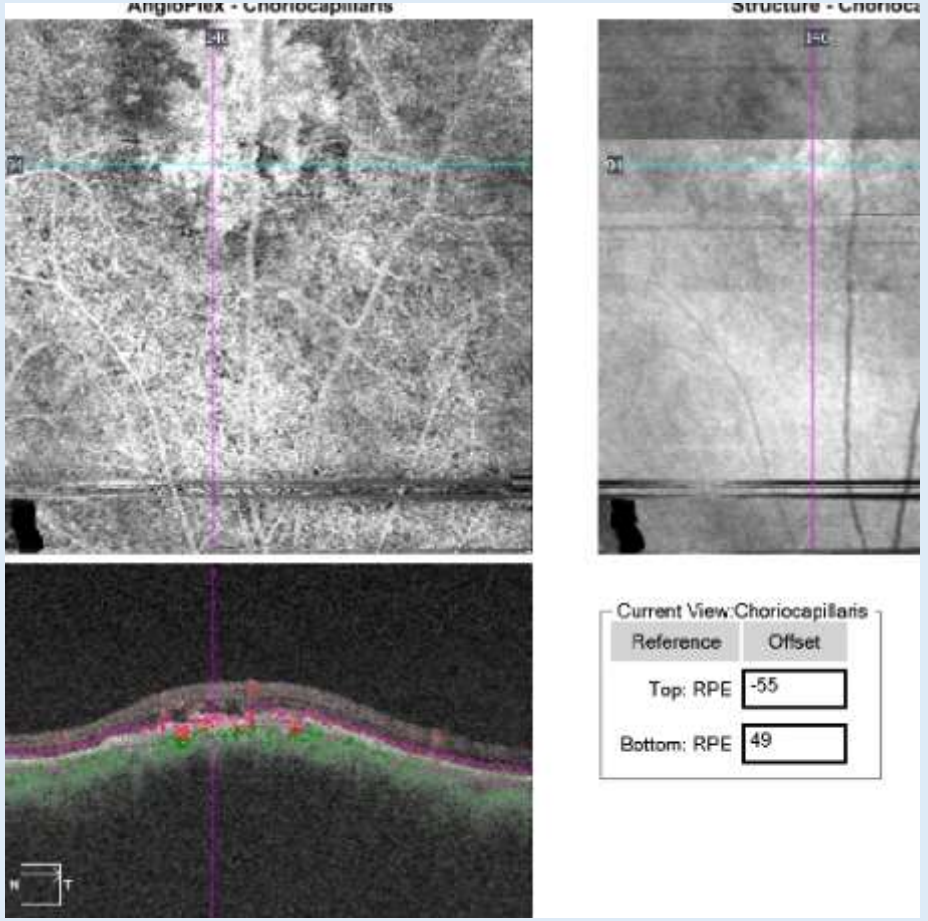
Instant differentiation of Choroidal vs Retinal disease

- Small aneurysms too slow to show in OCTA
- FFA vs OCTA
- High contrast
- Fewer MA’s show

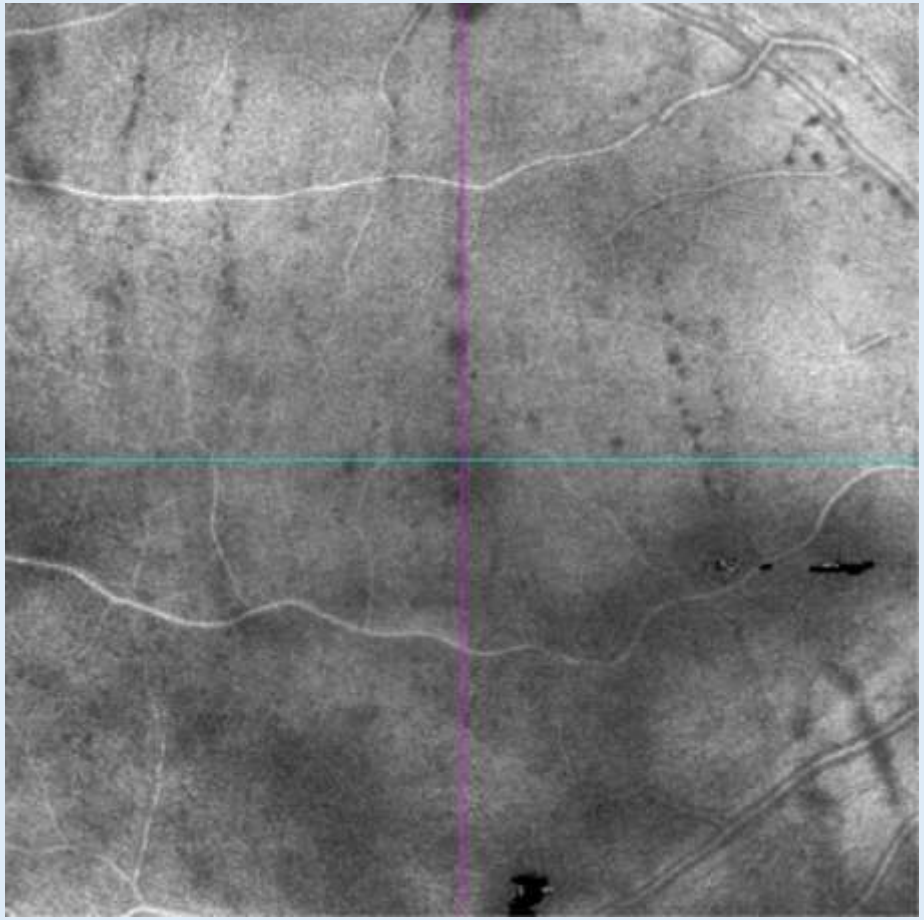


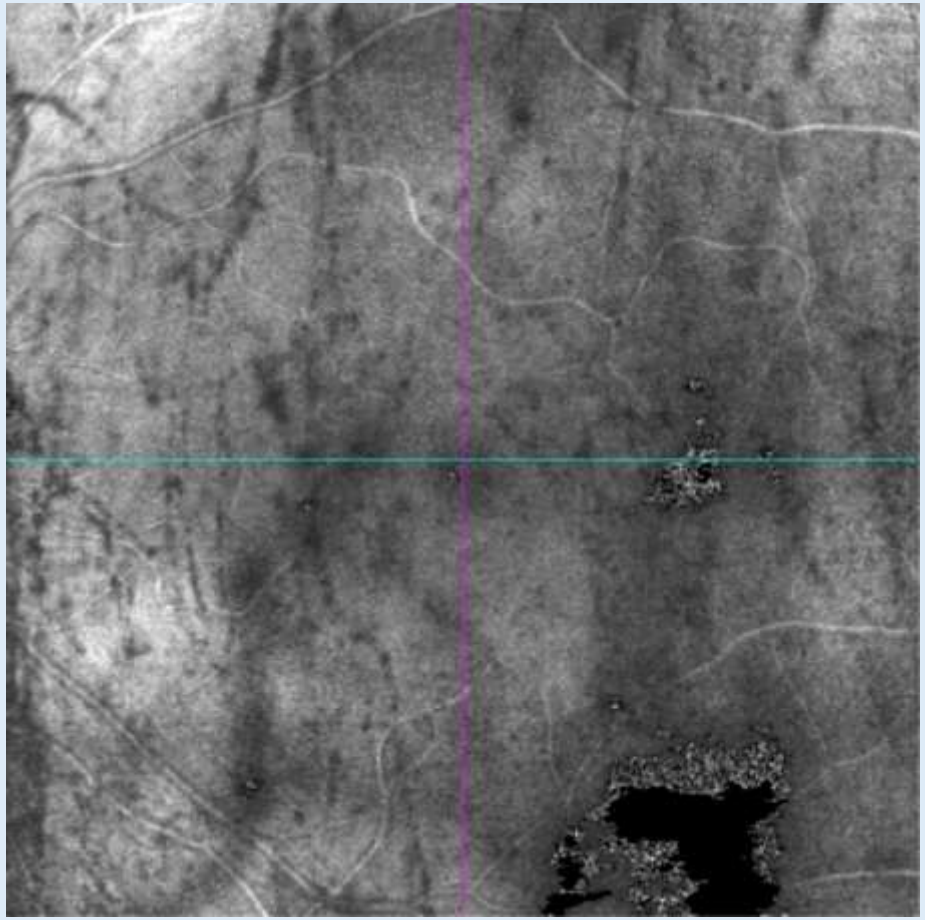
Naevus change to Melanoma
Change over one year Previously recommended observation
Now see Vascularisation present
For Plaque
Changed management



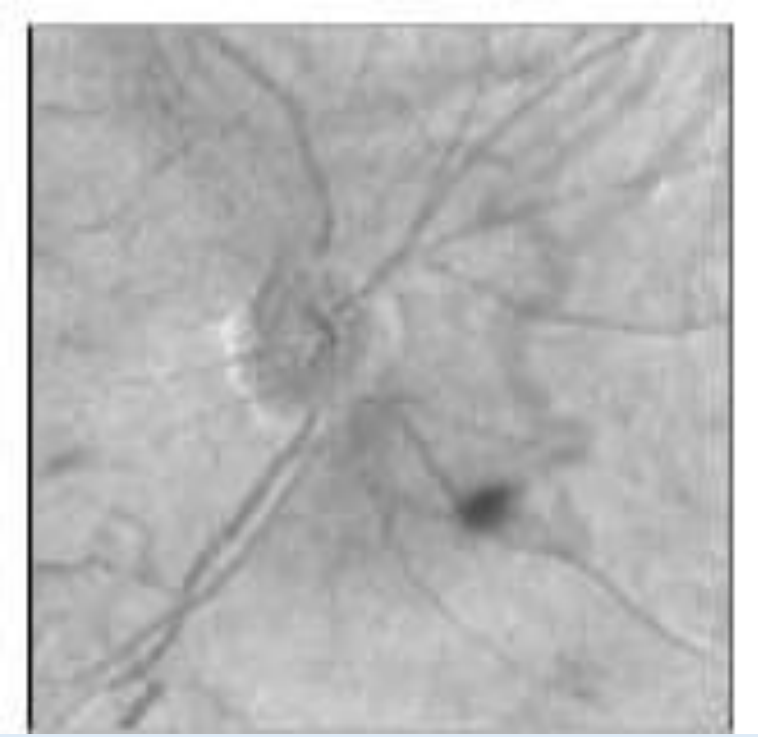


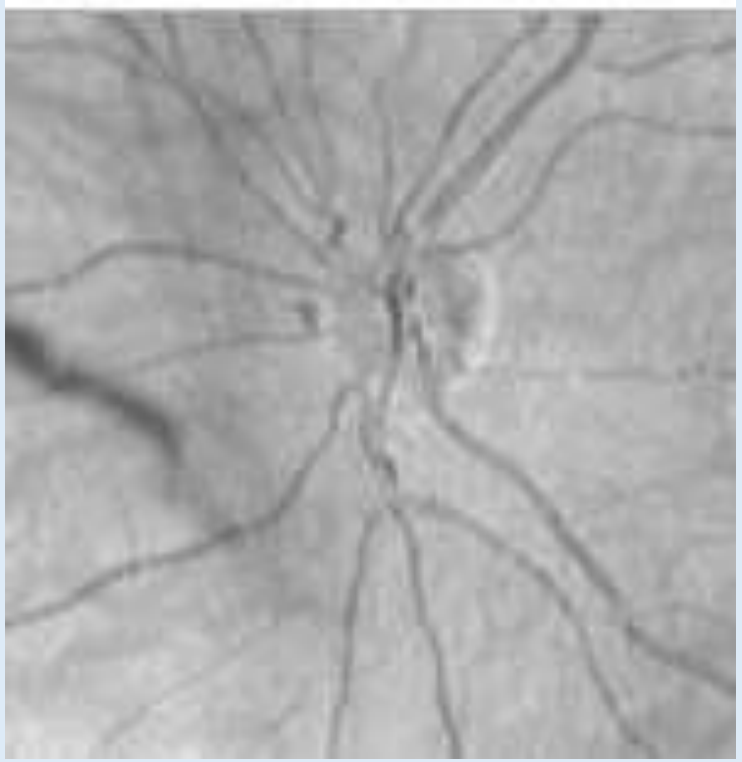
8 x8 mm AngioPlex Image of vitreous





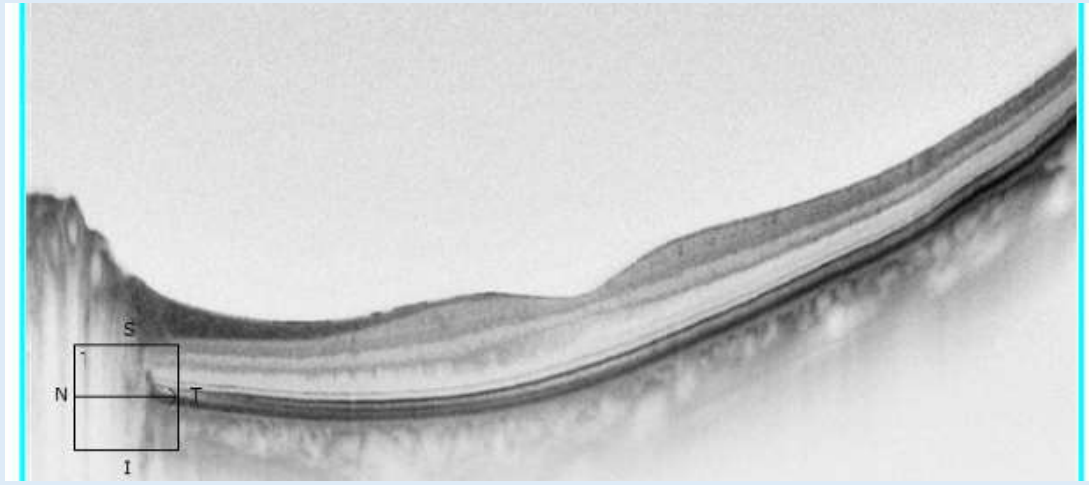
PVD – Weiss Rings on SLO



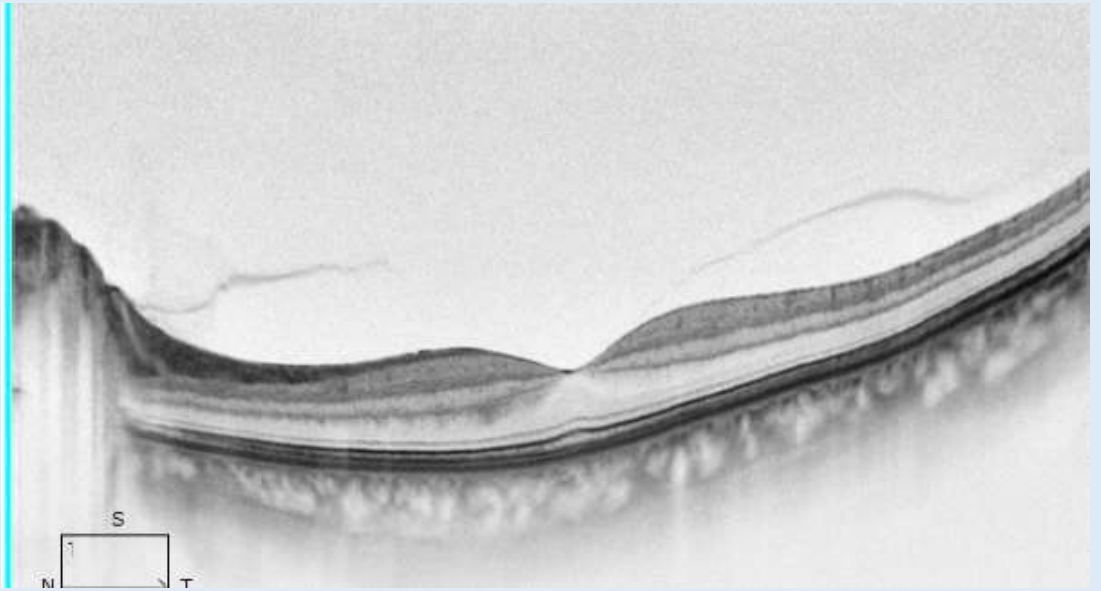


12 mm 100x HD scans Negative Image

1 Feb 17



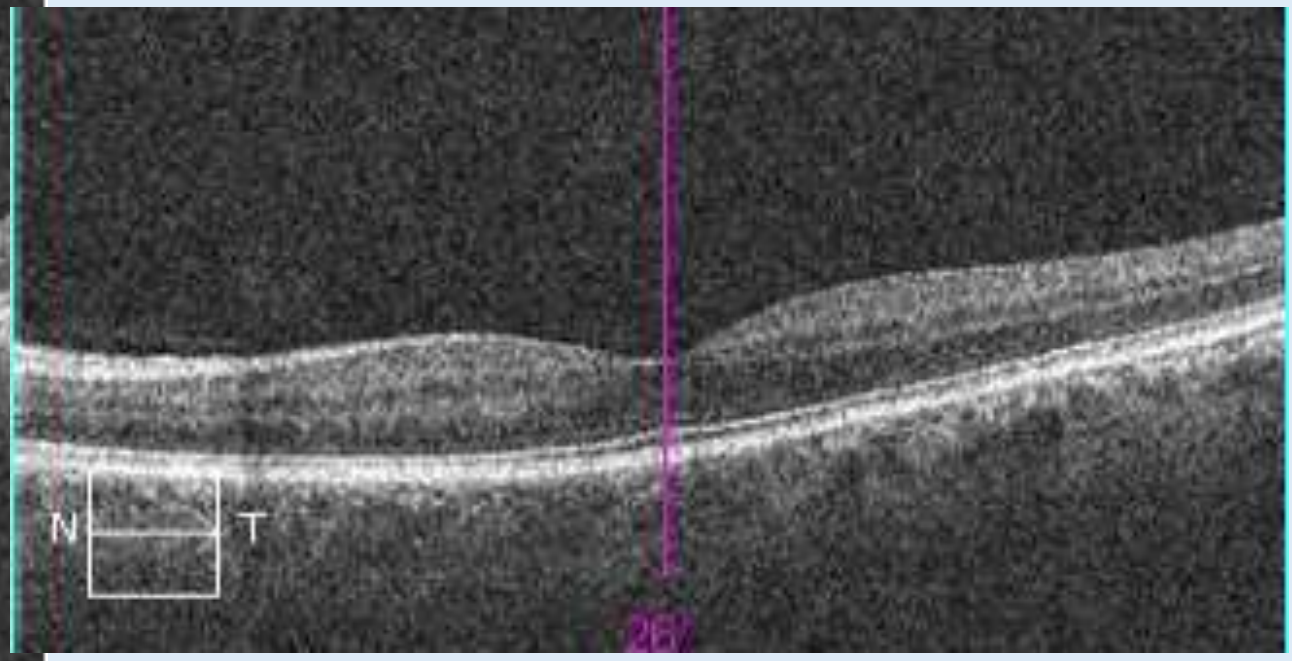
6 Jan 16



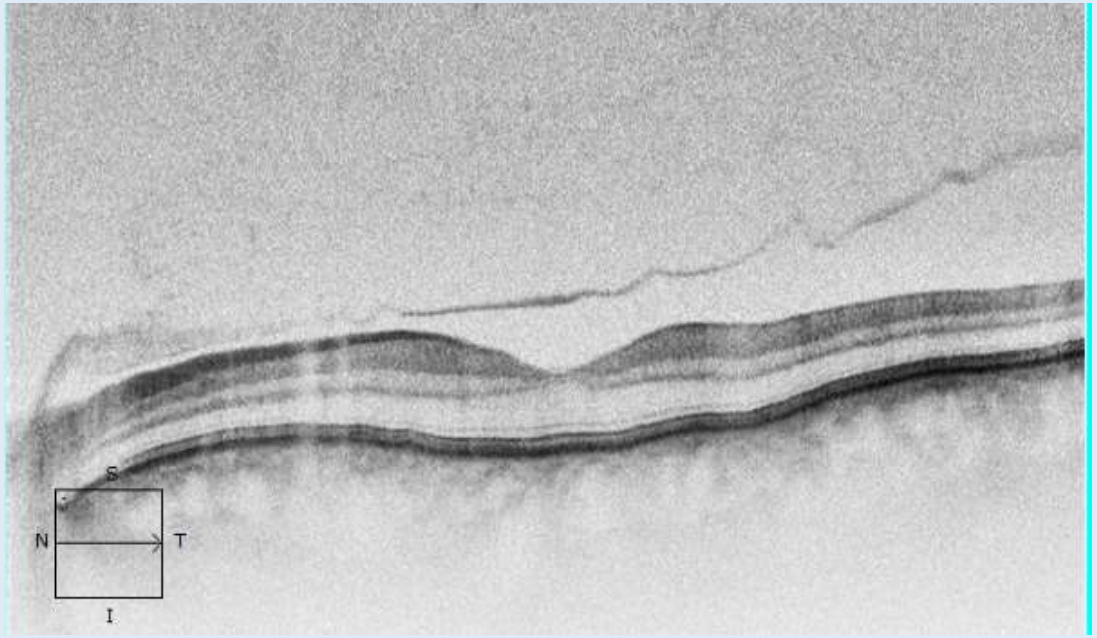
Evolution of a pvd

9/15

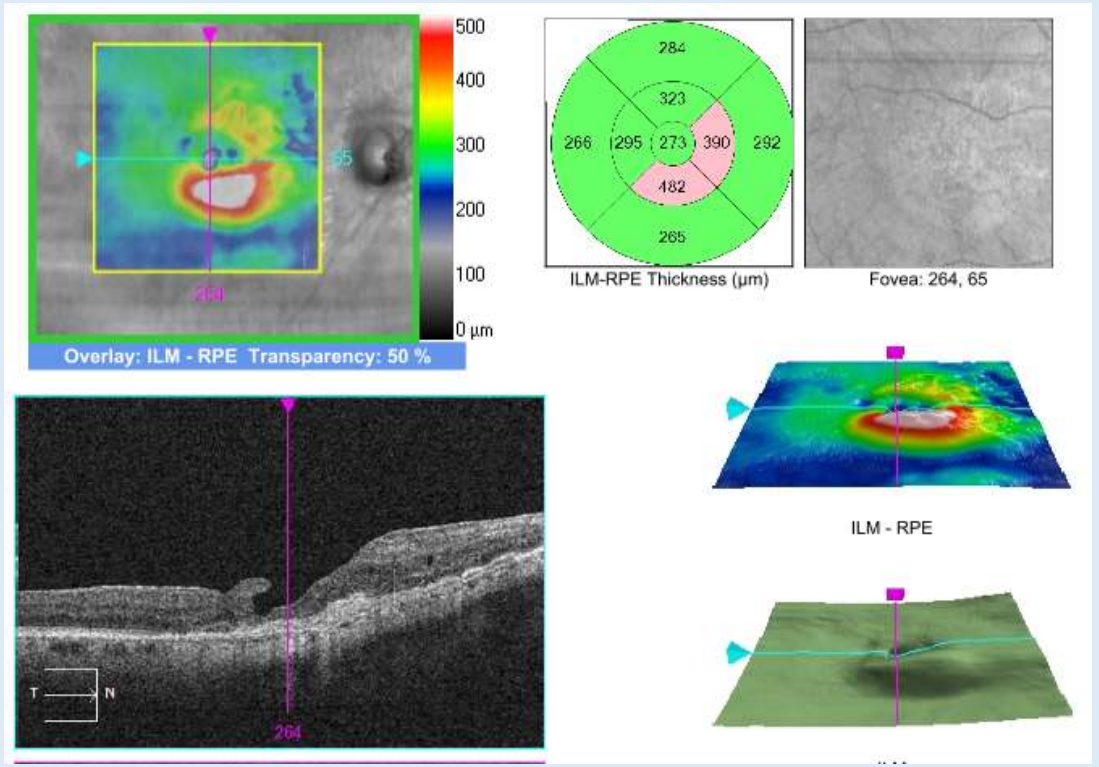
2013



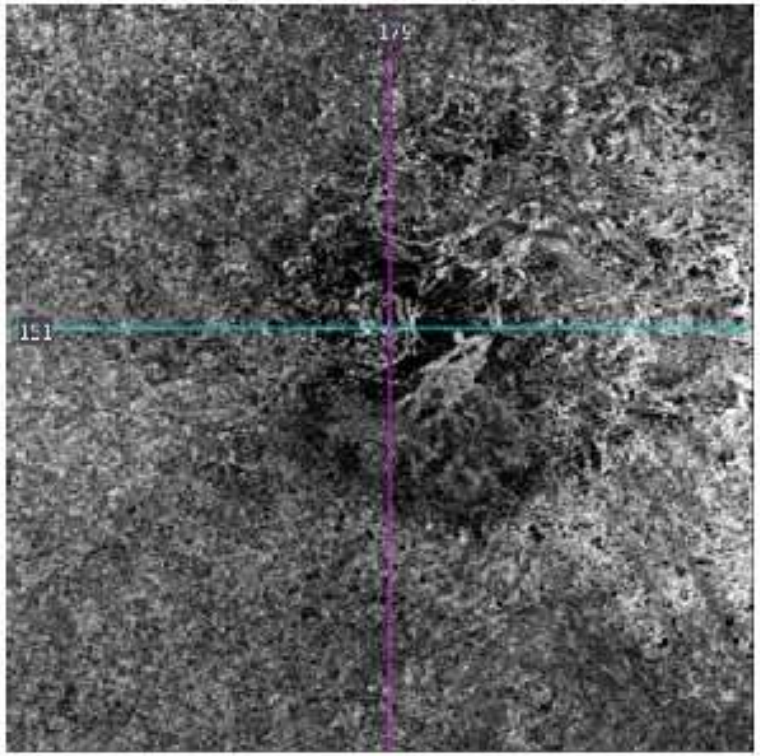
HD Negative Images

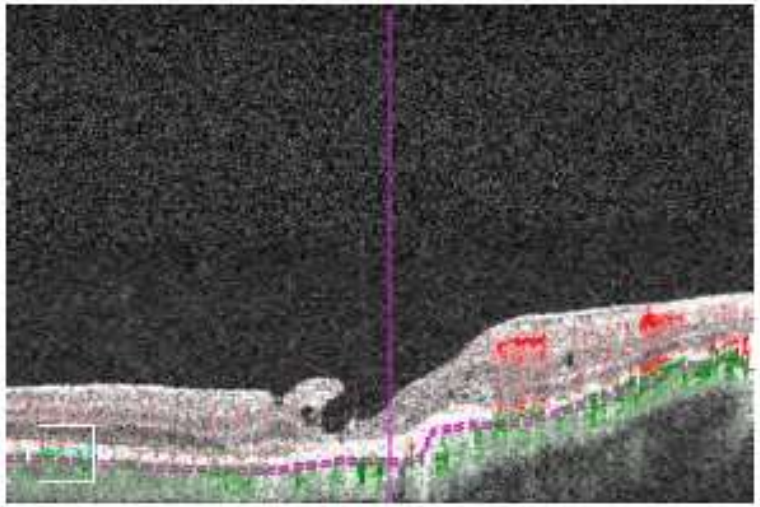


Slab sections helpful in GEA


500
400
300
200
100
0 µm
Overlay: ILM - RPE Transparency: 50 %
284
323
266
295
273
390
292
482
265
ILM-RPE Thickness (µm)
Fovea: 264, 65
T
N
264
ILM - RPE

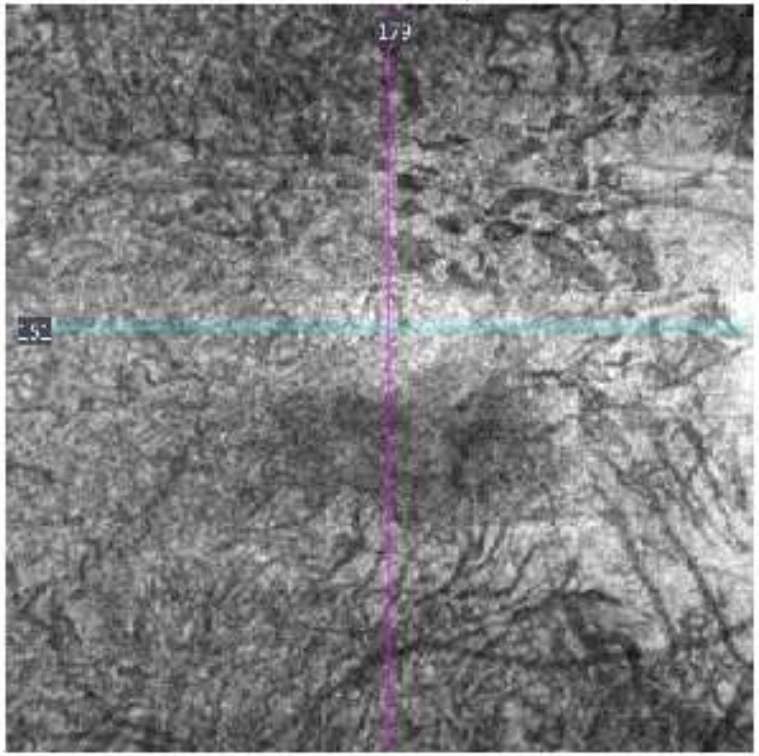
AngioPlex - Choriocapillaris





Slice: 151

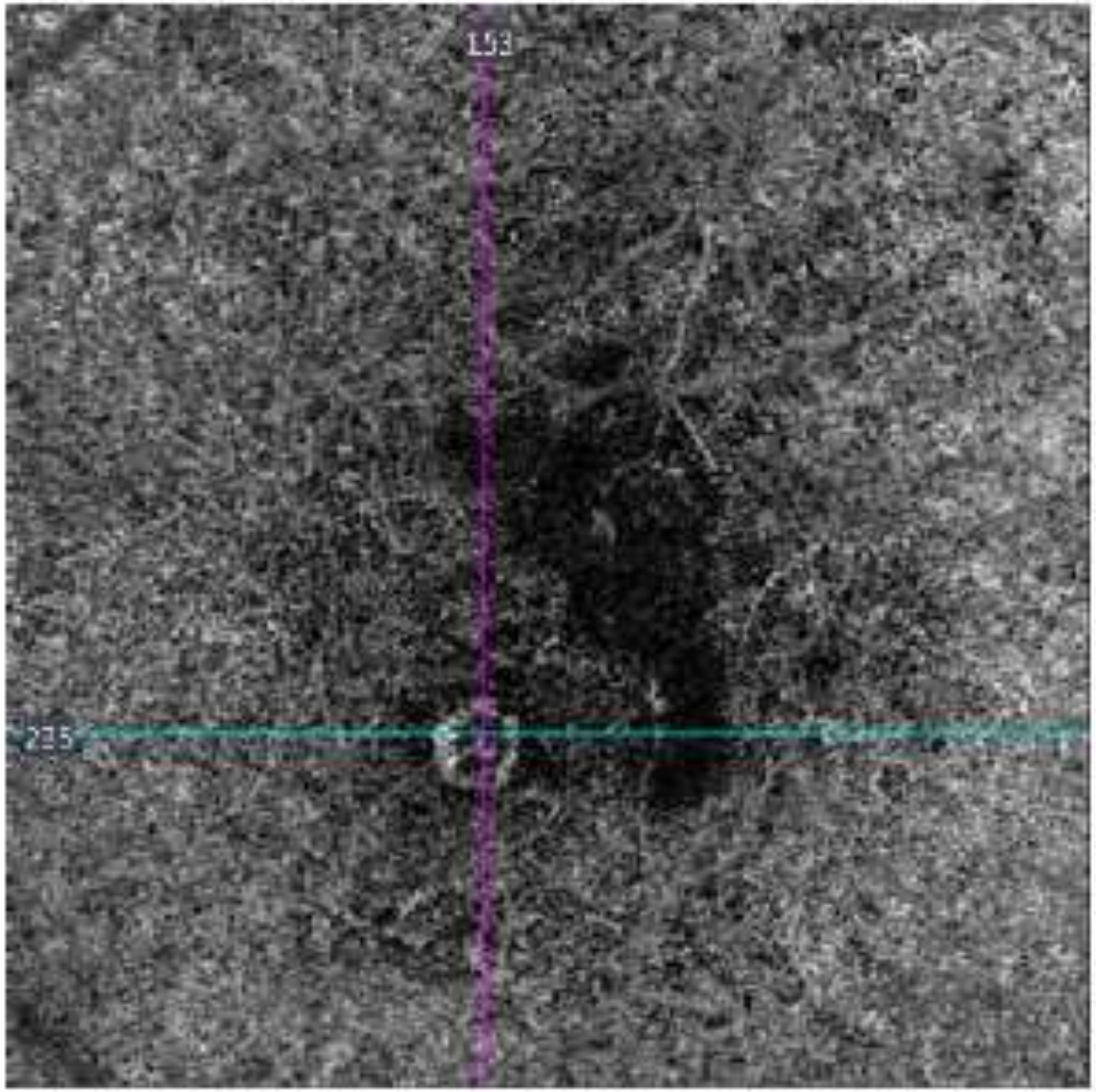
Structure - Choriocapillaris

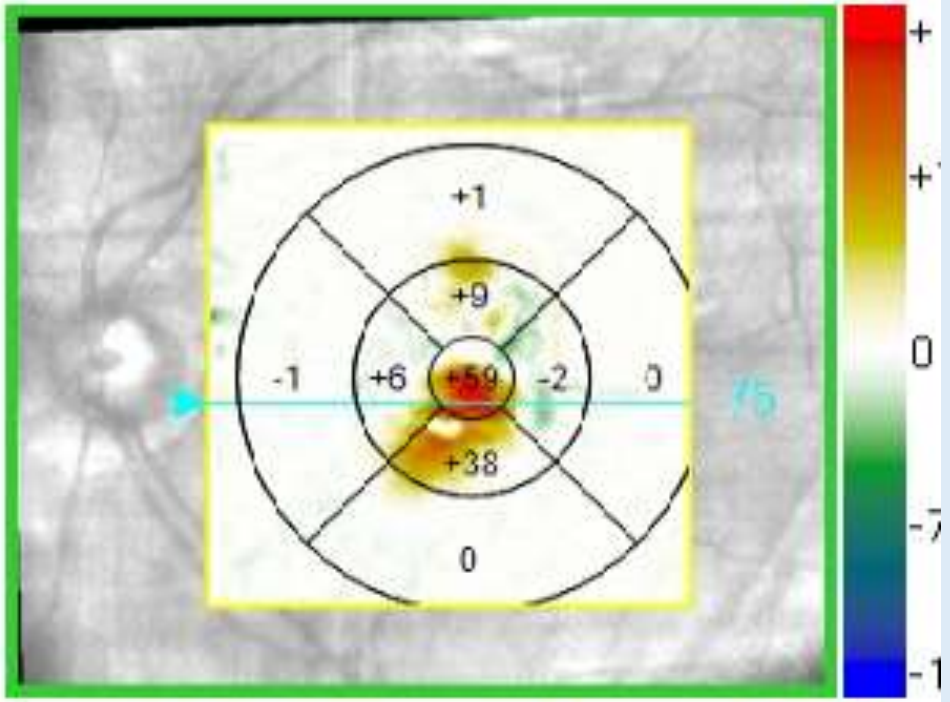


Current View:Choriocapillaris

Reference	Offset
Top: RPE	29
Bottom: RPE	49

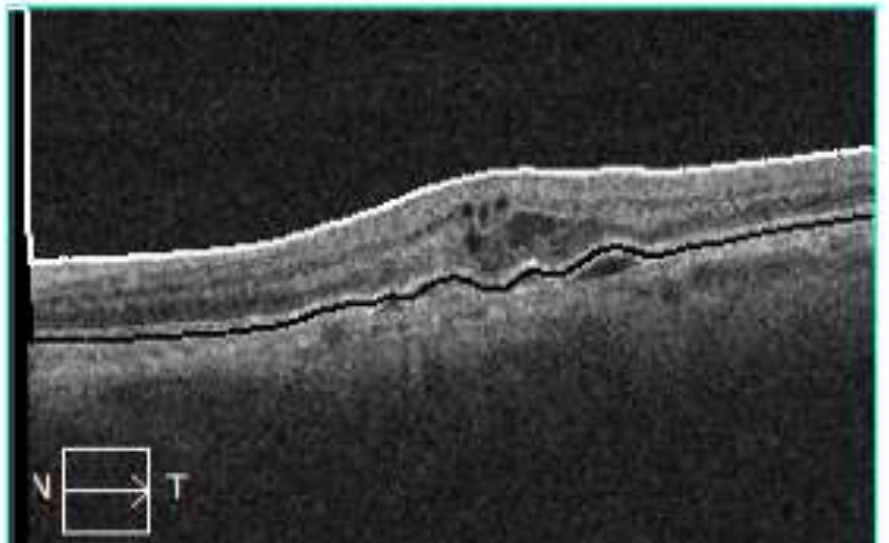
Tracked during scan



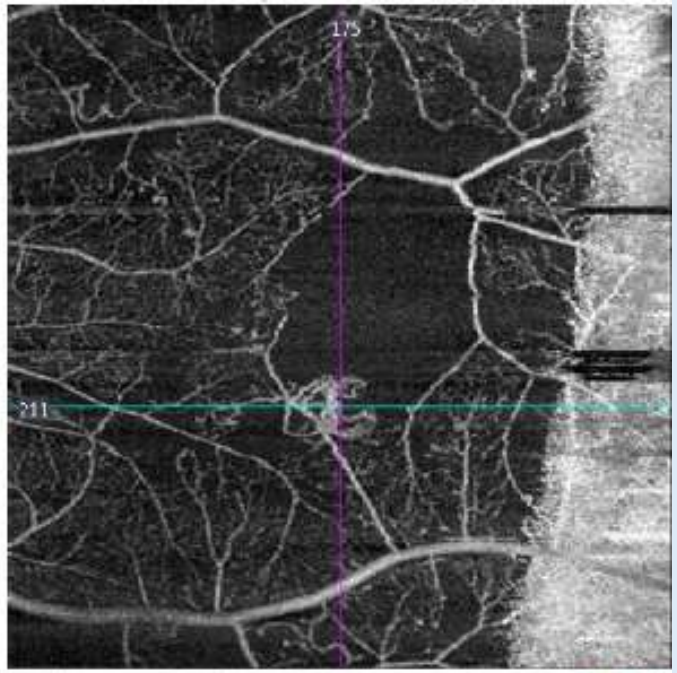


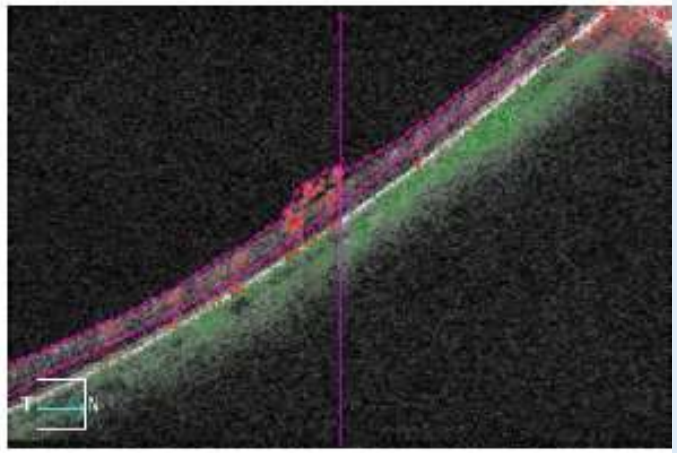
Overlay: ILM-RPE Difference Transparency: 0 %

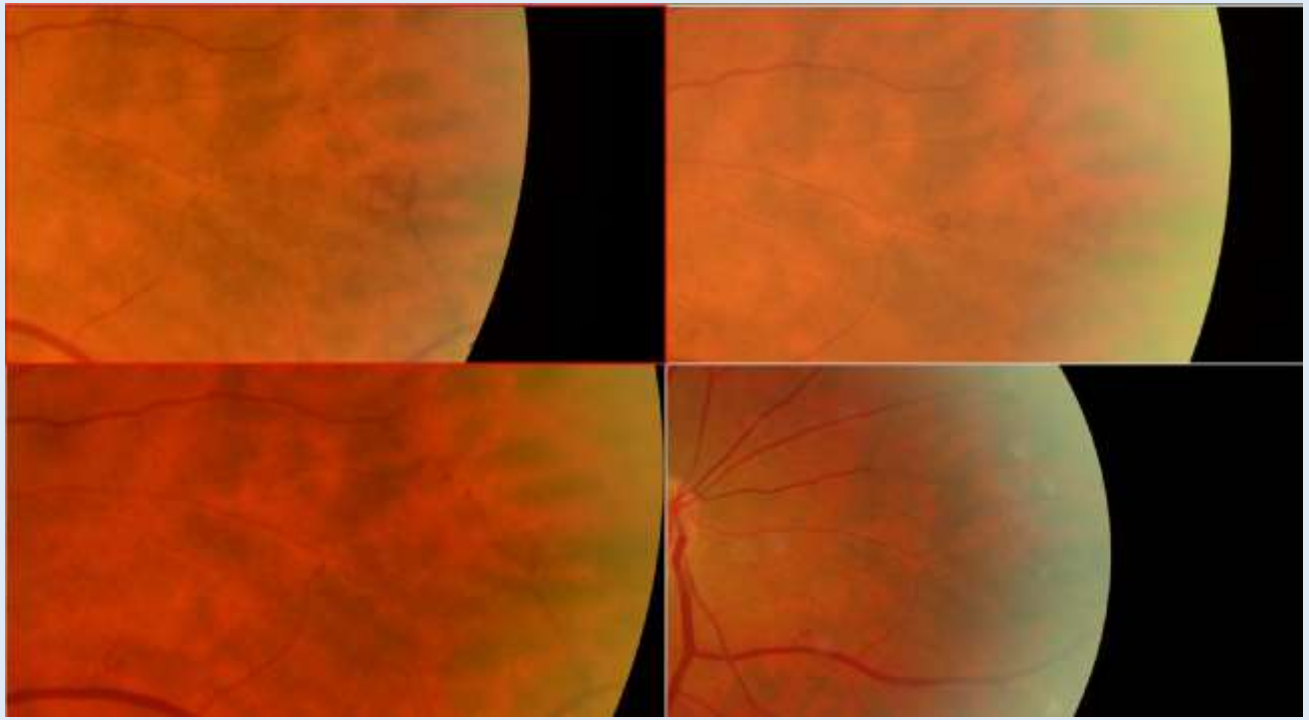
Extracted B-Scan



Diabetic IRMA or NVE?







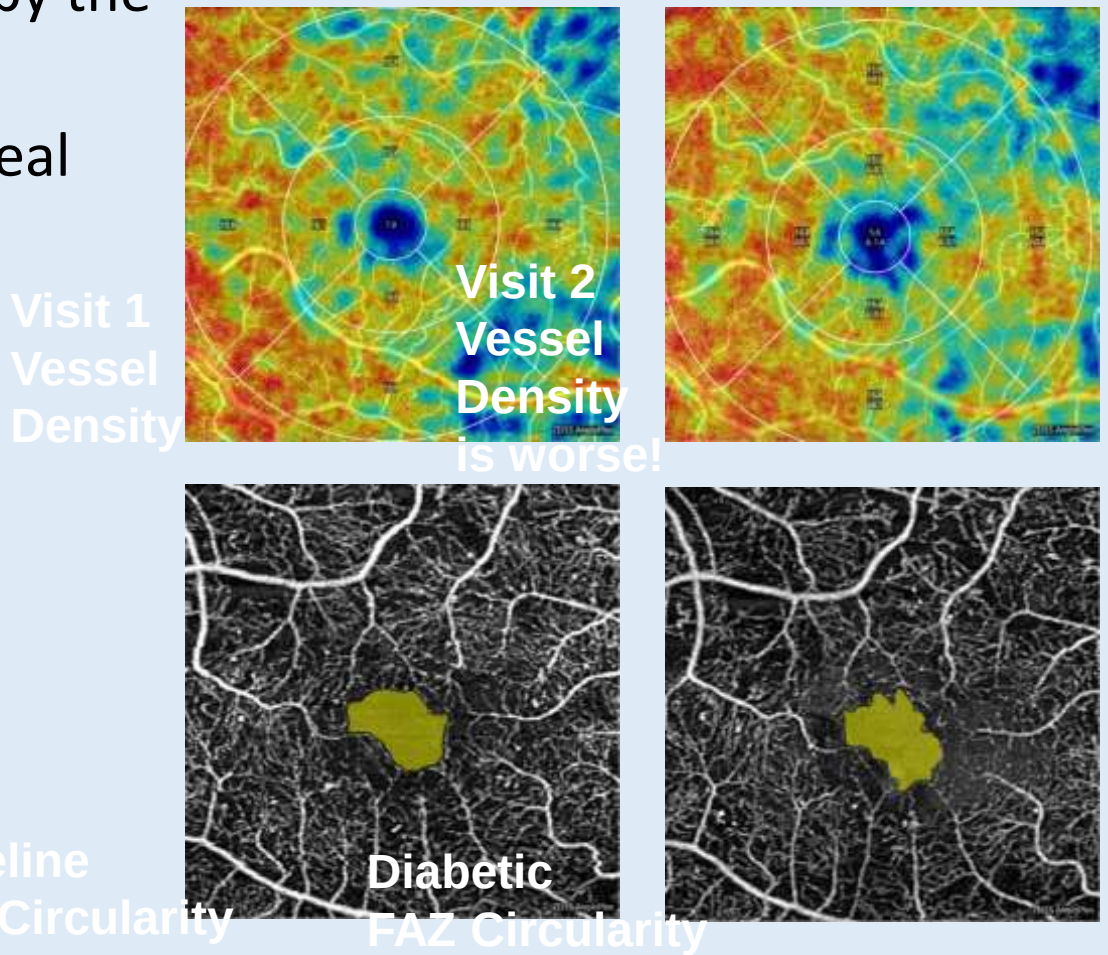
AngioPlex Metrix V10™

New Vascular Metrics for Diabetic Retinopathy Management

•**Clinical Value**

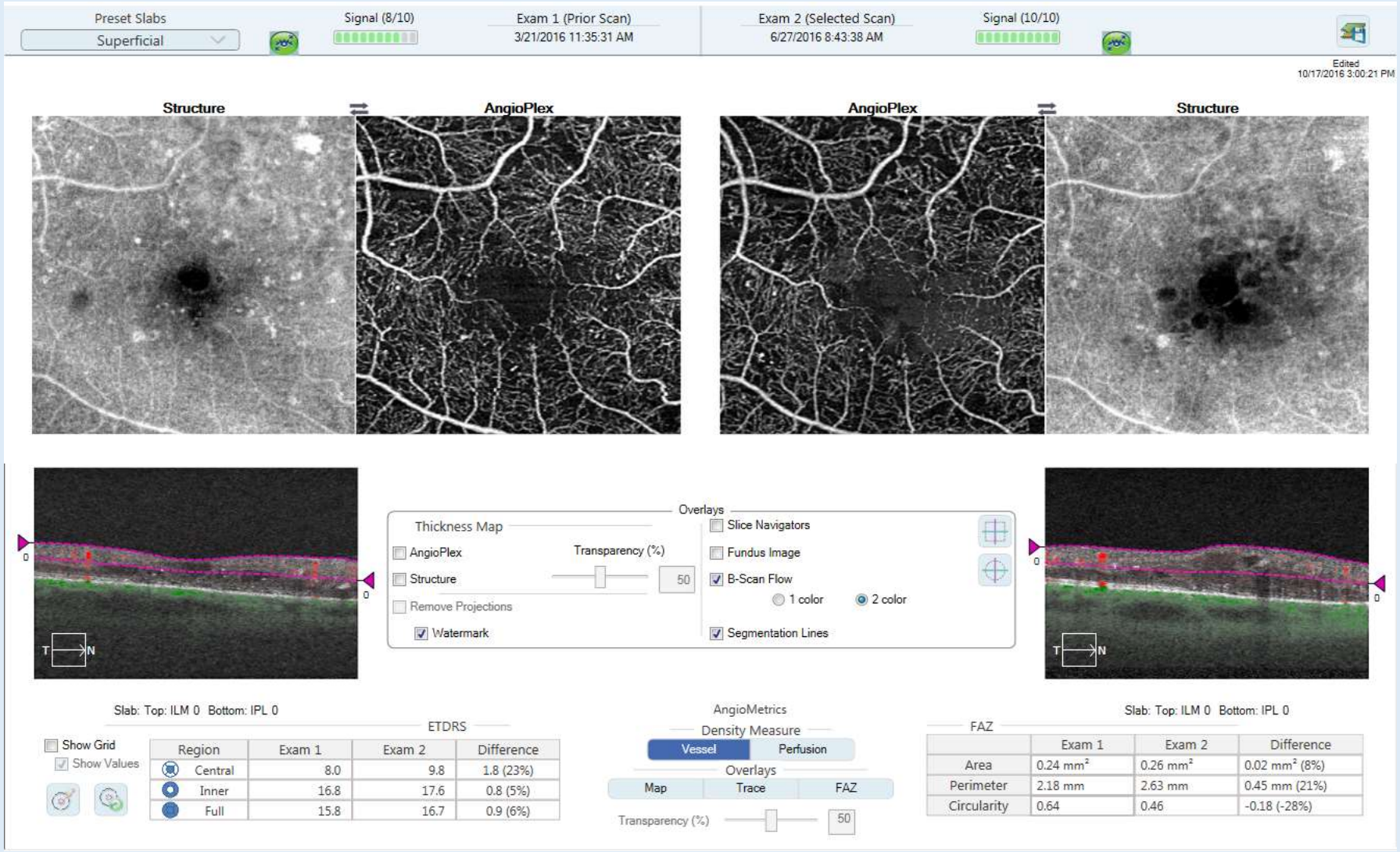
- Retinal vascular density is known to be affected by the presence of Diabetic Retinopathy (DR)..
- DR is also characterized by an irregular, large foveal avascular zone (FAZ)

- **AngioPlex Metrix**
- *Objectively* assess change over time
  - Vascular density
  - Perfusion density
- Help flag patients with early diabetic retinopathy changes.
  - Automatic detection of FAZ Area and Circularity



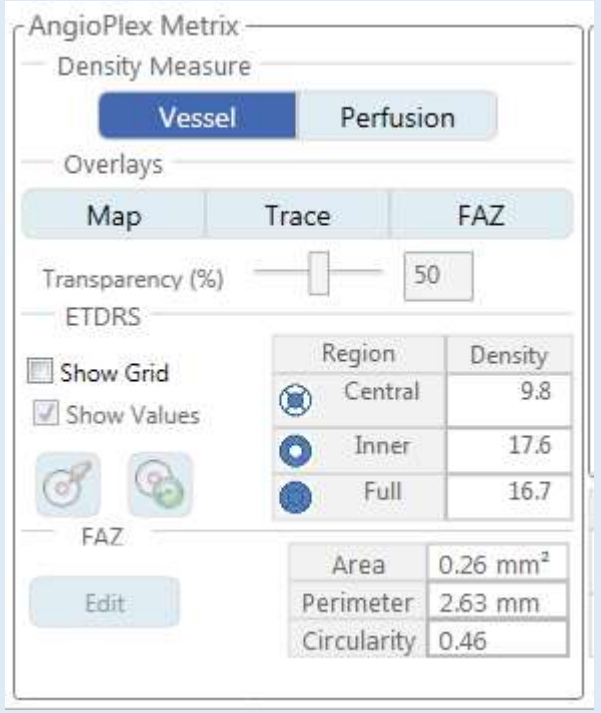
Angiography Change Analysis with AngioPlex Metrix

Clinical Value: Track changes across visits to monitor disease progression and the efficacy of treatment



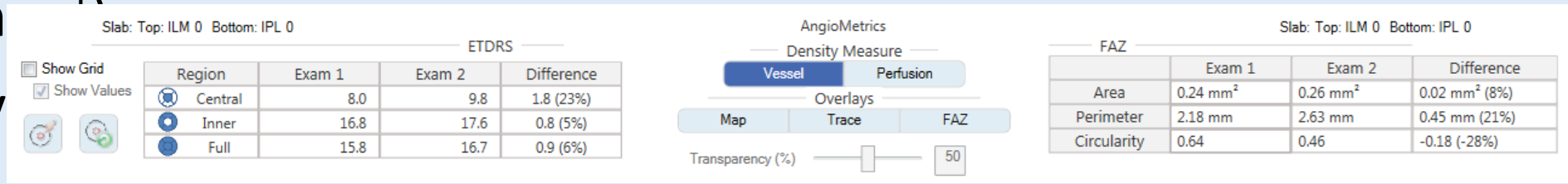
AngioPlex Metrix™ Parameters

- **FAZ Parameters**
- Area (mm^2)
- Perimeter (mm)
- Circularity (unit less)



Angiography Analysis Screen

- **Density Parameters (ETDRS Grid based)**
- Vessel Density (m
- Perfusion Density

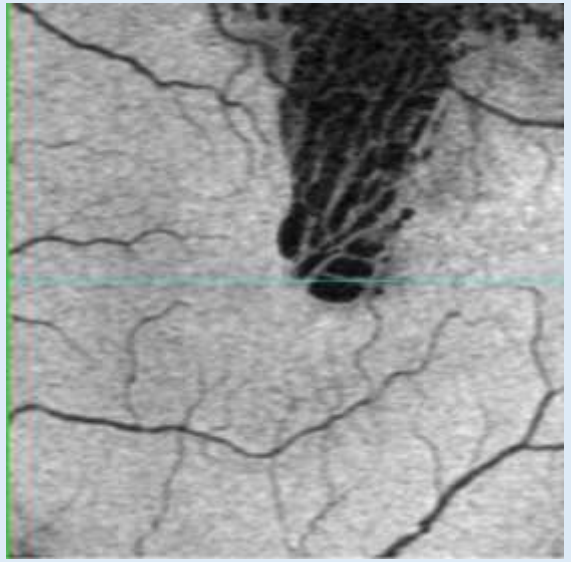


Angiography Change Analysis Screen

- Absolute and percentage change over time for all the above parameters is available in Angiography Change Analysis

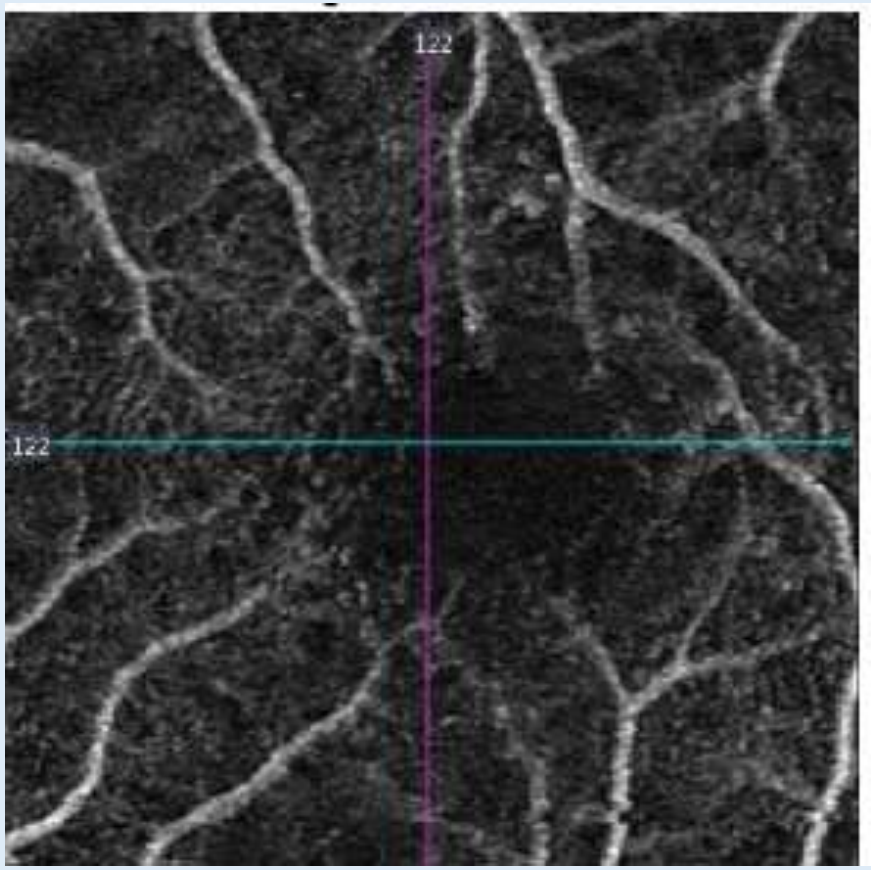
- Min-IP (Minimum intensity projection) Value Proposition:
- Fluid build-up in retina or disruptions in outer retina may generally be presented as hypodense regions.
- Going through all the cube b-scans to look for these regions is cumbersome
- Min-IP provides a quick and easy visualization of minimum intensity (hypodense) regions

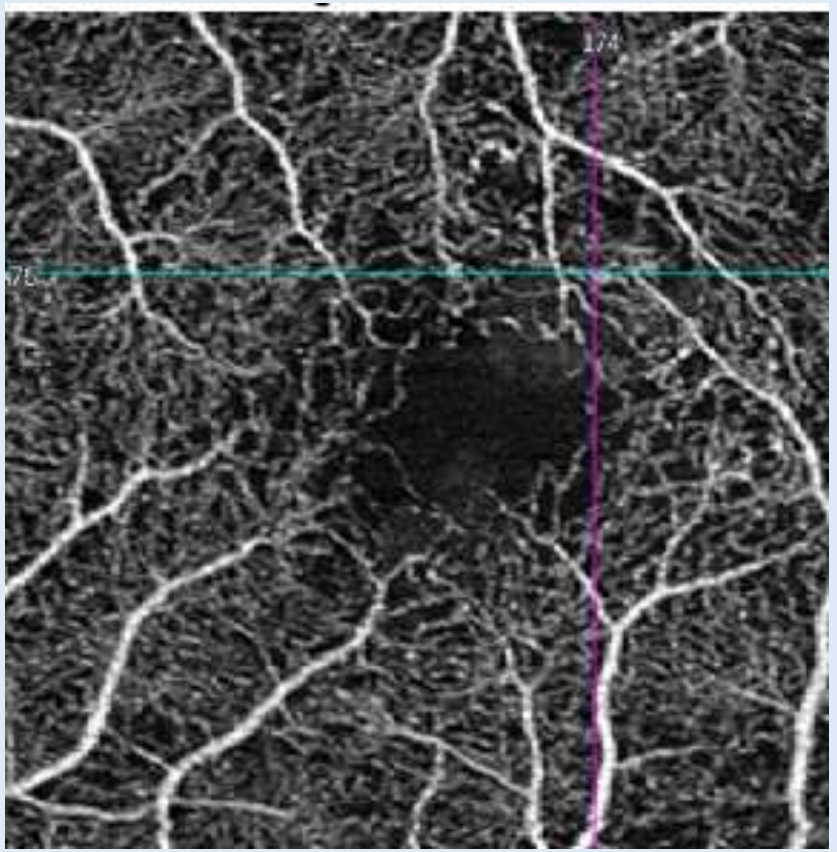
Summed Intensity



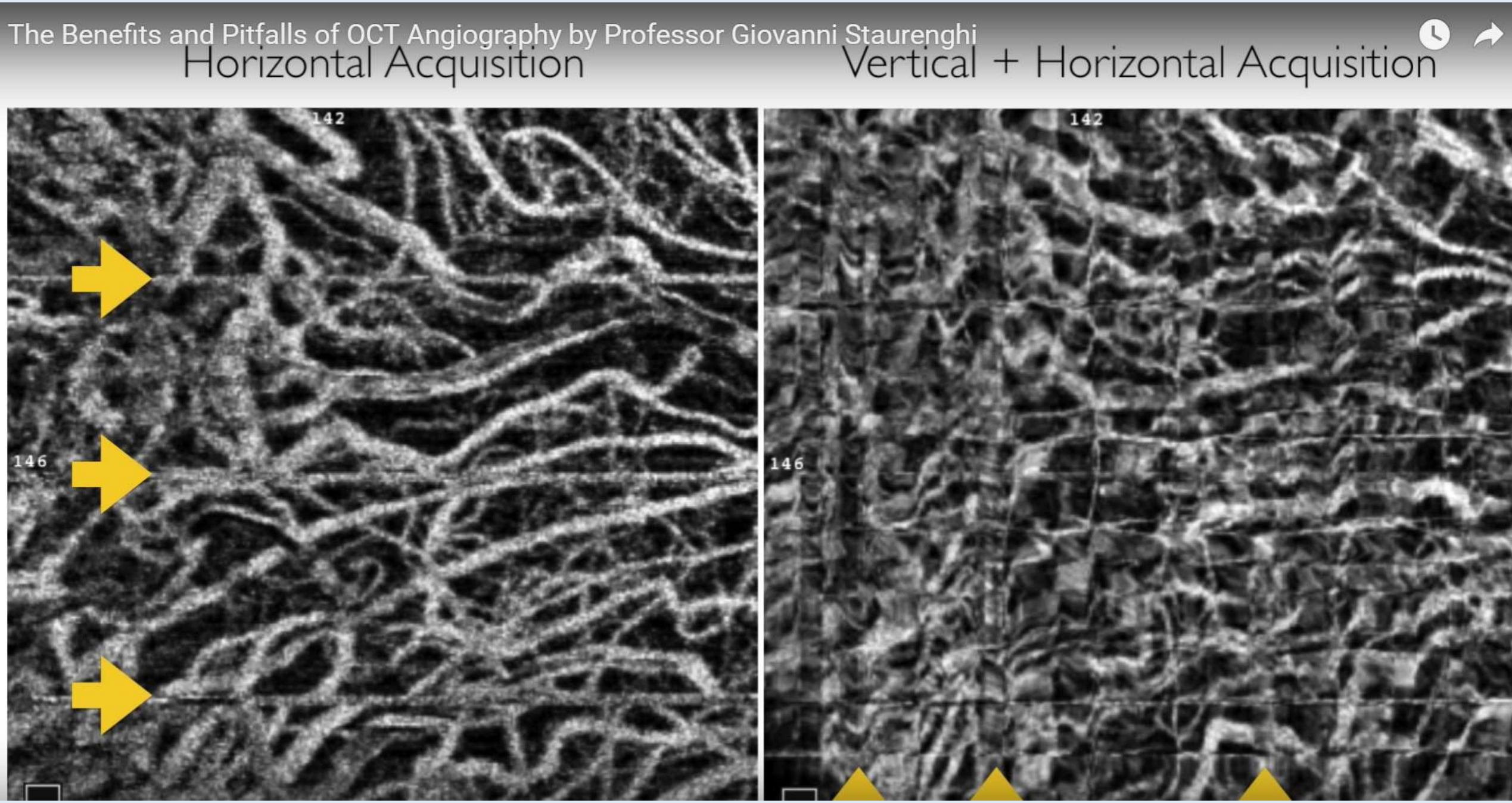
Minimum Intensity

Importance of Focusing





The Benefits and Pitfalls of OCT Angiography by Professor Giovanni Staurenghi



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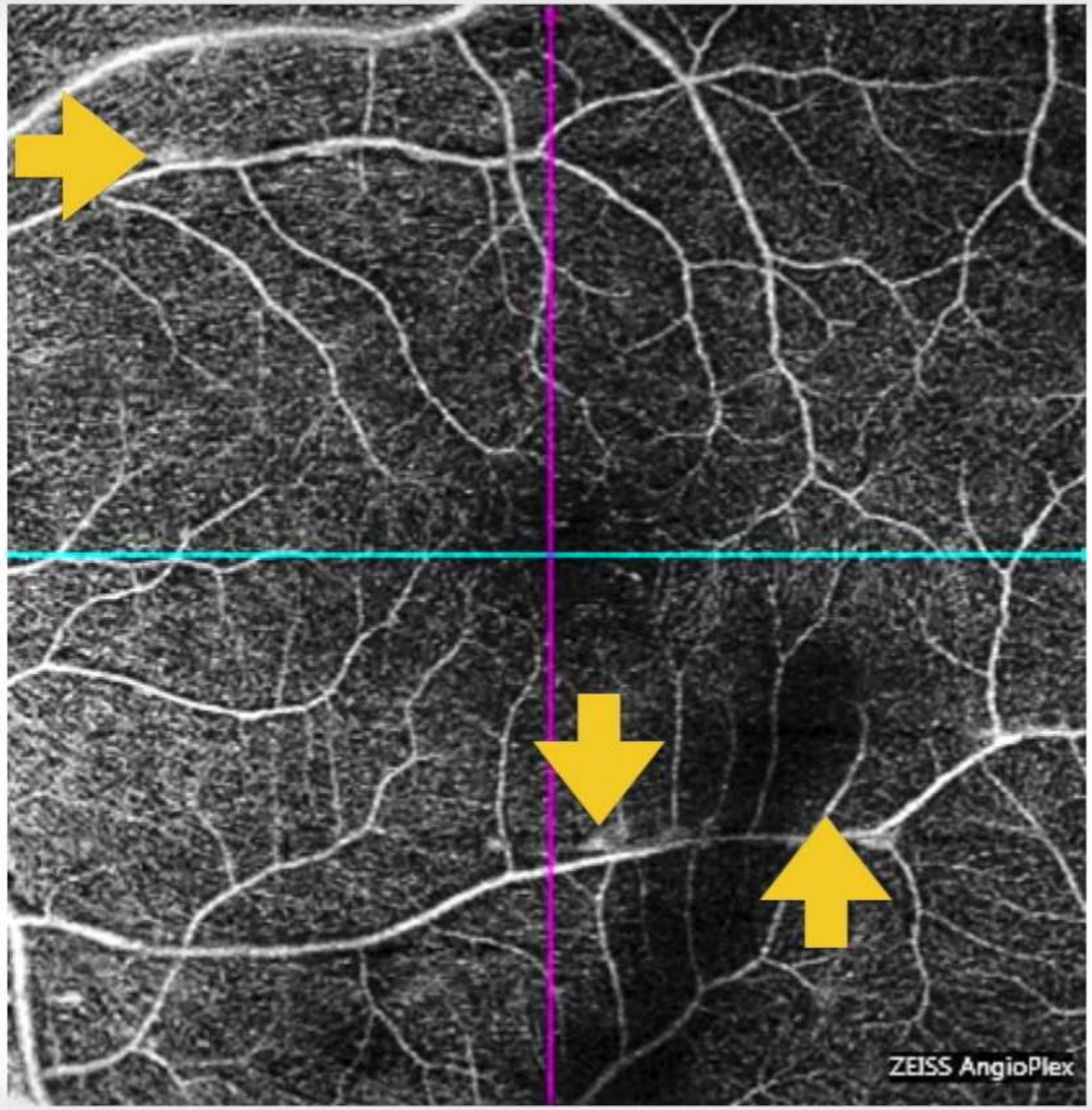

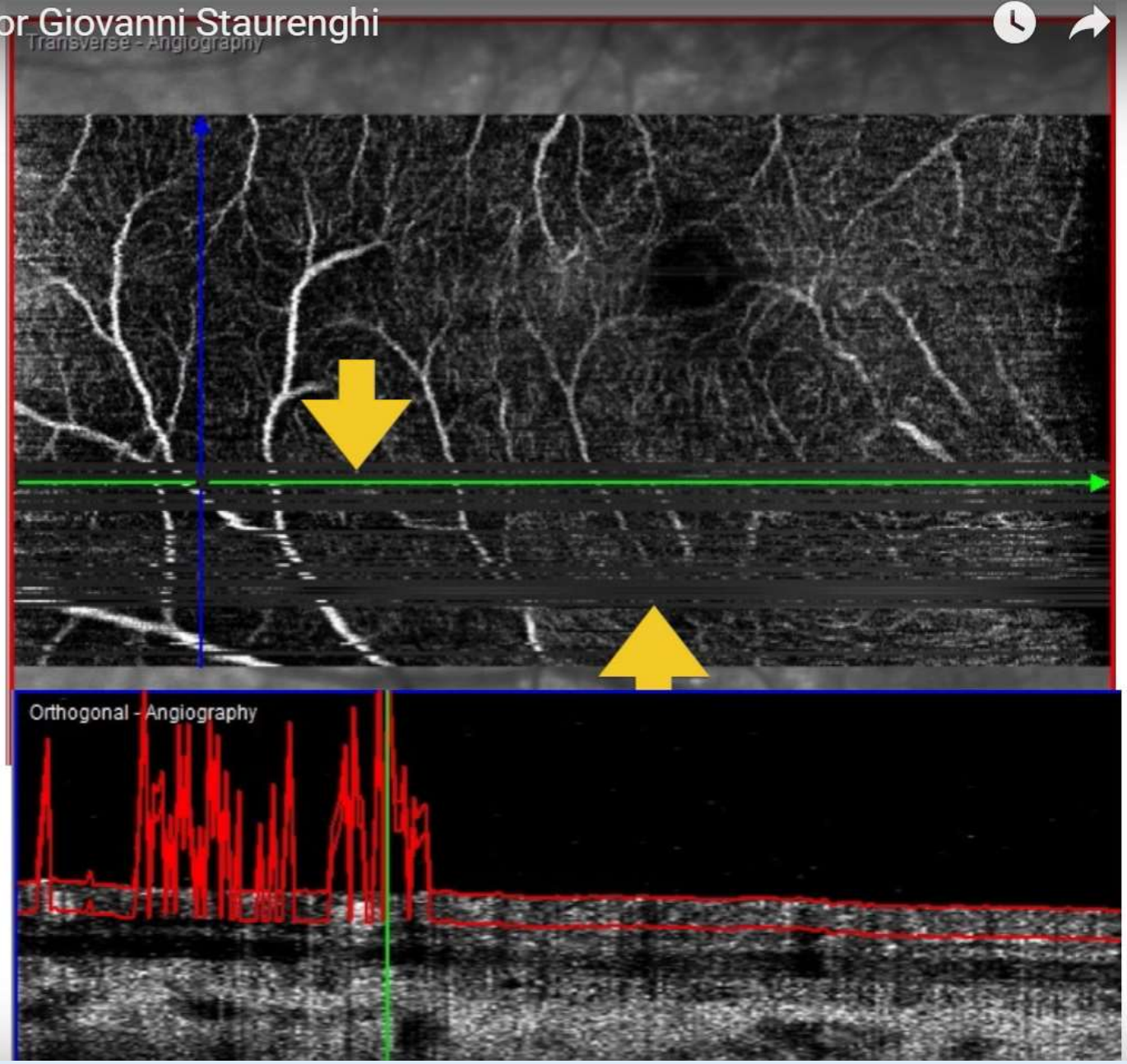

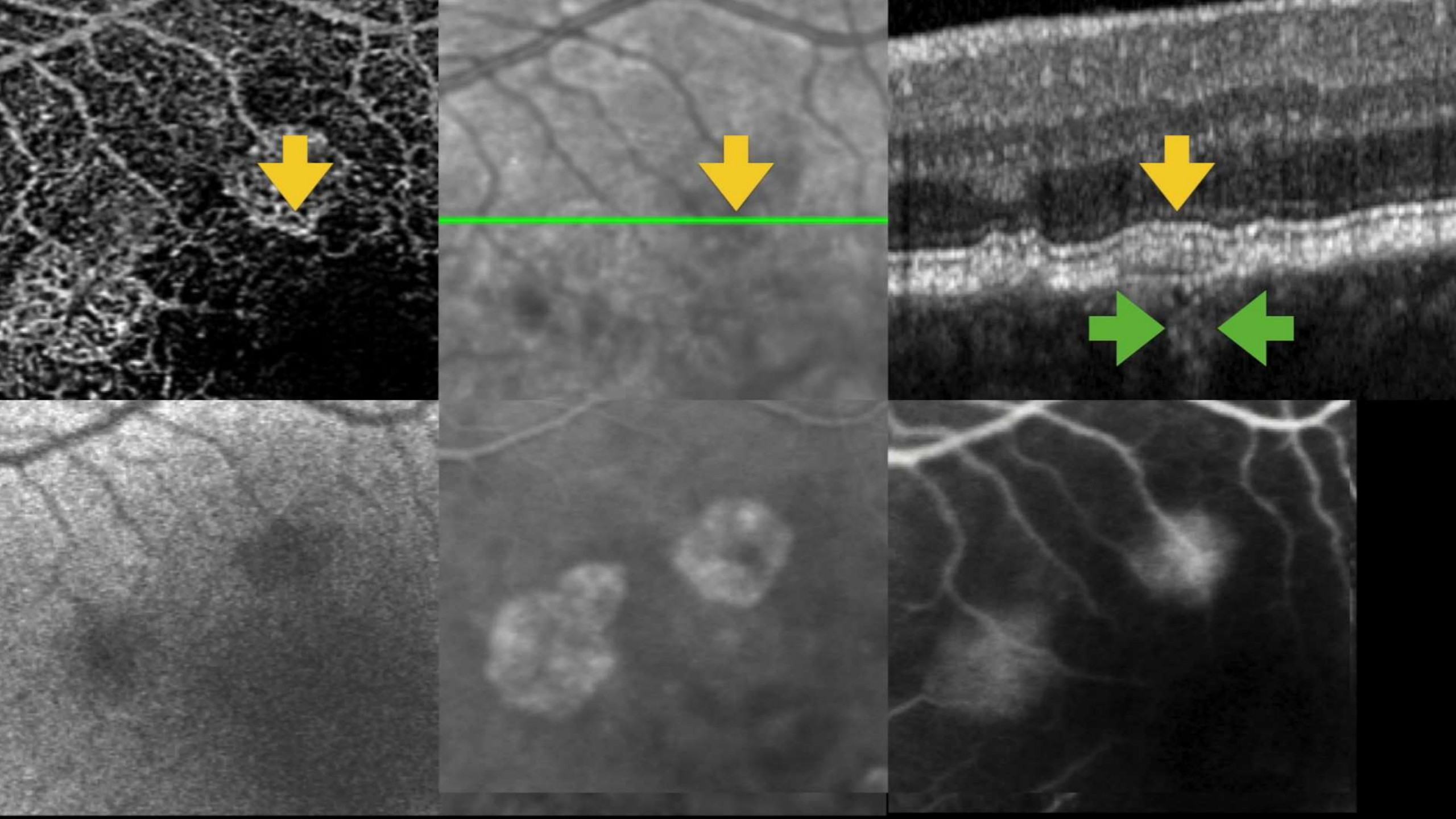

- Youtube
- The Benefits and Pitfalls of OCT Angiography by Professor Giovanni Staurenghi

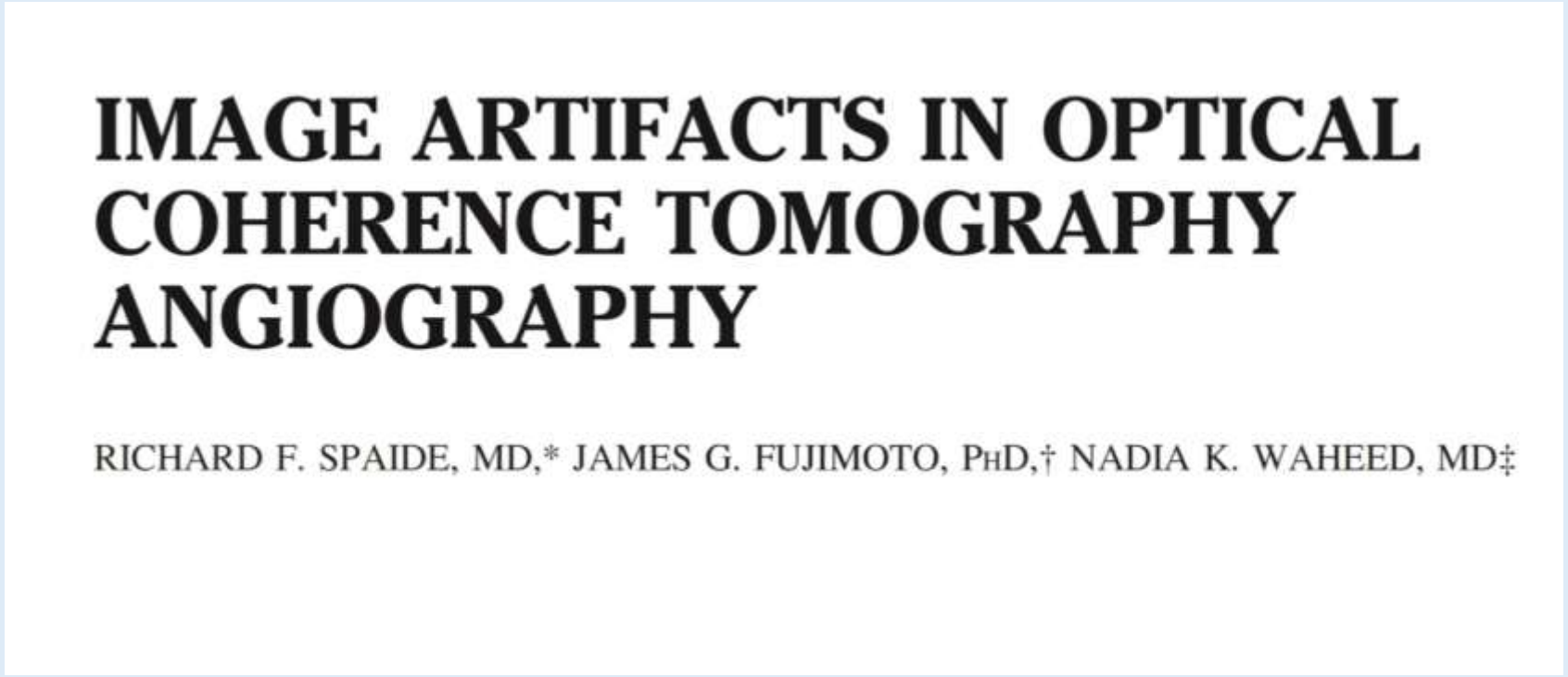

IMAGE ARTIFACTS IN OPTICAL COHERENCE TOMOGRAPHY ANGIOGRAPHY

RICHARD F. SPAIDE, MD,* JAMES G. FUJIMOTO, PHD,† NADIA K. WAHEED, MD‡

What can OCT-A DO and Not DO

- High resolution of Retinal Circulation
  - Ischaemia, Collaterals, Aneurysms
- Identify NVE growing above Retina
  - Differentiating IRMA VS NVE
  - Epiretinal membranes
- Mid retina circulation - RAP
- Choriocapillaris
  - New Vs Abnormal
  - SRNVM type and Size
  - Vascularised vs non vascularised PED
- Choroid – large vessels
- Doppler Blood flow
  - Retinal & Choroid
- Metrics
  - Fovea avascular areas measurements
  - Change analysis

- Can not see Leak like FFA
  - No help for:
    - CSR, Irvine-Gass,
    - Optic disc leak
    - NVD / NVE leak - activity
- Narrow field
  - FFA wide field – Surveys
  - Spectral domain Vs Swept source
- Poor ocular Media clarity degrades image
  - ? FFA any better
- ? Sizing for PDT ?
- No colour photograph (Topcon dose Provide)
  - No Auto fluorescence
  - ICG vs OCT-A – not worked out
- Limited Experience of intrepreation

OCT-A VS FFA

- Non- Invasive – no side effects
- Repeatable as often as needed – Follow Change
- Limited Clinical experience - 2016
  - Limited availability
  - Currently Hot-topic for publications
- Rapid diagnosis
  - Same day Scans with normal OCT
  - Reduce diagnosis to treatment time
  - Colour print out summary or Computer
- Duration of test – 5 minutes
  - 5 seconds per scan
- Cost
  - Per test 0 (Operator only)
  - Low skill set to operate
    - Community / Optometrist practices
    - Mobile – K9
  - Capital – New equipment £80K
  - Situate OCT in any room/area

- Clinical Experience since 1960
- Side effects 5 – 10%
  - Yellow urine – 100%
  - Nausea – Common
  - Urticaria – 1 in 300, Bronchospasm, Hypotension, syncope
  - Anaphylaxis – 0.4%, MI/Cardiac arrest
  - Death 1 in 220,000 7 in 50 years reported
- Clinic to FFA appt can vary – often delays
  - Delay in clinic to diagnosis to treatment
  - Review usually on Computer only
- Duration of test – 1 Hour+
- Consent required
- Unlicensed drug
- Cost
  - Per Test +++
    - High Skill set - Photographer, nurse, doctor
  - Capital £40K & All units have one
  - Dark Photographic room

Dawn of a New Era in Imaging

- New Clinic Diagnostic pathway
  - Spectral Domain/Swept OCT
  - OCT-A
  - Colour Photograph / Auto fluorescence
  - FFA
  - ICG
- Patient safety issue
  - Informed consent about options
    - Medico-legal situation
- Developing Technology