Thanks for inviting me to participate to this symposium
I wish to discuss with you about OCTA

EVER, Octobre 7th 2016

EVER SYMPOSIUM

OCT-A, useful tool and artifacts

Florence COSCAS
Marco LUPIDI, Gabriel COSCAS

Disclosure
Bayer, Novartis, Allergan, Thea, Heidelberg, Topcon

Here, Full-Spectrum Algorithm used with OCT2, Heidelberg : No Comment

$$I(x,k)=\int_{-\infty}^{\infty}R(k)A(x,k,z)cos(2kz)dz$$

$$G(n)=\exp[-\frac{(n-m)^2}{2\sigma^2}]$$

$$\tilde{I}(x,z)=FFT\{I'(x,k)\}=A(x,z)\exp[i\varphi(x,z)]$$

$$\bar{D}(x,z)=1-\frac{1}{N-1}\sum_{n=1}^{N-1}\frac{A_n(x,z)A_{n+1}(x,z)}{[\frac{1}{2}A_n(x,z)^2+\frac{1}{2}A_{n+1}(x,z)^2]}$$

$$\bar{D}(x,z)=1-\frac{1}{N-1}\frac{1}{PQ}\sum_{n=1}^{N-1}\sum_{p=1}^{P}\sum_{q=1}^{Q}\frac{A_n(x+p,z+q)A_{n+1}(x+p,z+q)}{[\frac{1}{2}A_n(x+p,z+q)^2+\frac{1}{2}A_{n+1}(x+p,z+q)^2]}$$

$$\bar{D}(x,z)=1-\frac{1}{N-1}\frac{1}{M}\sum_{n=1}^{N-1}\sum_{m=1}^{M}\frac{A_n(x,z)A_{n+1}(x,z)}{[\frac{1}{2}A_n(x,z)^2+\frac{1}{2}A_{n+1}(x,z)^2]}$$

Jia Y; Optom Vis Expr. 2012

OCT- ANGIOGRAPHY

This label-free angiography is a transformative approach imaging ocular vessels based on flow, not simple reflectance intensity

It allows both :

- 3D visualization, and
- Retinal and choroidal structures perfusion

Principle is based on that very hypothesis:

"In an infinitely short time interval, the structures which move actively are the blood cells which flow in the vessels"

OCT-ANGIOGRAPHY **uses different Technologies**

Doppler-OCT

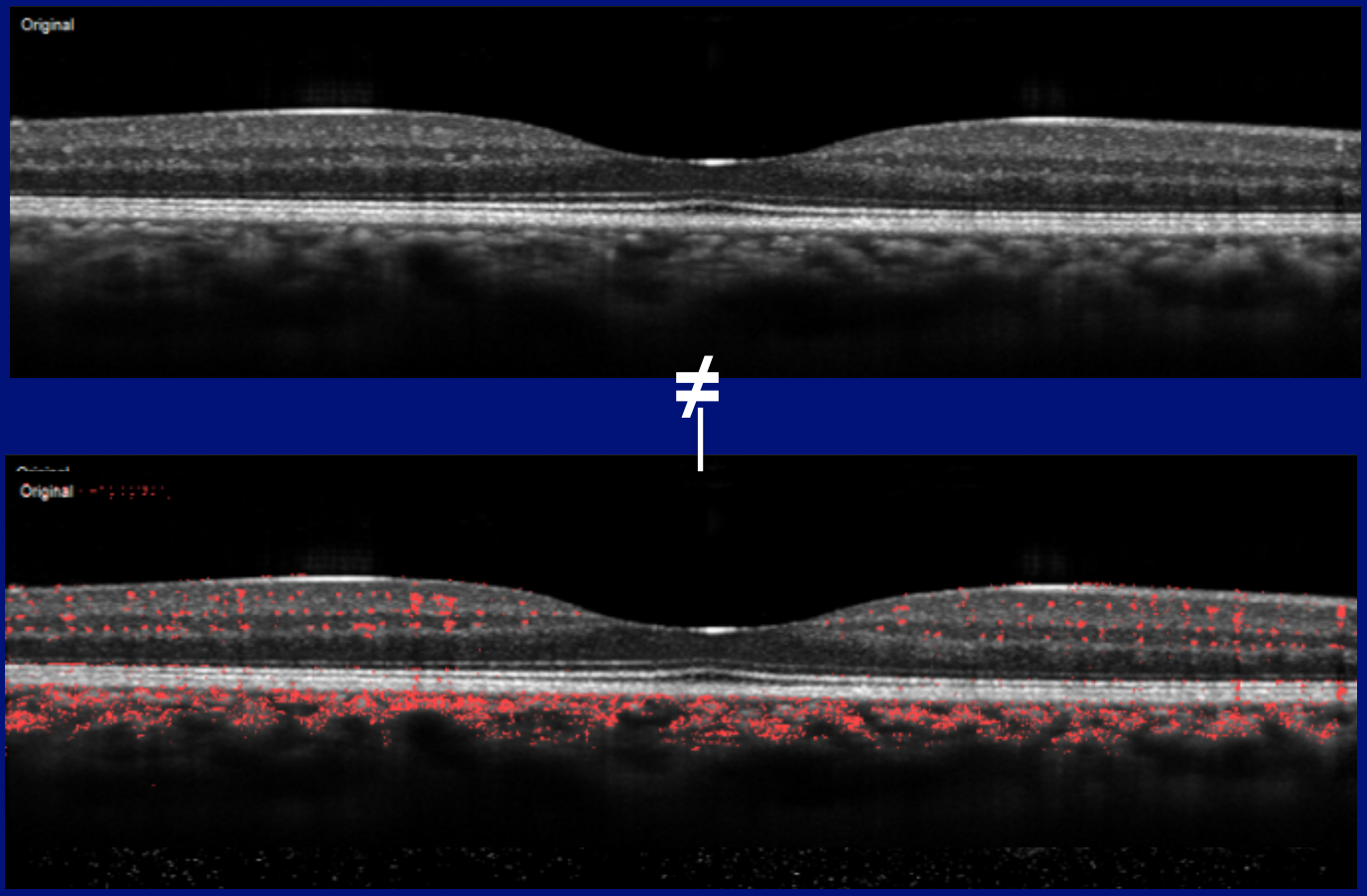
- **Doppler OCT** uses the flow-induced Doppler phase shift between adjacent A-scans to calculate axial velocity
- **Doppler OCT** could measure and quantify blood velocity in larger vessels
- Potential limitations might be retinal and choroidal microvasculature, where **vessels are nearly perpendicular to the OCT beam**

OCT-Angiography

- **Speckle/Intensity (or Amplitude) Decorrelation: is a** Method for detecting motion contrast based on detection of speckle or intensity changes in OCT structural images
- **Phase Variance: is a** Method for detecting motion contrast assessing changes in the phase of the light waves
- **Combined Technologies: it** incorporates the amplitude of the OCT signal in addition to phase

Exact computation is based of the differences between:

- 2 consecutive OCT B-scans
- In the same location
- In a time interval ($\Delta T_{1,2}(-\infty)$), as you can see



We need to use new Technical Wording and we had to create some new terminologies

DECORRELATION is
The amount of change in a region from 1 sequentially repeated image to the next.

SPECKLE or INTENSITY DECORRELATION is the
Method for detecting motion contrast based on detection of speckle or intensity changes in OCT structural images.

PHASE VARIANCE is the
Method for detecting motion contrast assessing changes in the phase of the light waves.

SEGMENTATION is the
Process of dividing a larger set into two or more smaller ones according to a set of rules.

THRESHOLDING
Refers to the mechanism replacing the pixel or voxel values above or below a certain value with another value to aid in image visualization or analysis.

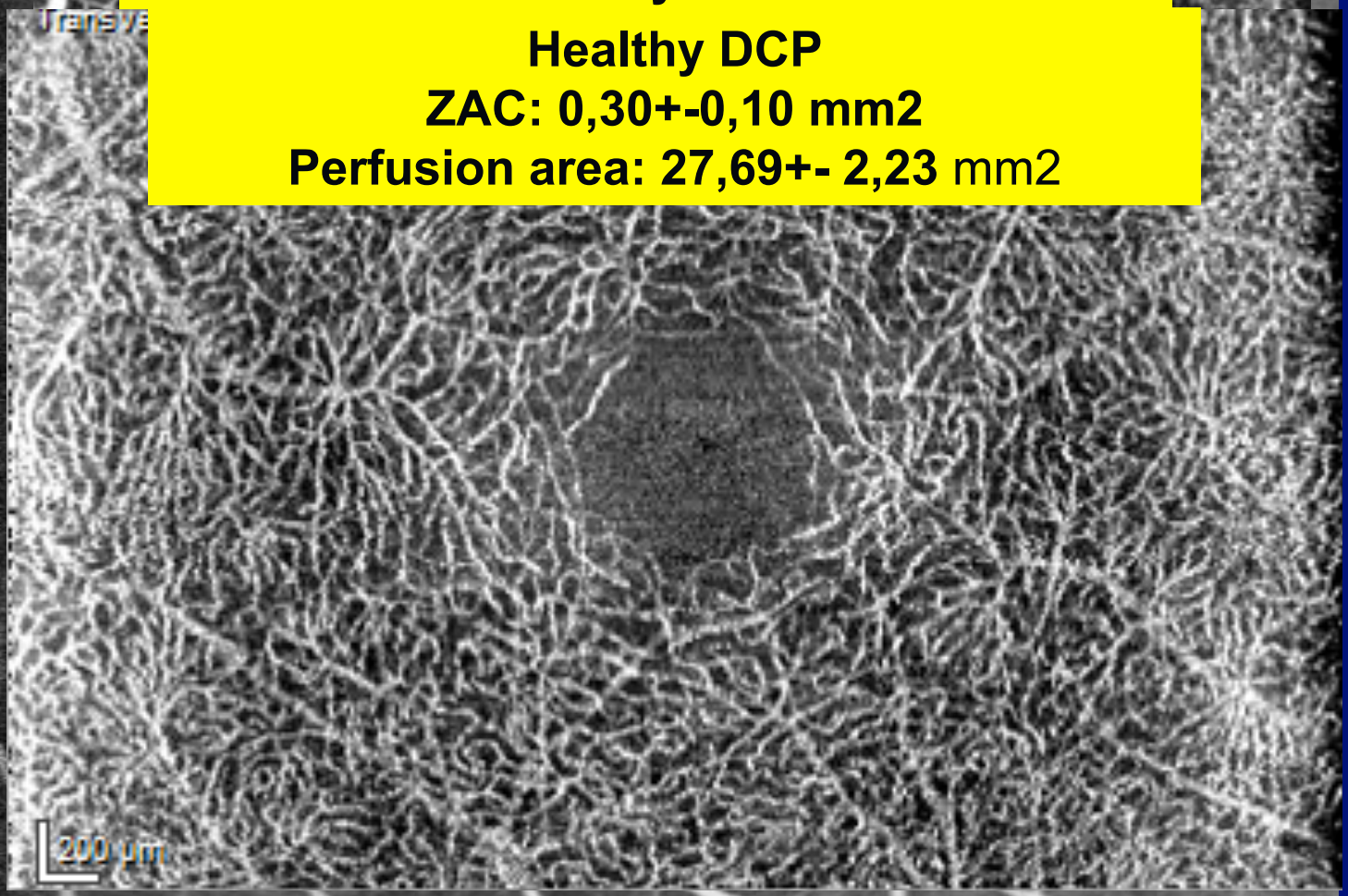
Standard Fluorescein Angiography gives normal retinal vessels
OCTA shows SCP and DCP with qualitative and quantitative signs
All vessels are hyper intense on these plexuses

Healthy SCP

Healthy DCP

ZAC: 0,30+-0,10 mm2

Perfusion area: 27,69+- 2,23 mm2

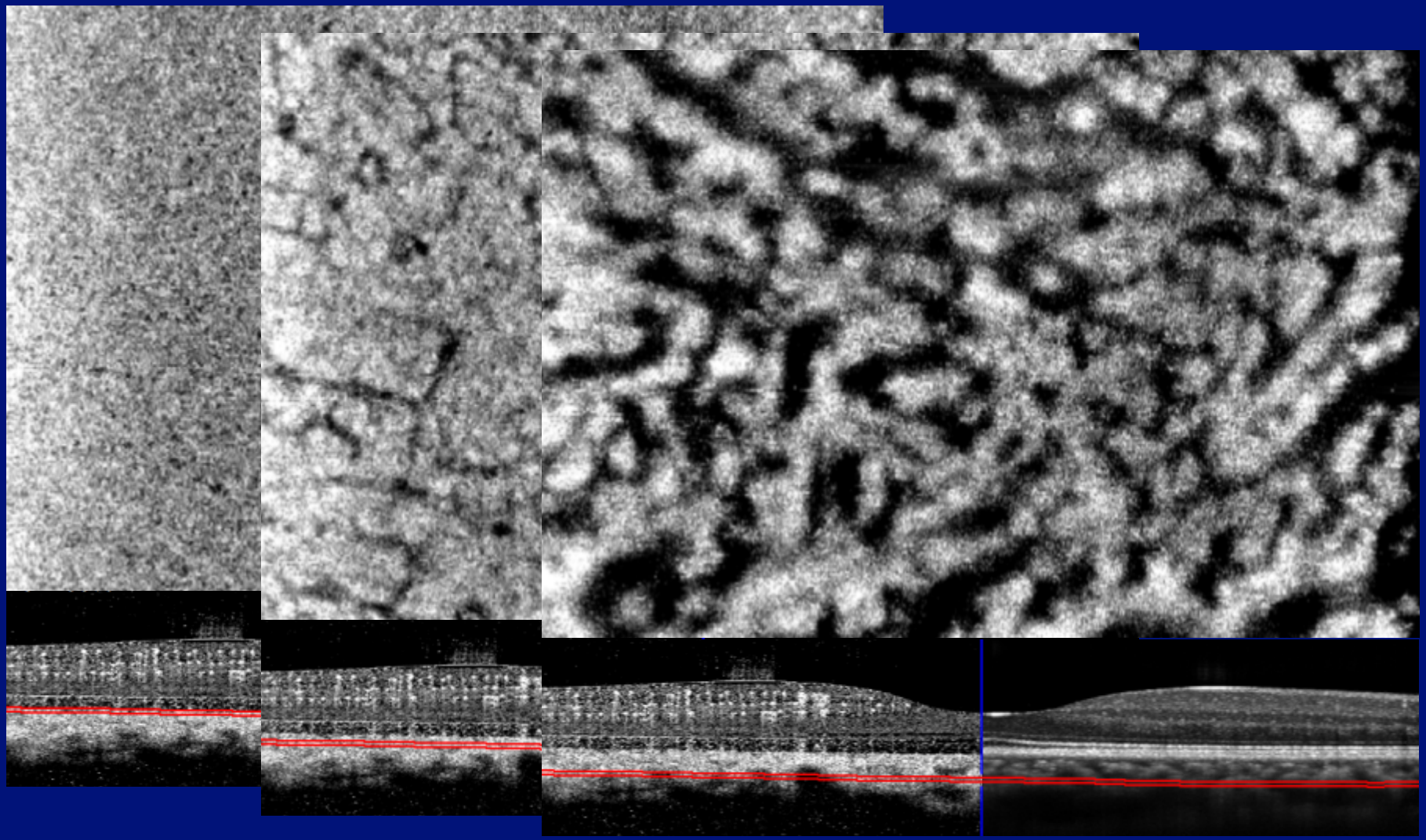


Superficial Capillary Plexus

FA

bellow RPE («shield effect»):
OCT-A shows that all choroïdal vessels are hypo intense

HALLER'S LAYER



OCT-A False Friends in clinical application

OCT-Angiography gives the good diagnosis
But…is it “always” true?

For the a good analysis, we have 2 concerns:

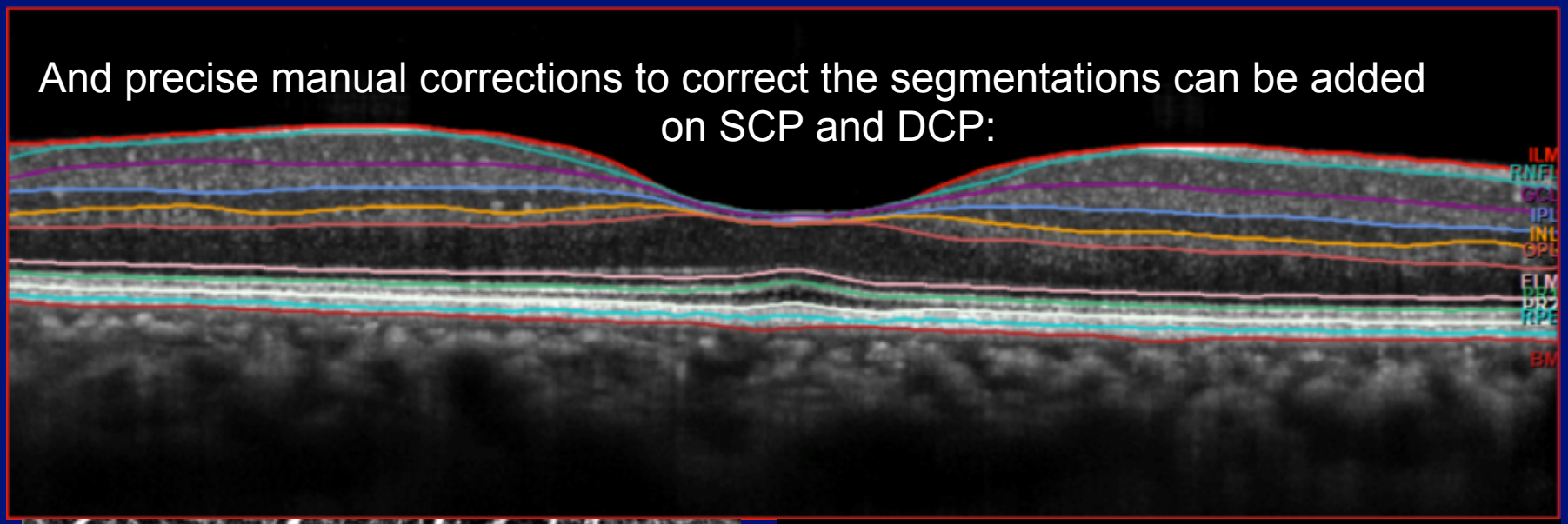
- LAYER SEGMENTATION

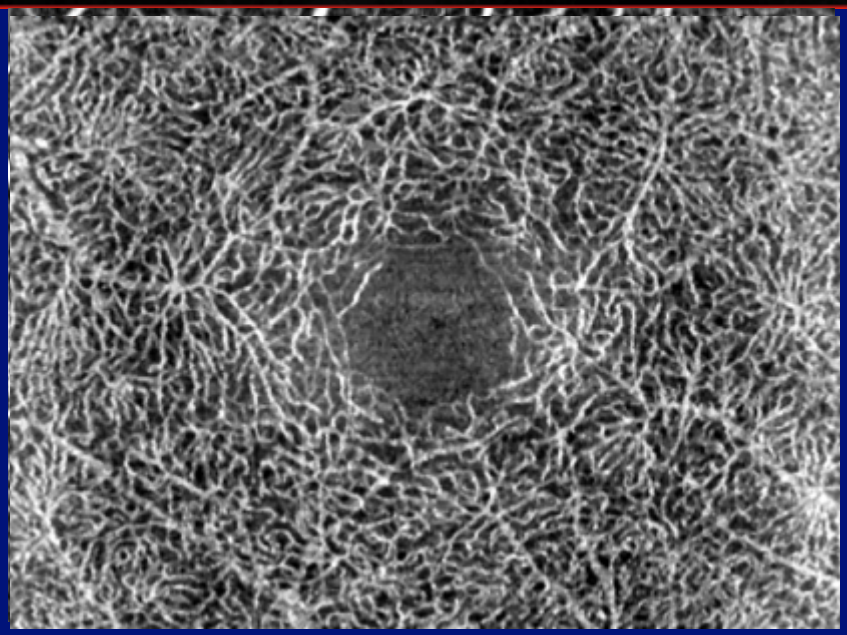
- (In first papers,) the two capillary plexuses were not always perfectly separated, the variable superimposition of the main superficial vessels could alter the visibility of the DCP.

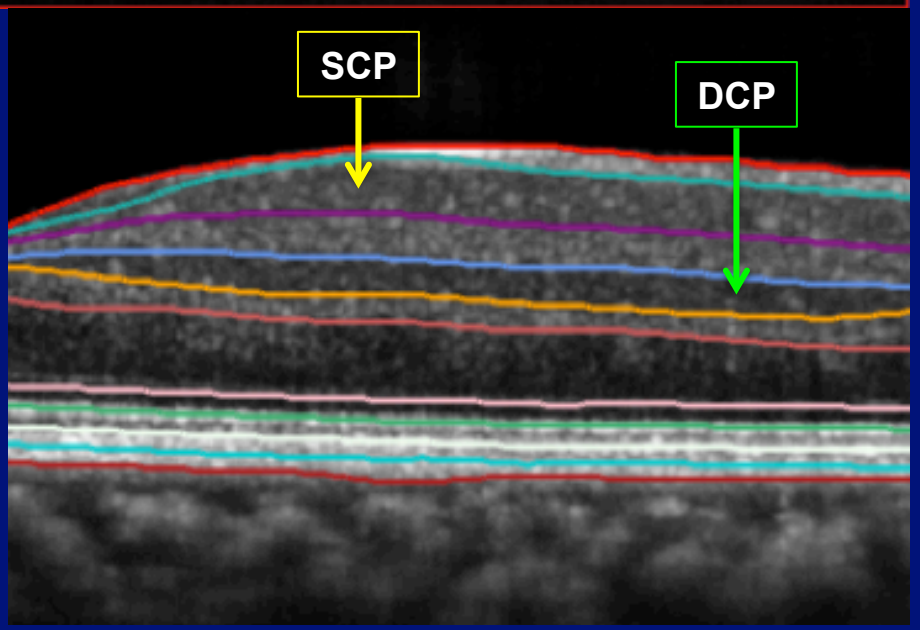
- PROJECTION ARTIFACTS

Now, segmentation protocol has been improved in the latest version of OCT2

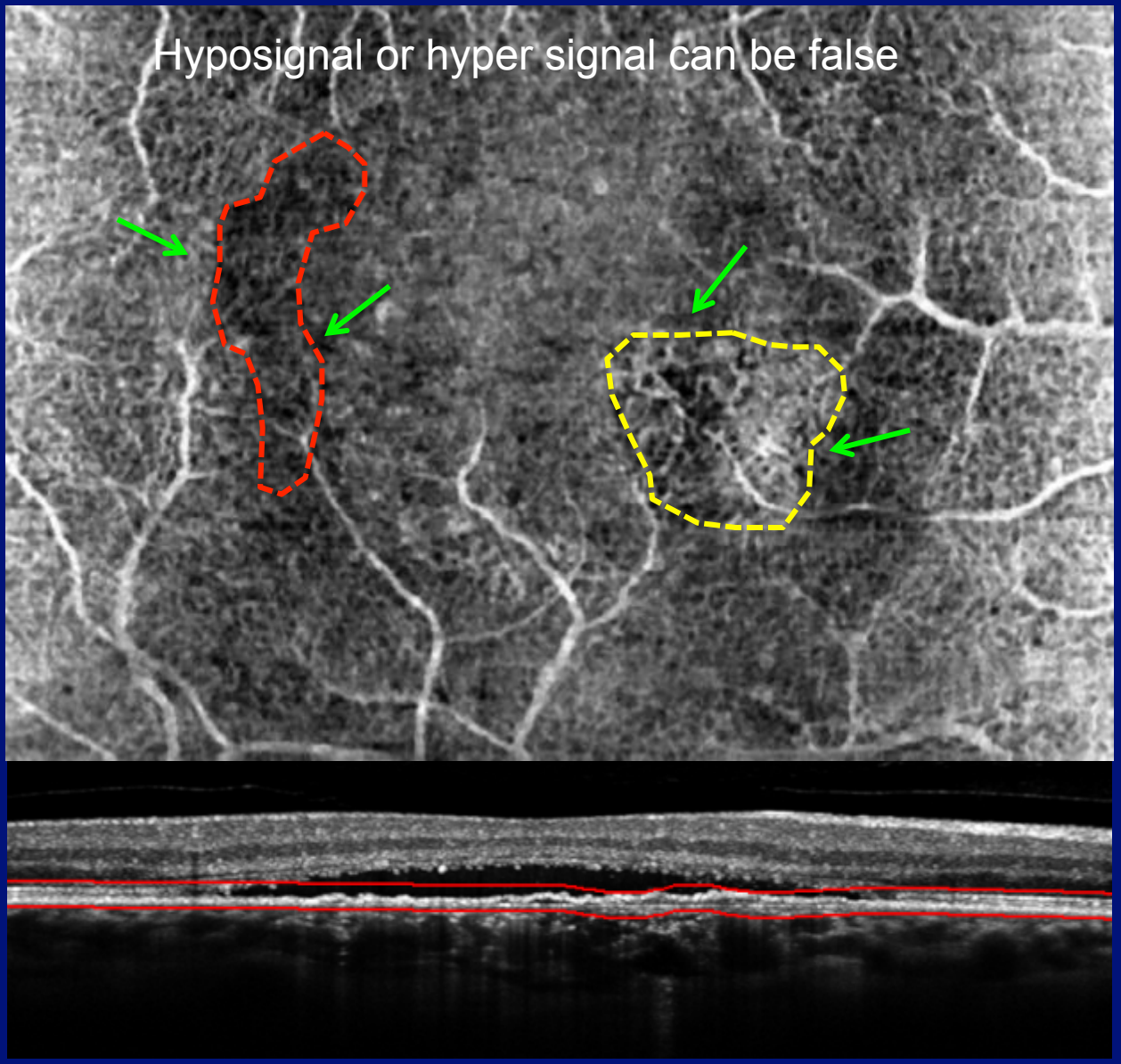
And precise manual corrections to correct the segmentations can be added on SCP and DCP:



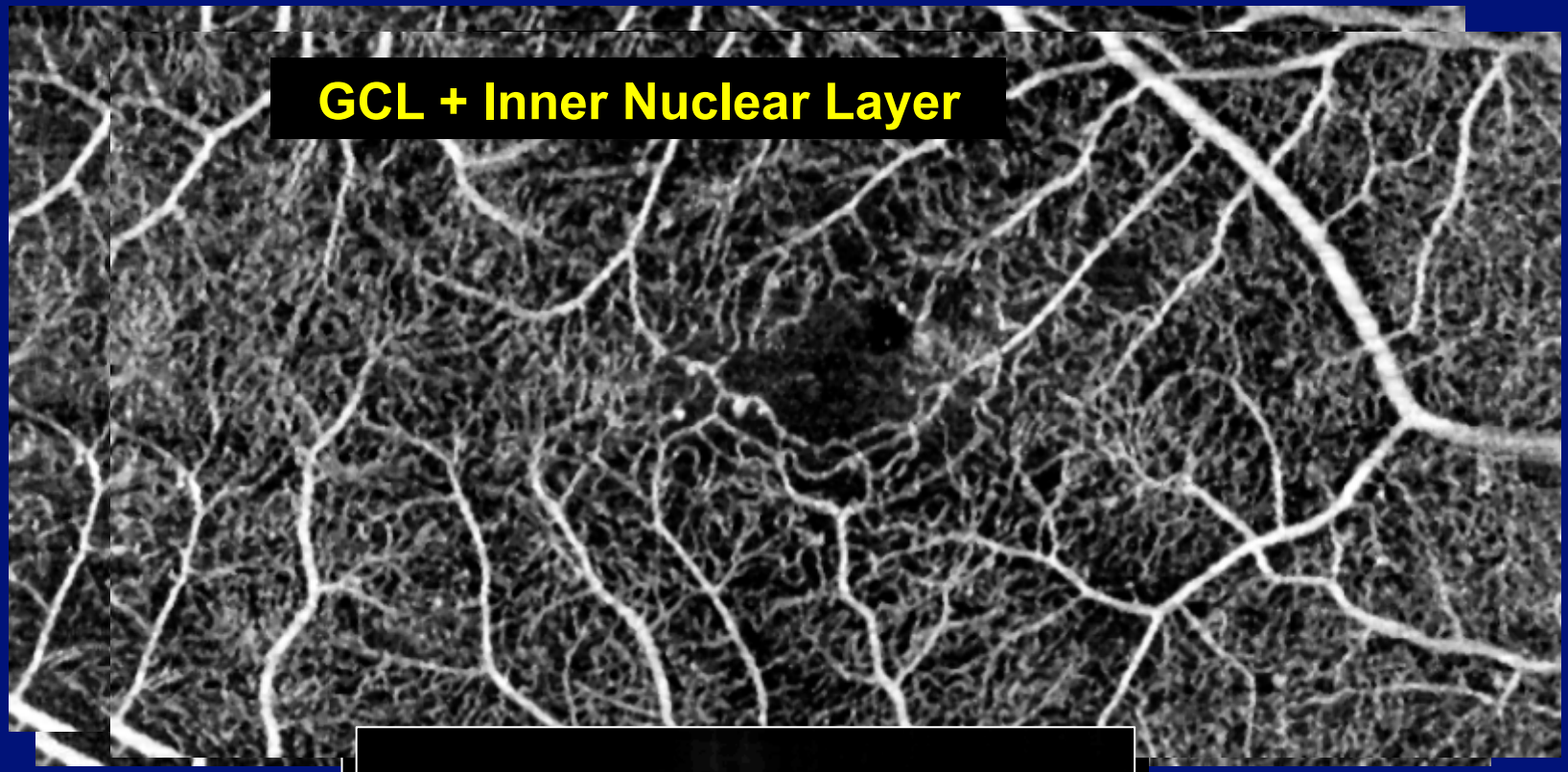


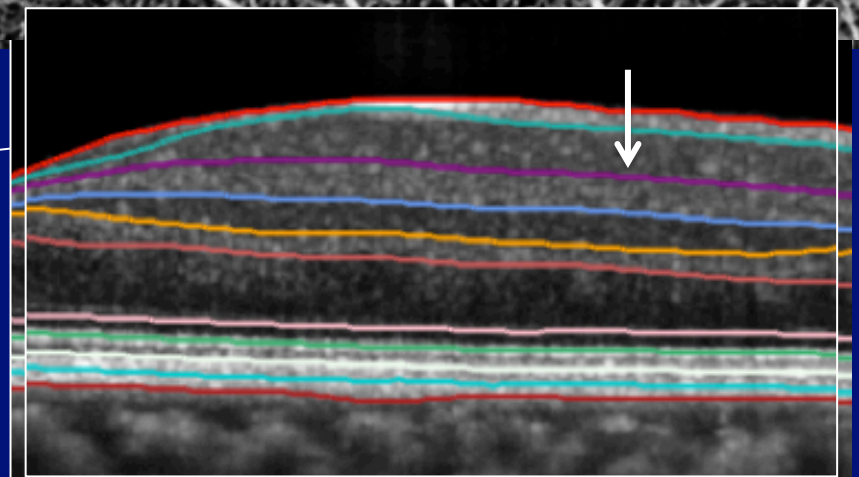


Be Careful With Automated Segmentation!!!



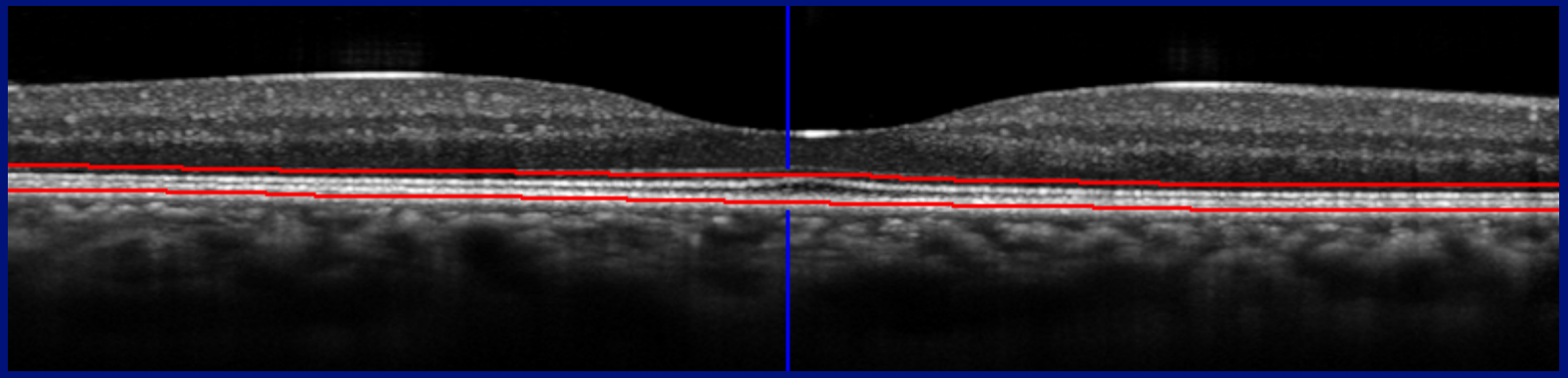
Let's look at a manually corrected Segmentation Protocol, we can see



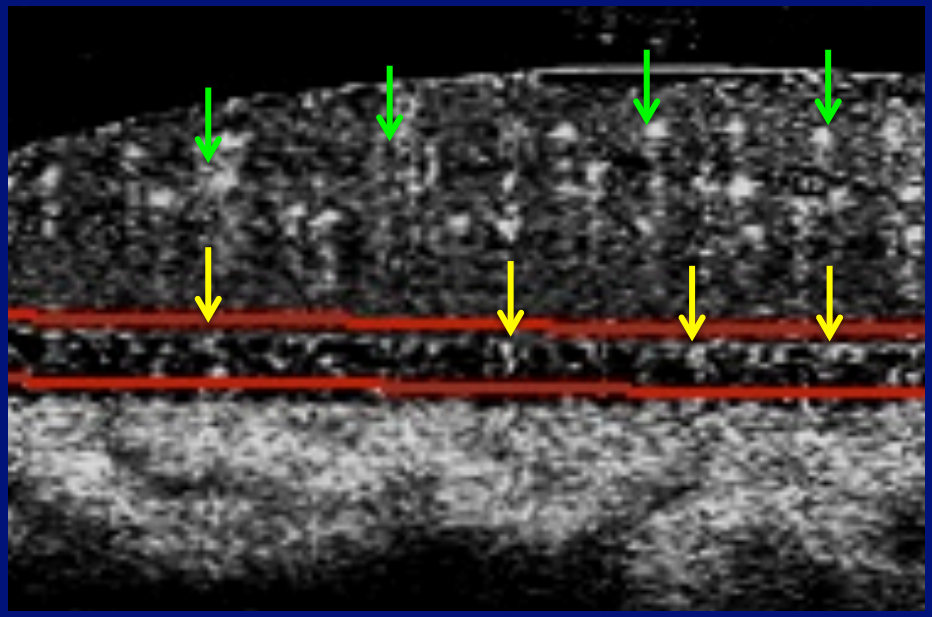


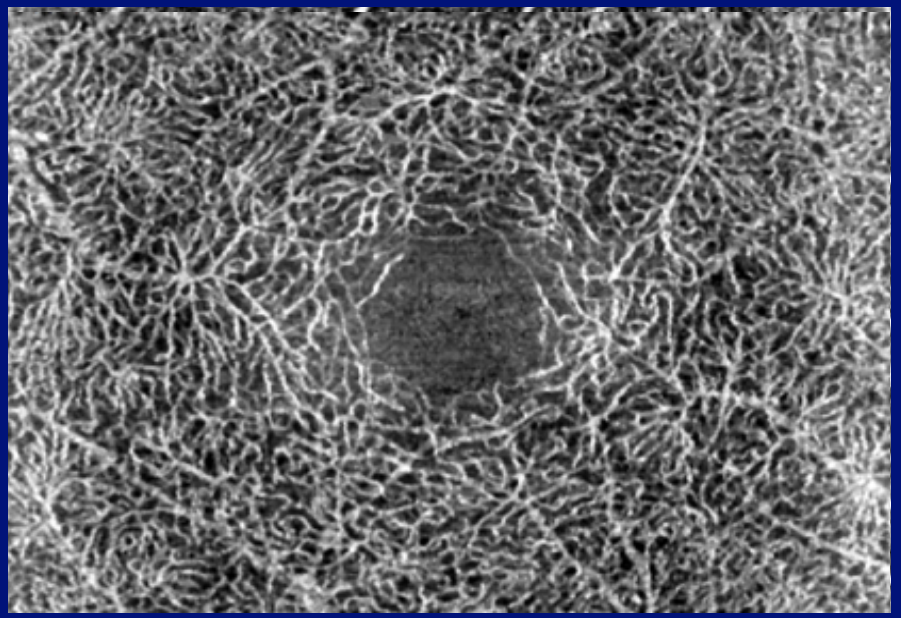
A more precise view

We observe PROJECTION ARTIFACTS of retinal vessels from superficial and deep plexuses On RPE



On Angiomode OCT-B: vessels are hyper intense and not hypo reflective as with structural OCT-B
At each level: superficial and deep plexuses





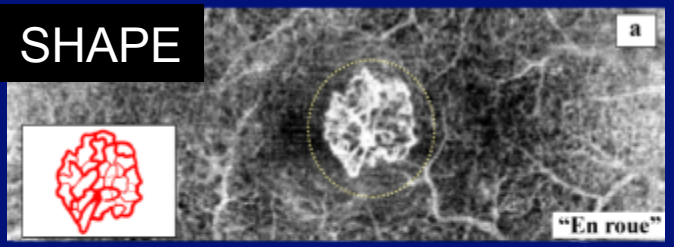
OCT-A: we have also some new signs

Such as active versus quiescent criteria and quantitative values

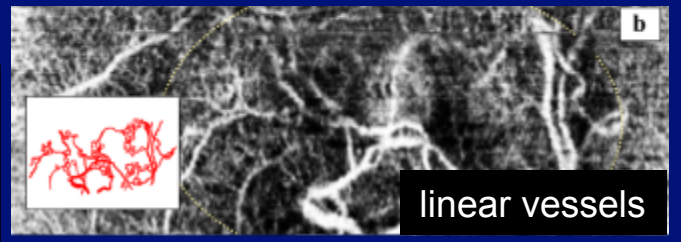
active criteria

quiescent criteria

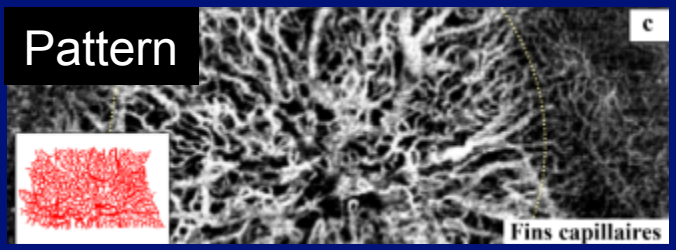
SHAPE

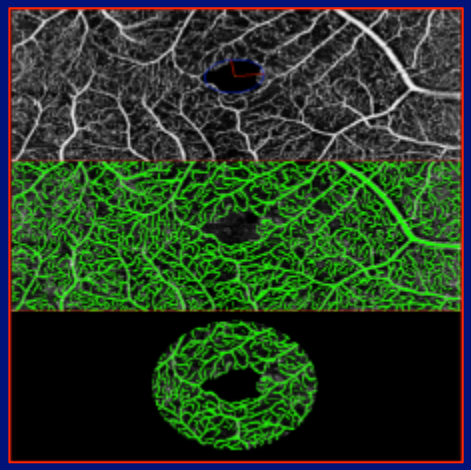


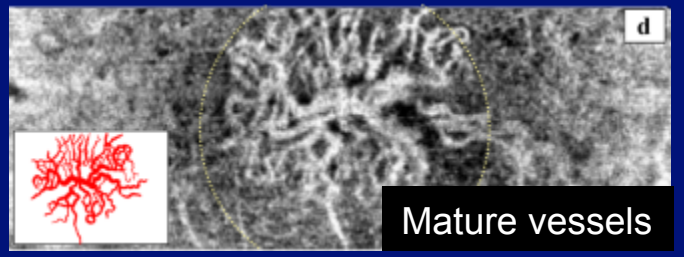
FAZ:
SCP: 0,28+-0,11 mm2
DCP: 0,30+-0,10 mm2

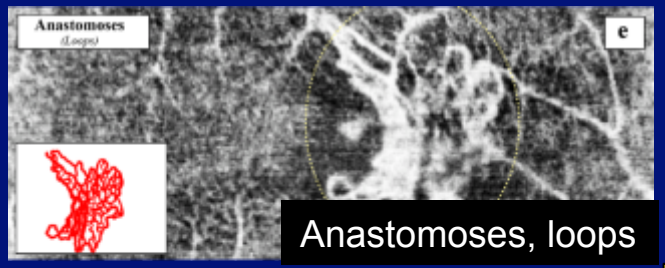


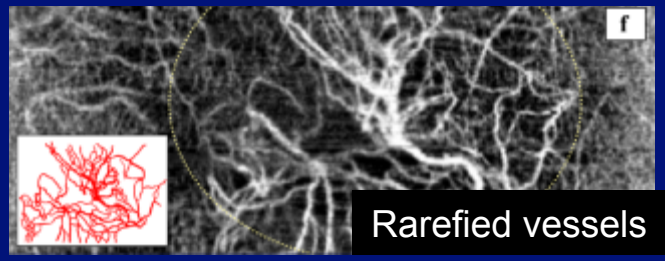
Pattern



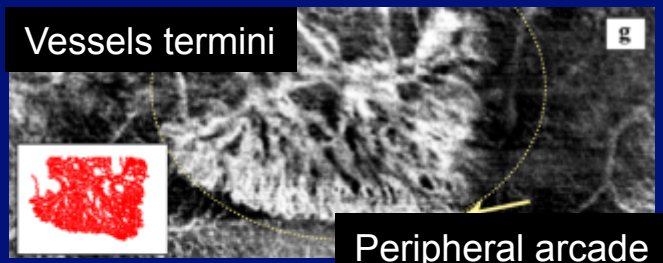




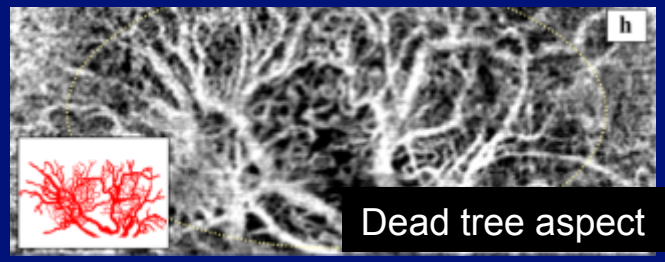




Vessels termini

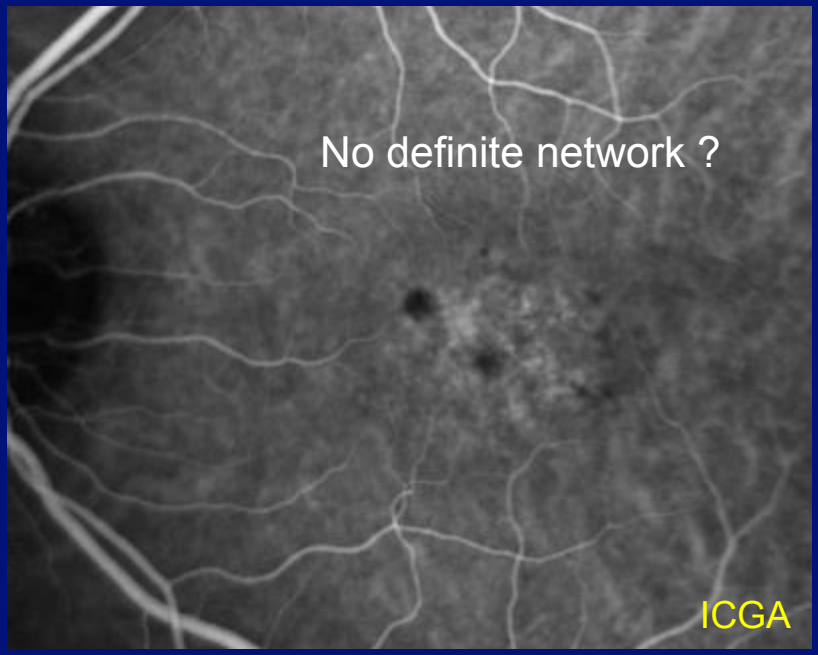


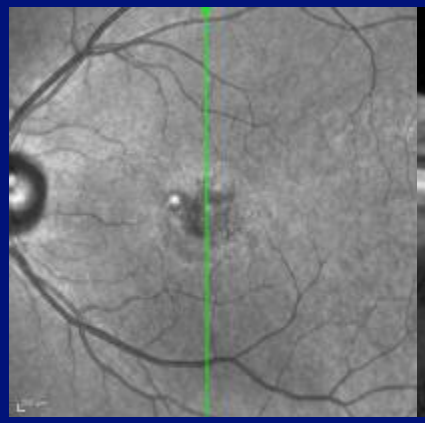
Vascular area :
SCP:27,84+-1,93 mm2
DCP:27,69+- 2,23 mm2

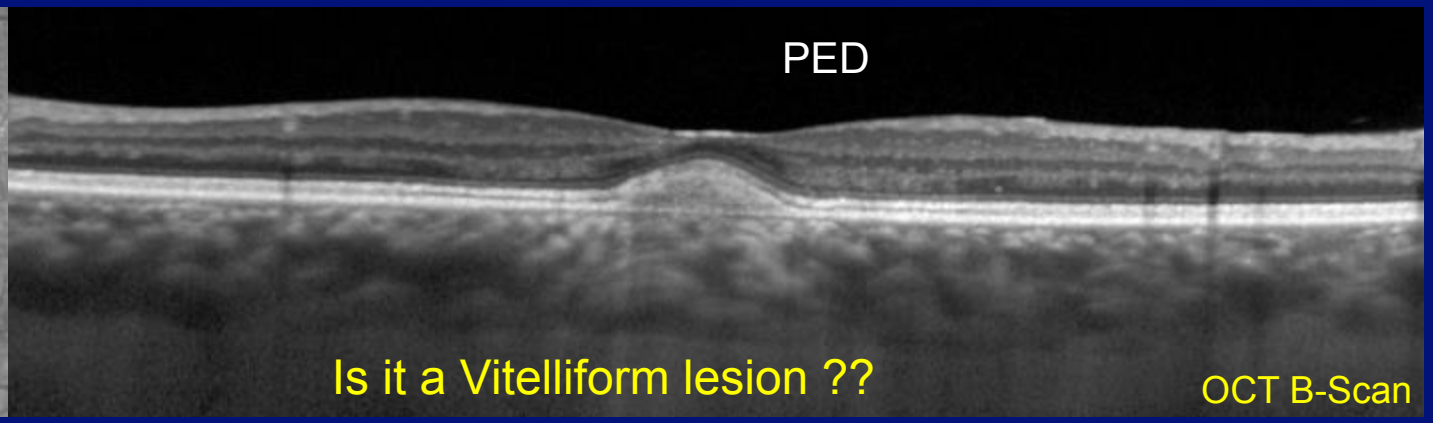


Coscas G et al, Retina 2015
Coscas G et al, AJO 2016

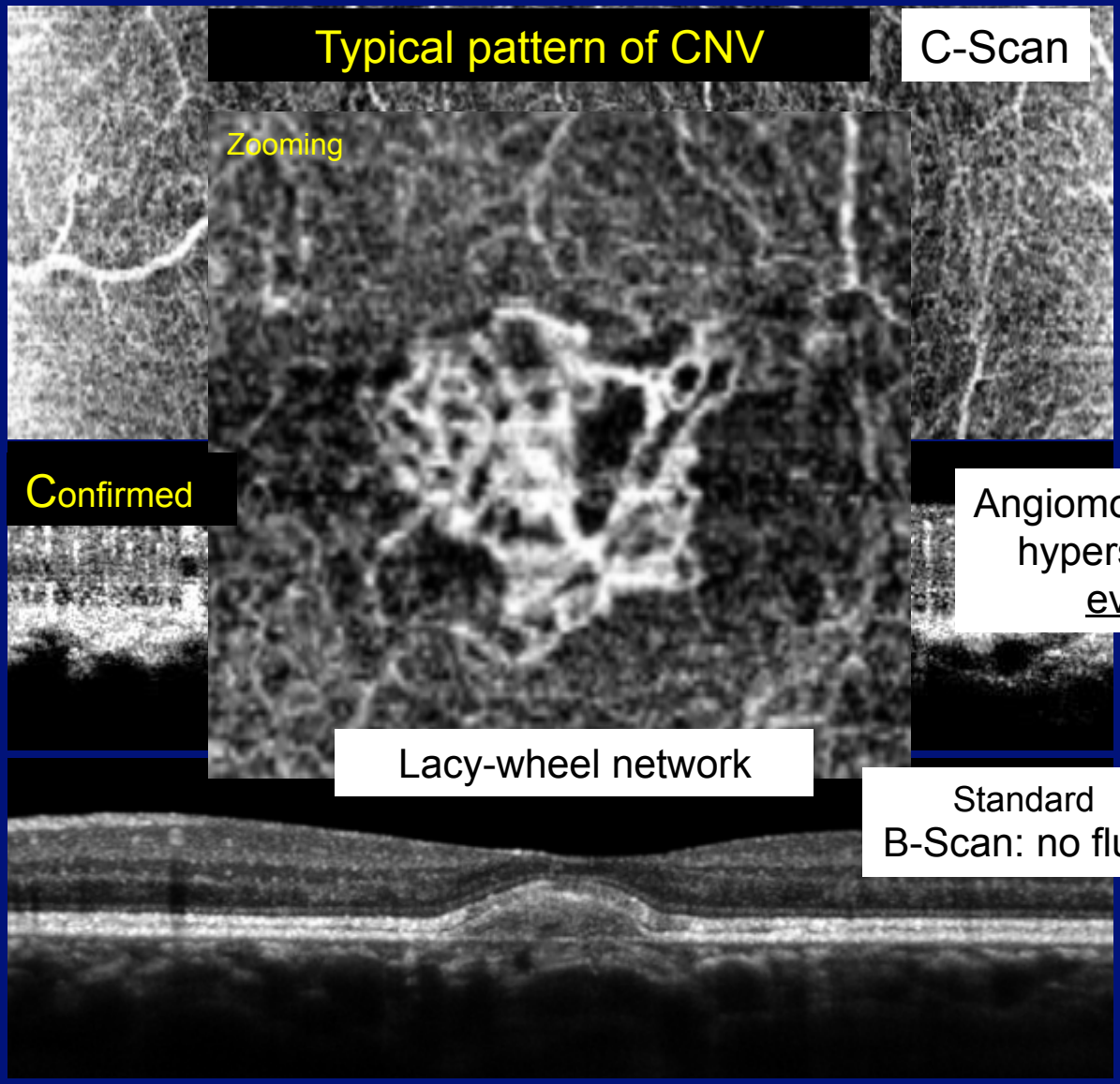
Somes exemples: CONVENTIONAL MULTIMODAL IMAGING



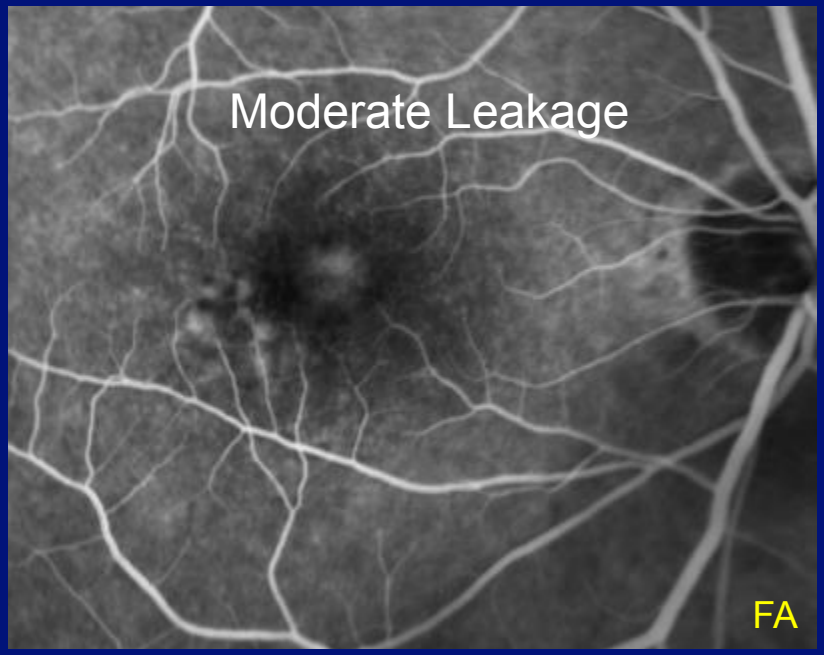


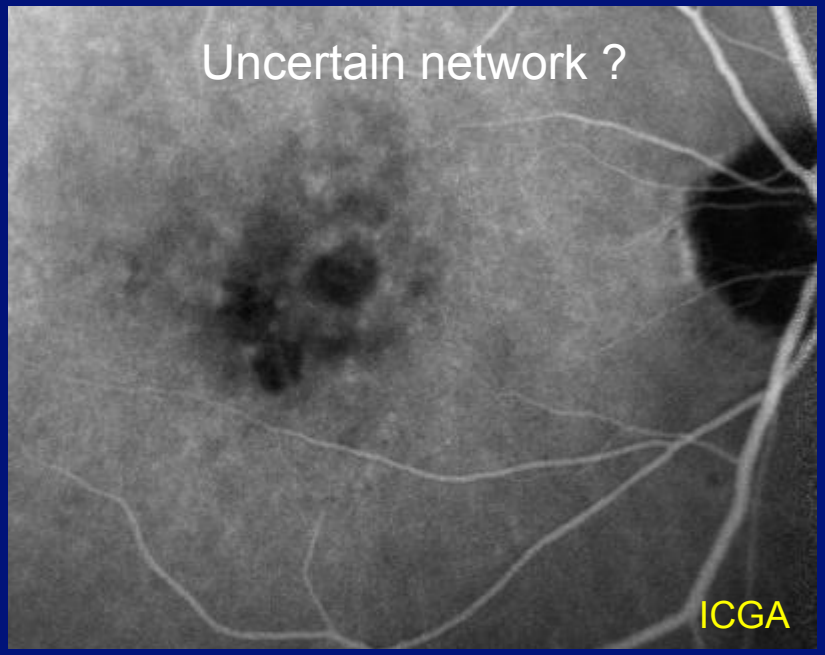


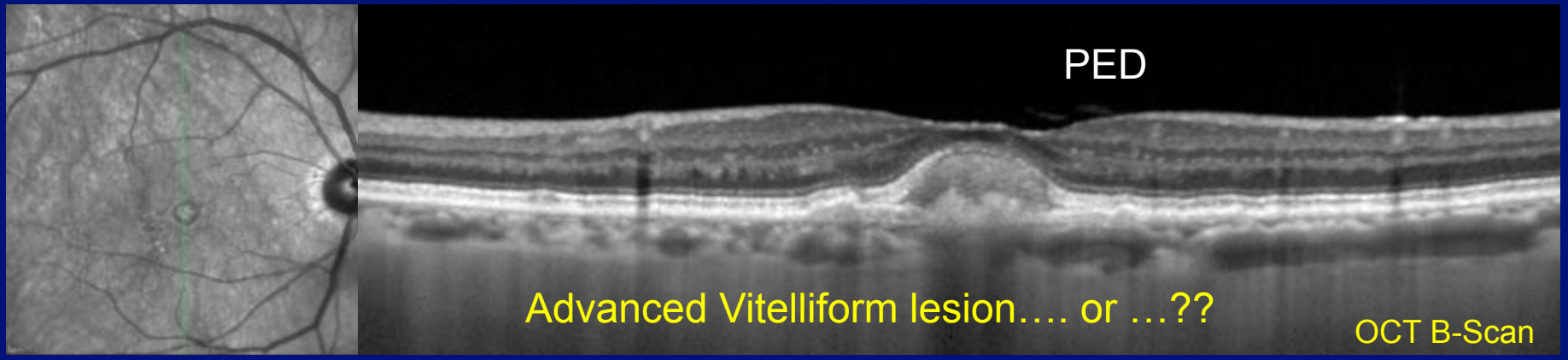
OCT-A will bring immediate and sriking diagnosis of CNV presence!



Let's look at a second case

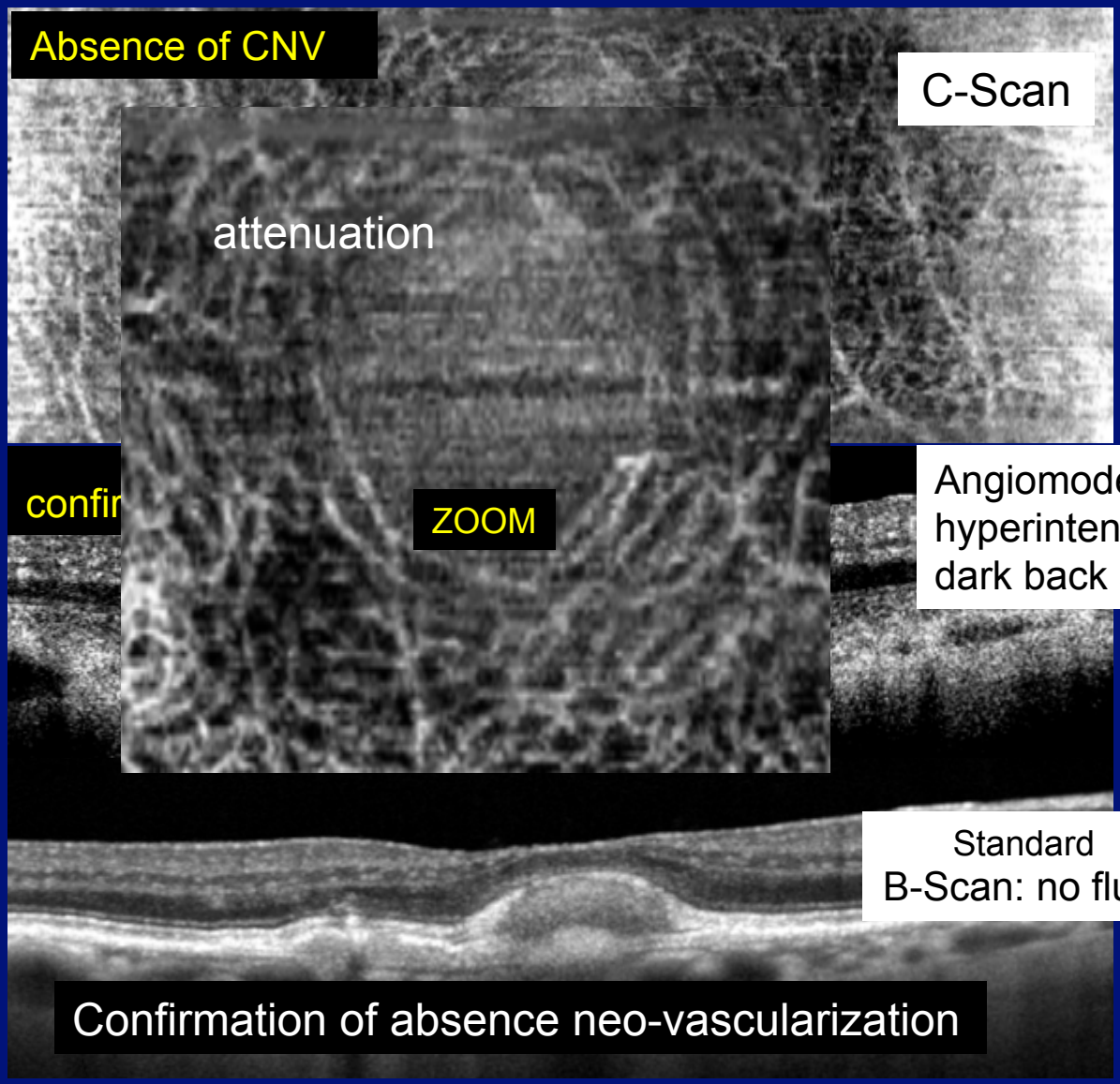






OCT-ANGIOGRAPHY: doesn't detect any CNV!

[visibility of retinal vessels (reflexion)]



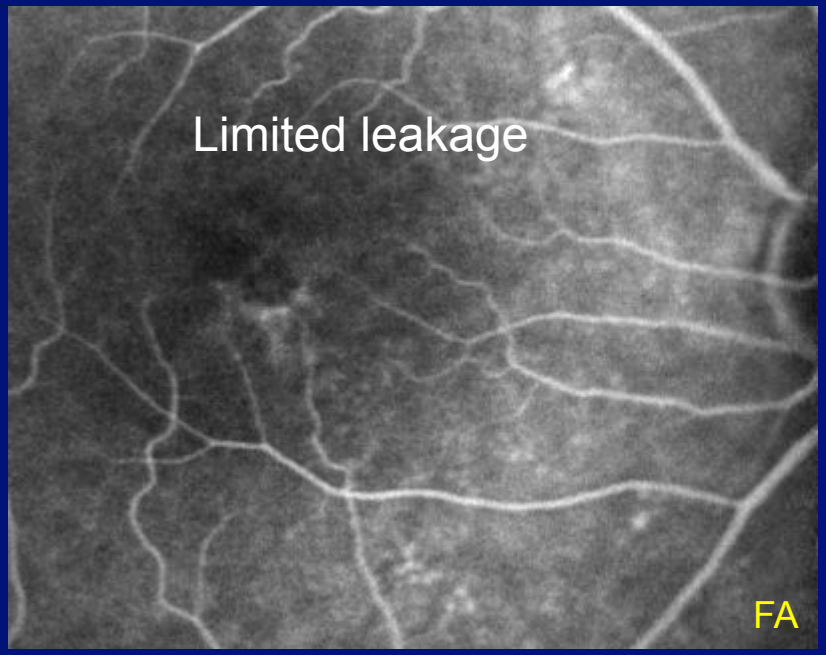
...But it's not always that easy…..!

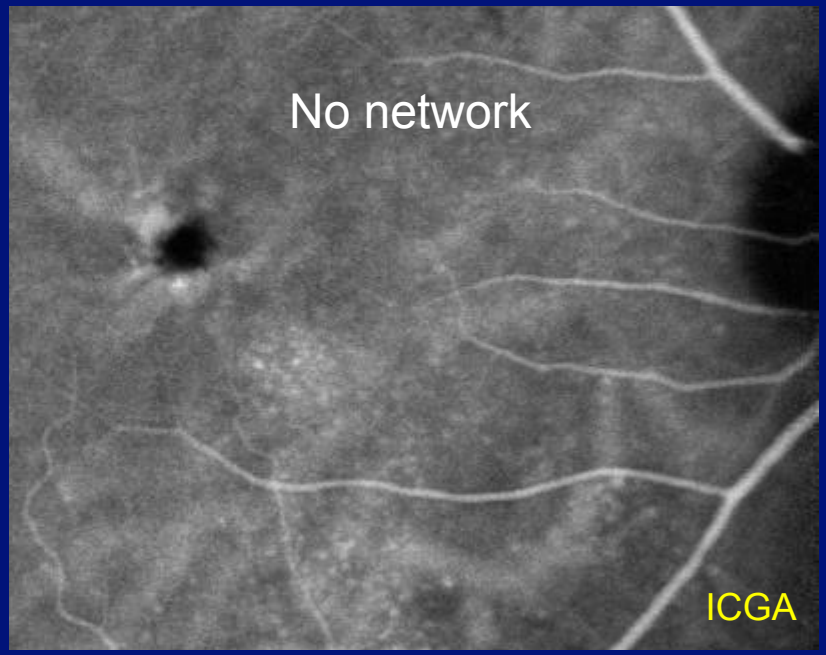
Another example could bring such a different answer!

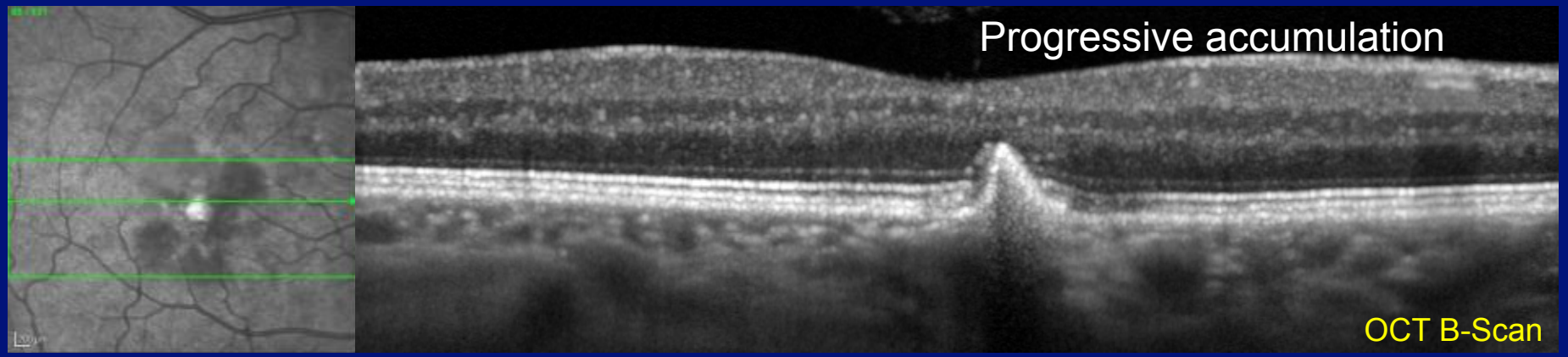
Lupidi M, Coscas G, Cagini C et al. OCT- Angiography of a Choroidal Neovascularization in AOFVD- Pearls and Pitfalls. **IOVS Dec 2015**.

CONVENTIONAL MULTIMODAL IMAGING

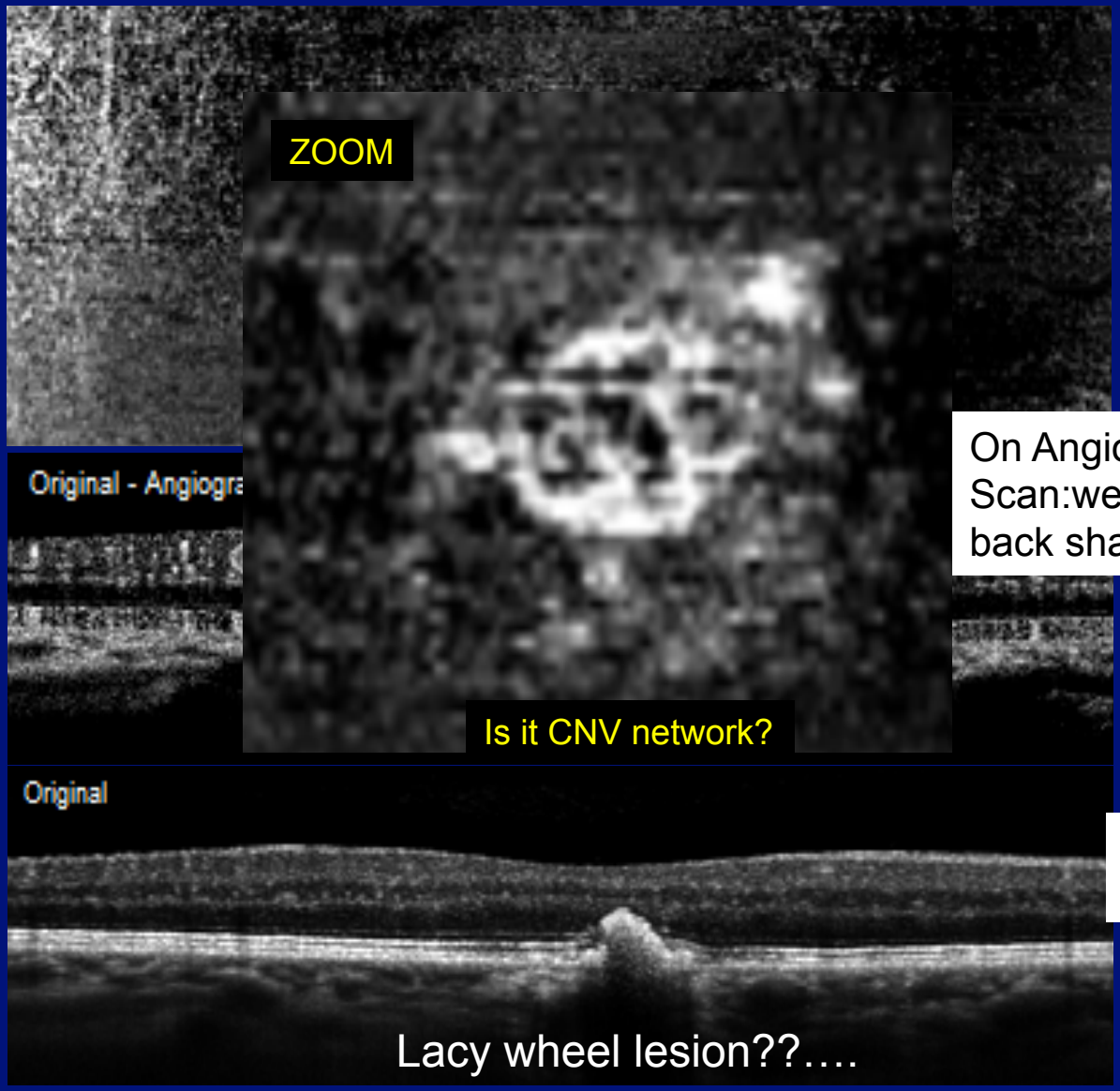
With Recent metamorphopsias….







OCT-A: is it a Limited CNV? We observe a hyper flow signal Is it an early proliferation of CNV ???

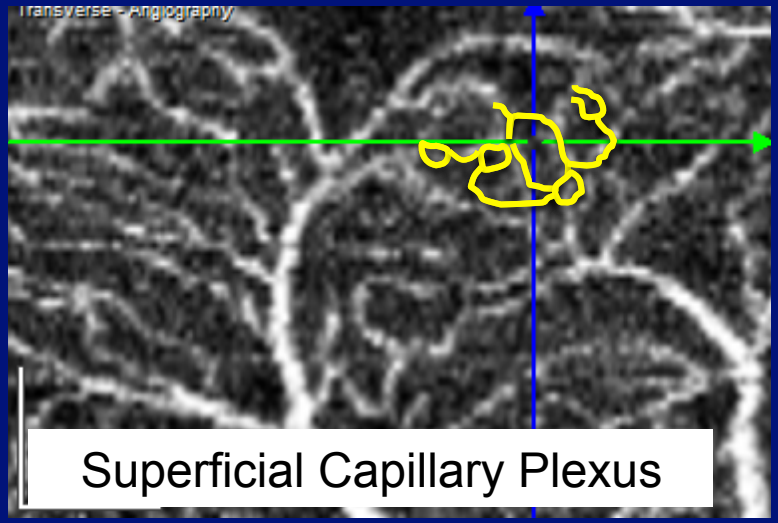


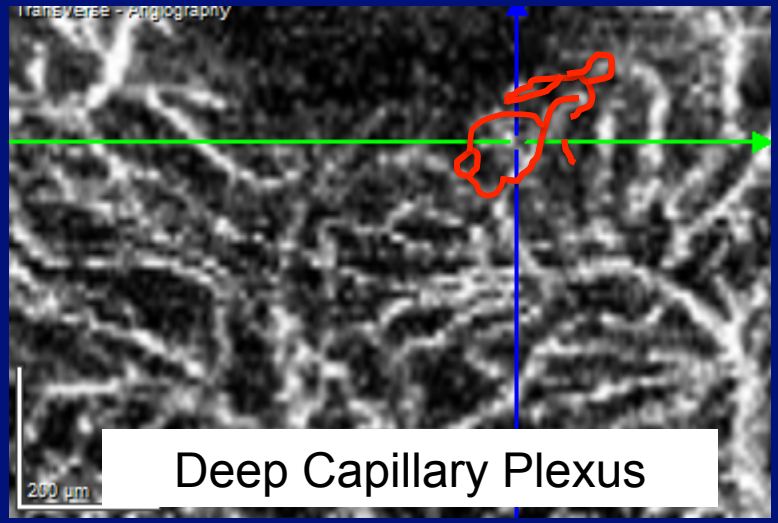
C-Scan

On Angiomode-OCTB-Scan:we observe dark back shadowing?

Standard B-Scan: no fluid

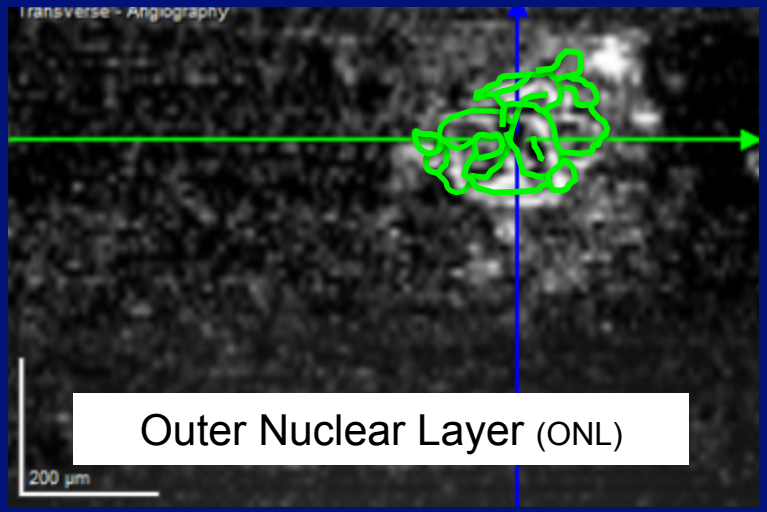
We need to analyze separately the Superficial and the Deep Capillary Plexus. In fact the combined structure is derived by their fusion with a similar shape of the hyper-intense structure, found at the Outer Nuclear Layer





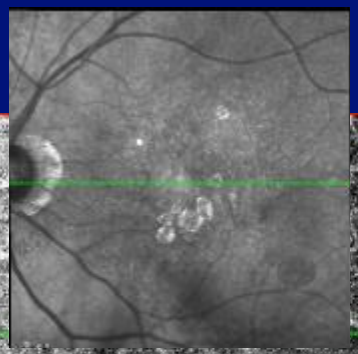
This is only

- An **ARTEFACT**
- Not a true CNV !



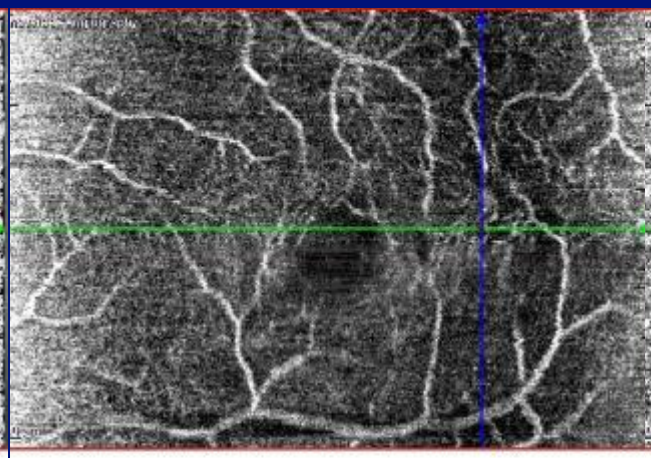
Hyper-reflective intraretinal deposits may mimick perfused vascular structures

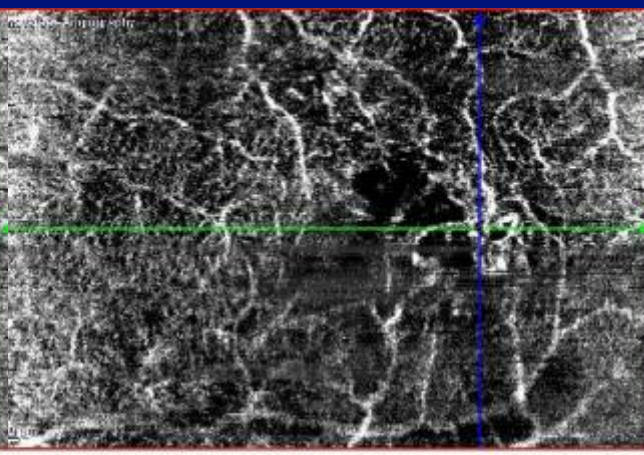
In this another case, we consider an CNV aspect with metamorphopsias and macular edema
We observe an hypersignal on RPE segmentation but it is DCP projection

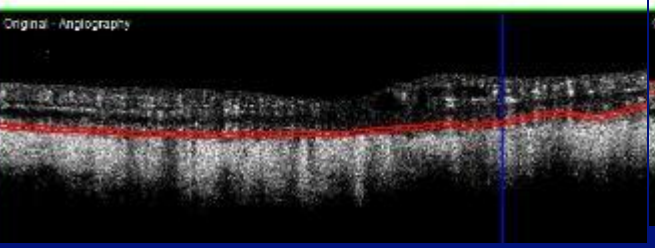


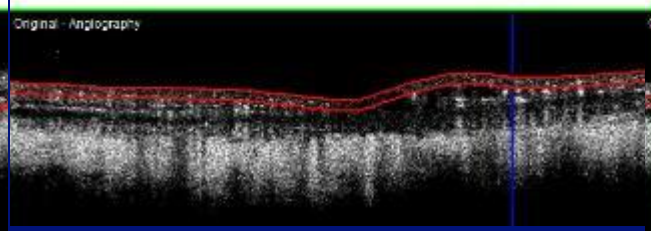
SCP: no anomalies

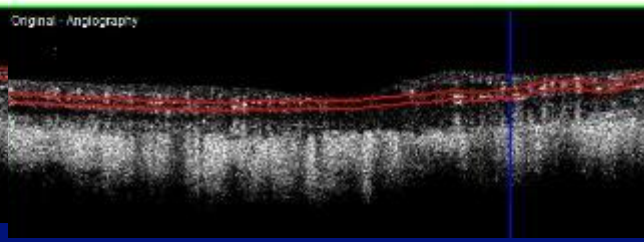
DCP: dilatations

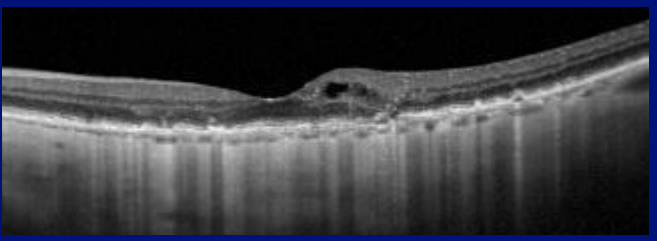




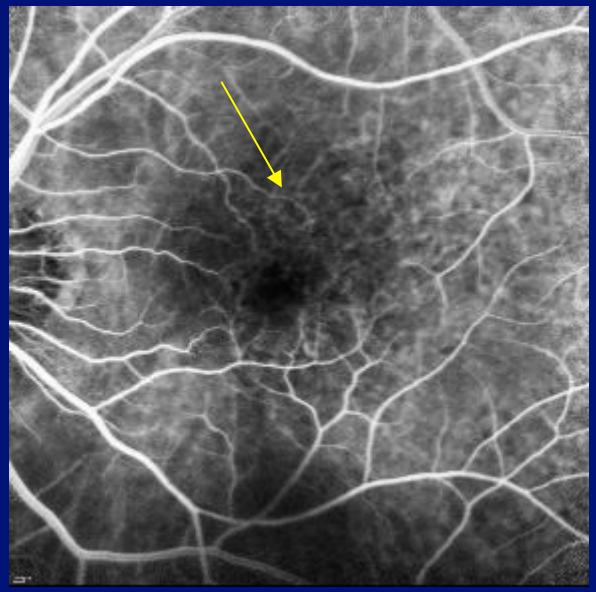


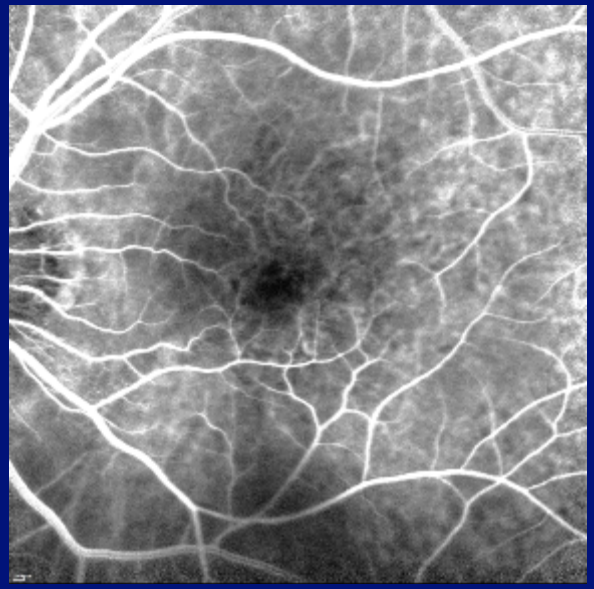


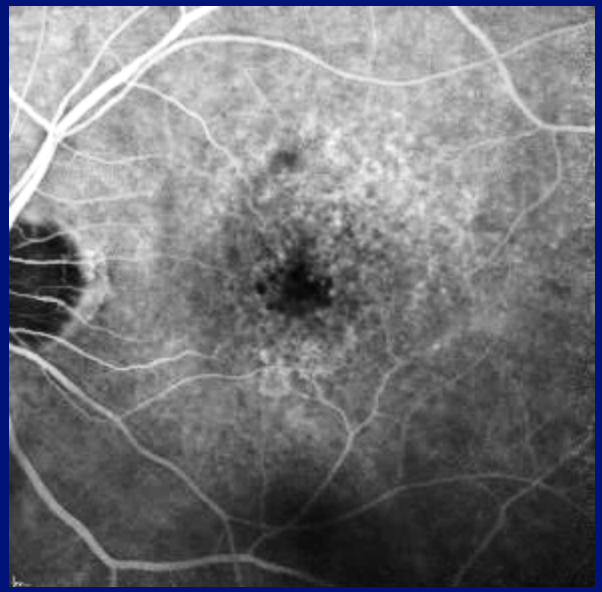




The residual venular occlusion is confirmed by FA, the gold standard!!





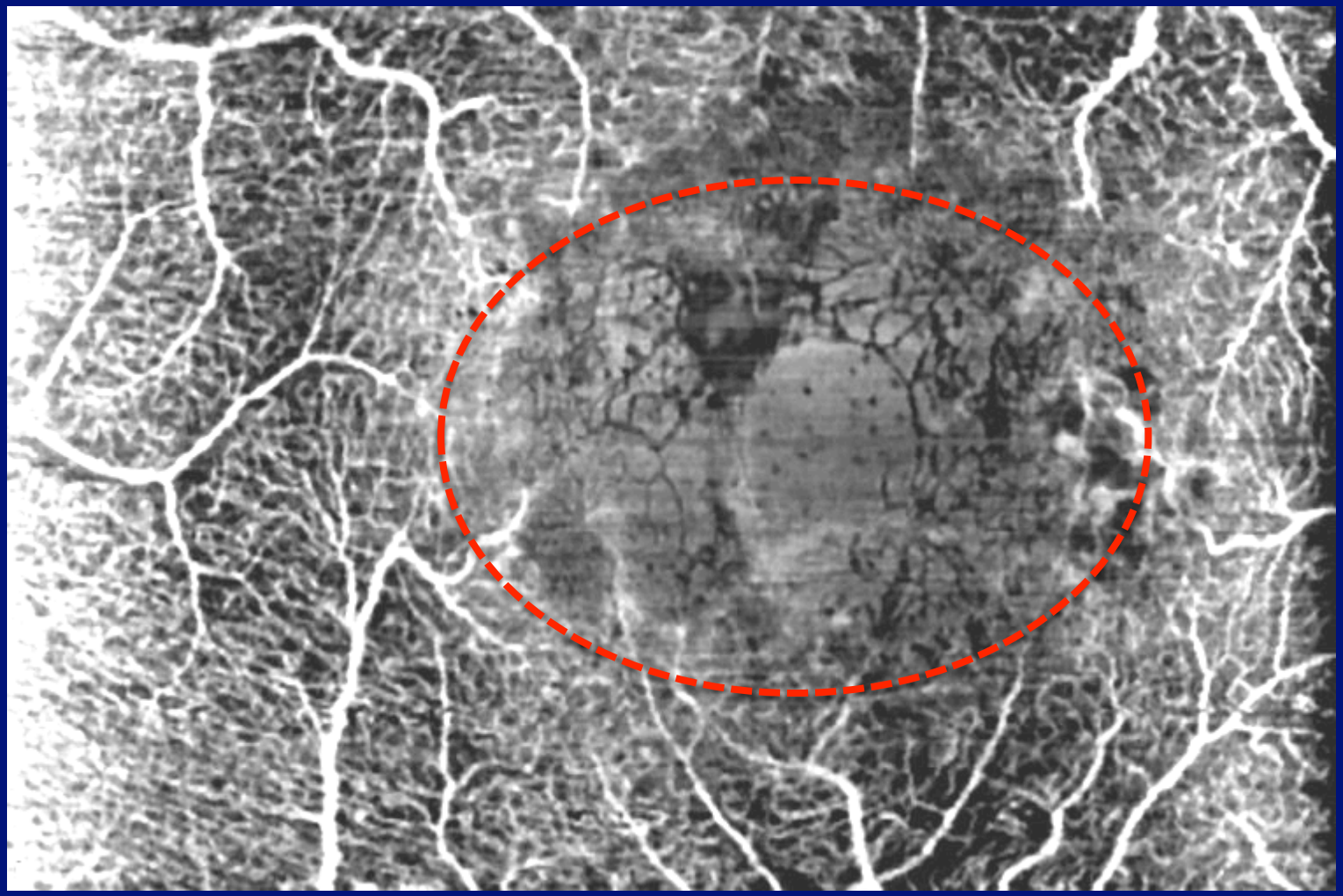


OCT-ANGIOGRAPHY: Pearls and Pitfalls

- To summarise
  - A **typical CNV** will show
    - a hyper-intense signal,
    - present even in depth (thickness of the lesion),

- An atypical lesion will show,
  - a hyper-intense signal
  - associated
  - with an evident dark back-shadowing

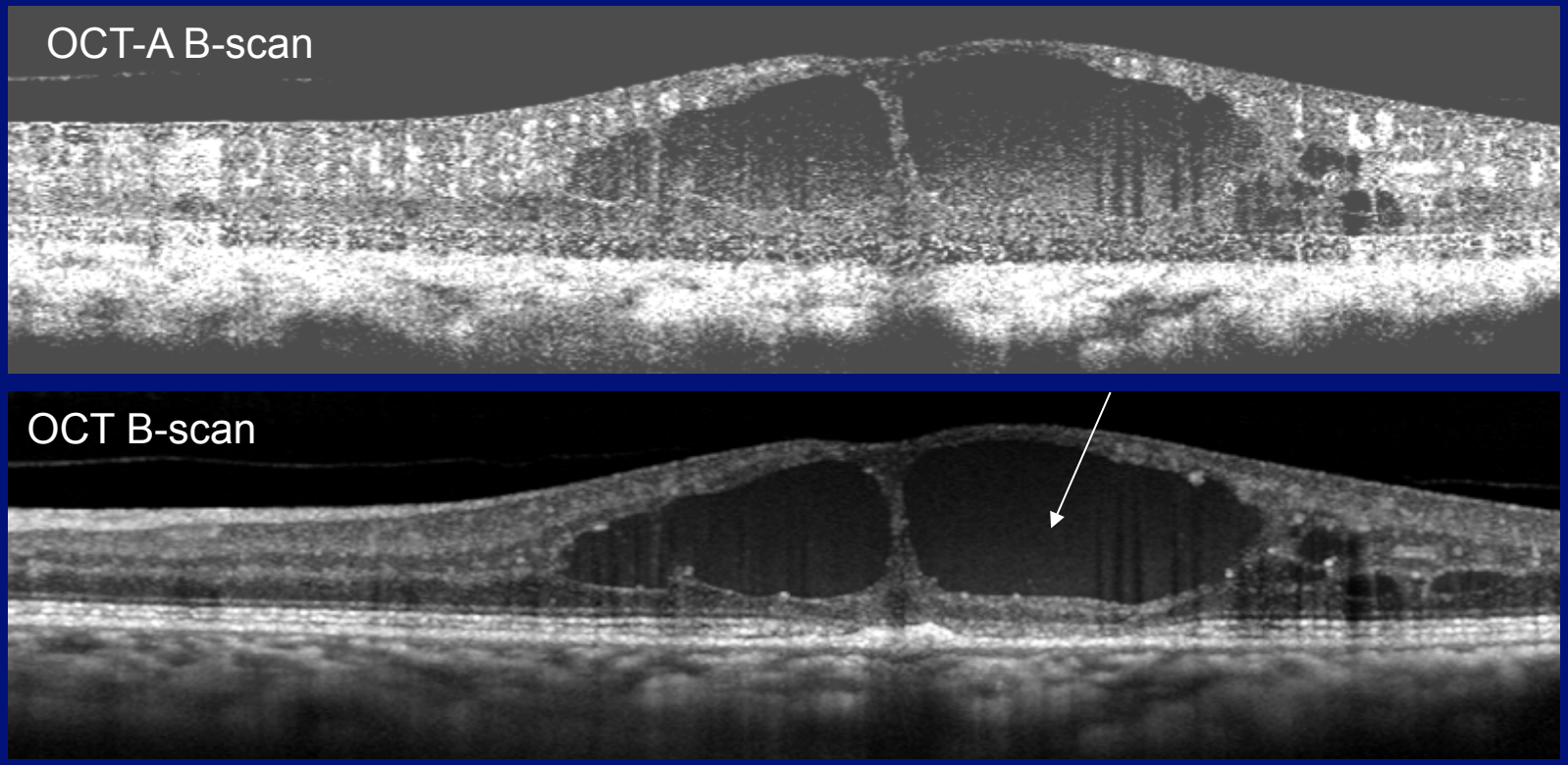
Let’s look 2 another artifacts; in Macular edema



These “intra retinal grey spaces” have

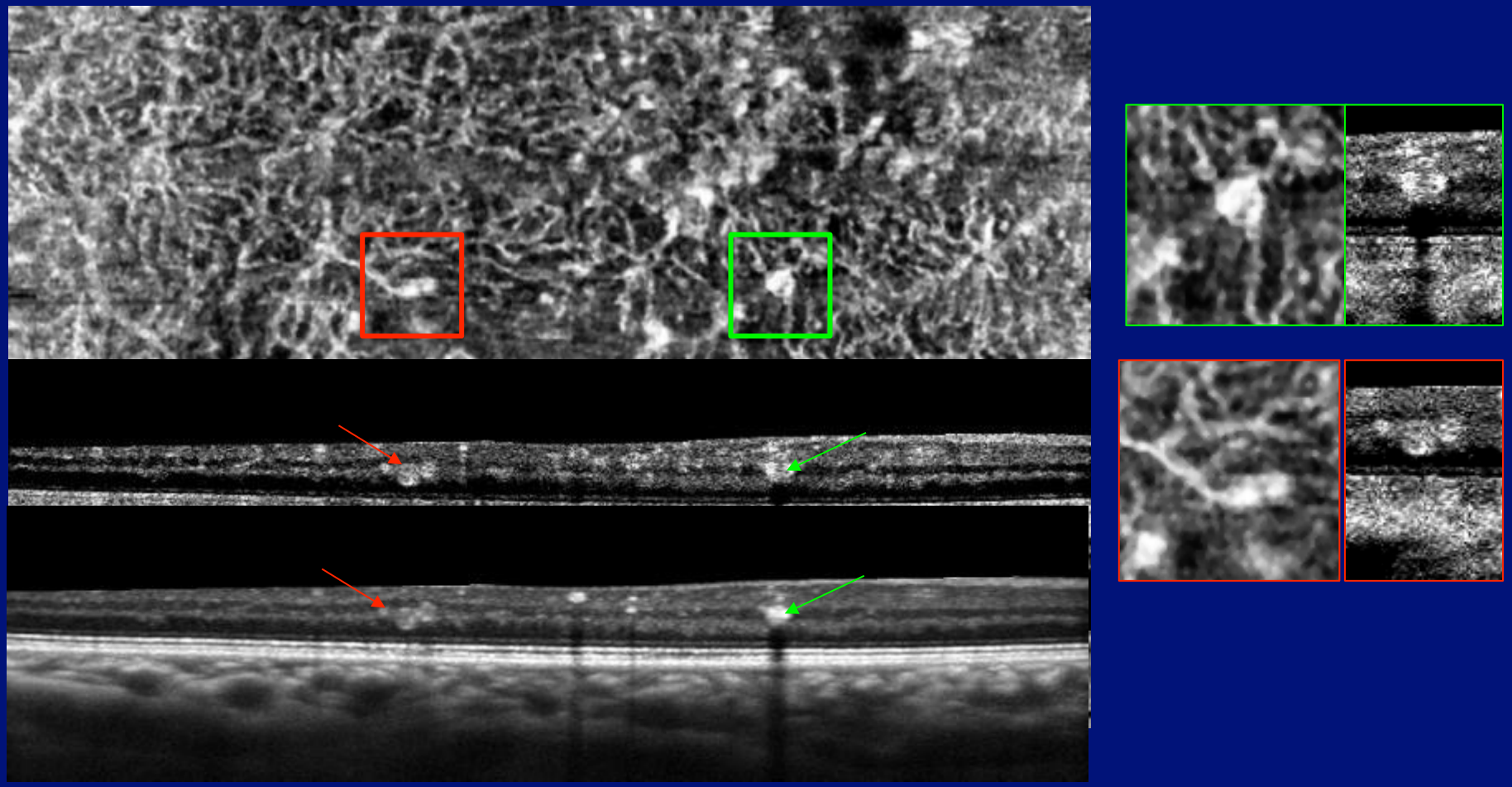
- poor decorrelation signal
- essentially due to the Brownian movement of the molecules in the cysts

on structural OCT-B
we observe no reflectivity
the cysts are black, void signal !!



“intra retinal grey spaces”

The last exemple of artifact: “localized hyper-intense sods”



These Structures (green arrow) are lipidic exudates with high signal resulting in back-shadowing effect.
They will be distinguished from hyper intense perfused lesions (red arrow) without shadowing who are micro anevrisms

Coscas G, Lupidi M, Coscas F et al. False friends, ***Acta Ophthalmologica 2016***

CONCLUSION

- we have to perform a careful segmentation

- To Identify
  - the presence and
  - type of “back- shadowing”

- to avoid Potential Diagnostic Pitfalls

THANK YOU FOR THE ATTENTION