On behalf of Vision Expo, we sincerely thank you for being with us this year.

Vision Expo Has Gone Green!

We have eliminated all paper session evaluation forms. Please be sure to complete your electronic session evaluations online when you login to request your CE Letter for each course you attended! Your feedback is important to us as our Conference Advisory Board considers content and speakers for future meetings to provide you with the best education possible.

VISION EXPO

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OCT ANGIOGRAPHY

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Oklahoma College of Optometry

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- 918-444-4155

Disclosures:

- Paid consultant/speaker for:
  - Carl Zeiss Meditec
  - Regeneron Pharmaceuticals
  - Optomed
- Paid advisory board member for Apellis Pharmaceuticals, Iveric Bio, Ocuterra, Notal Vision, LENZ Therapeutics
- Non-financial support (writing assistance) from Roche
- All relevant relationships have been mitigated

3

OVERVIEW

- Retinal blood supply
- Technology
- Principle (motion contrast)
- Displays
- Comparison to intravenous fluorescein angiography (IVFA)
- Artifacts unique to OCTA
- OCTA clinical applications

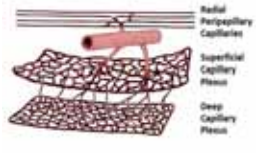
4

RETINAL BLOOD SUPPLY

NFL
GCL
IPL
INL
OPL
ONL
PR

CRA

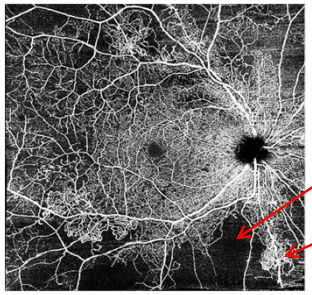
Choroid



5

OCT ANGIOGRAPHY: THE BASICS

- Non-invasive "flow" imaging



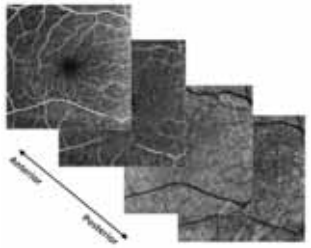
Dark → no flow or too slow to detect

Bright → blood flow

6

OCT ANGIOGRAPHY: THE BASICS

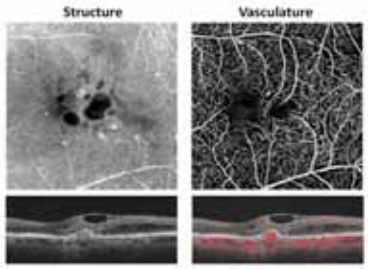
- Non-invasive "flow" imaging
- 3D volumetric data



7

OCT ANGIOGRAPHY: THE BASICS

- Structure/ vasculature in tandem



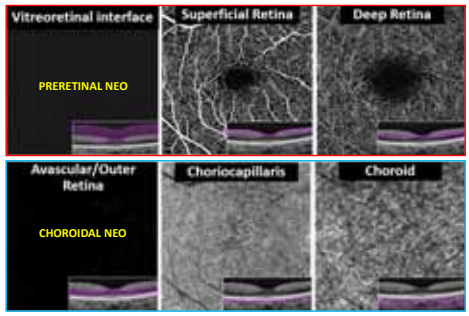
8

DISPLAY – En Face

Preset Enface Displays (3mm macula)

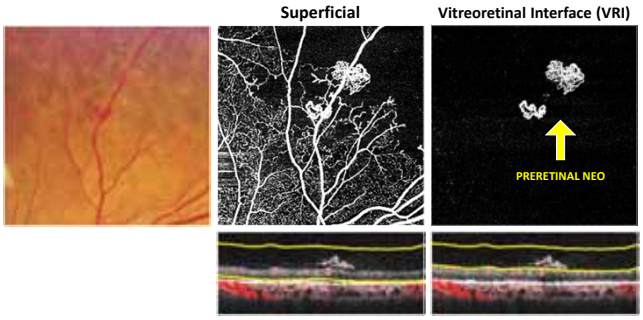
Look here for inner retina disease (DR, VO, etc.)

Look here for outer retina disease (AMD, CSCR, myopic degen, etc.)



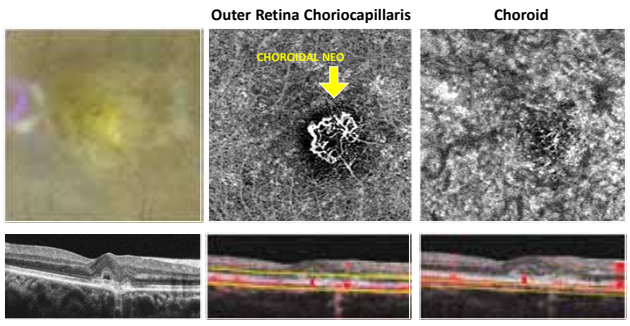
9

DISPLAY – En Face



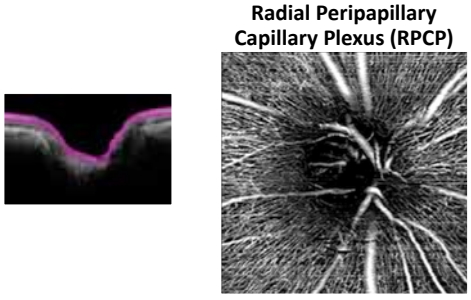
10

DISPLAY – En Face



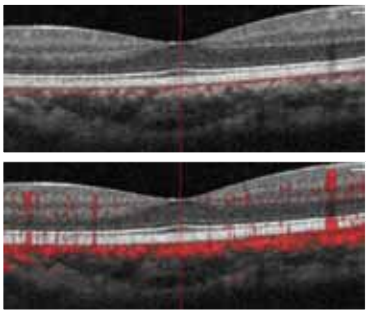
11

DISPLAY- Optic Nerve En Face



12

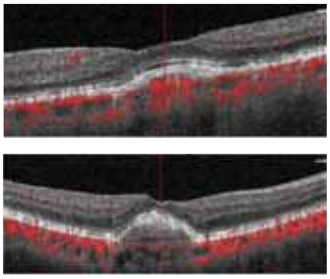
DISPLAY- B Scan Overlay



13

DISPLAY- B Scan Overlay

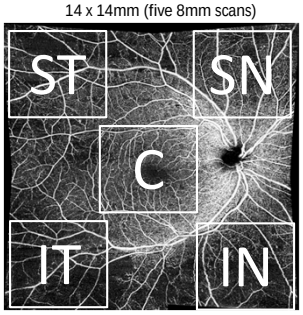
Which PED is vascularized?



14

MONTAGE OCT ANGIOGRAPHY

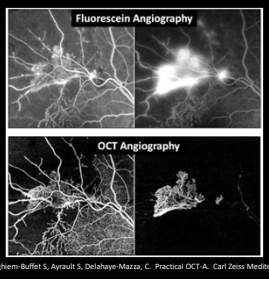
14 x 14mm (five 8mm scans)

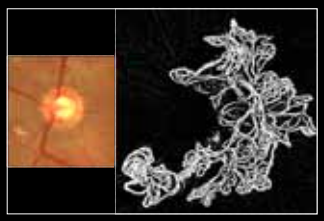


15

COMPARISON TO IVFA

- Absence of late stage hyperfluorescence patterns (aka leakage)
  = Precise delineation/measurement of neo





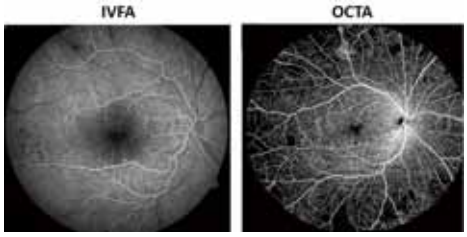
HIGH RESOLUTION IMAGES OF NEOVASCULAR MEMBRANES = MEASURE SIZE & CLASSIFY MORPHOLOGY PATTERNS

Nghiem-Buffet S, Ayrault S, Delahaye-Mazza, C. Practical OCT-A. Carl Zeiss Meditec.

16

COMPARISON TO IVFA

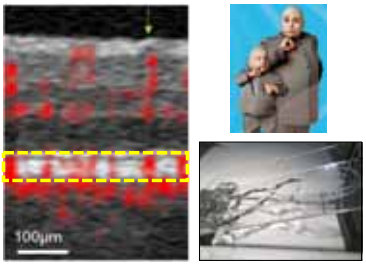
- Higher microvascular resolution to IVFA



Zhang Q et al. Ultra-wide OCTA in DR. Quant Imaging Med Surg. 2018

17

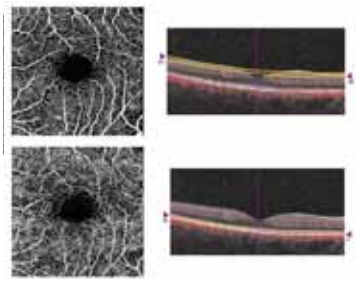
ARTIFACTS- Projection



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

18

ARTIFACTS- Projection



Most often encountered on the avascular/ORCC enface images and interfere with CNV detection

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OCTA Clinical Applications

Highlight and localize vascular abnormalities

- Sub-clinical disease detection
- Identify sources of macular edema
- Visualize vascular abnormalities in the deep plexus

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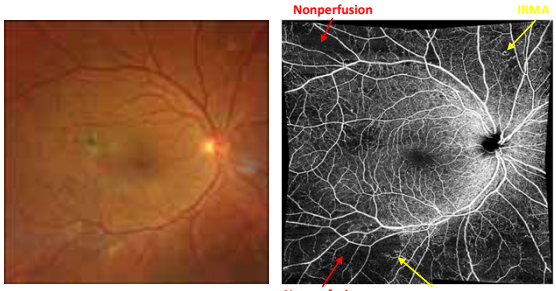
HIGHLIGHT VASCULAR ABNORMALITIES

- OCTA highlights subtle vascular abnormalities = more accurate DR staging



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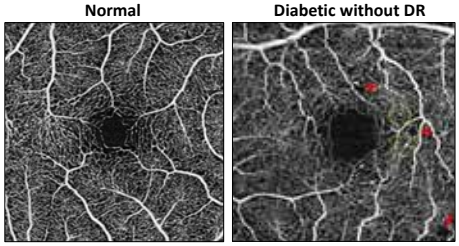
OCTA DETECTION OF SUBCLINICAL DR

NO CINICALLY DETECTABLE DR!!!



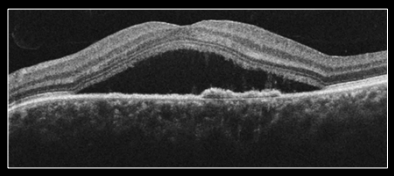
De Carlo TE, et al. Detection of microvascular changes in eyes of patients with diabetes but not clinical DR using OCTA. Retina 2015.

22

HIGHLIGHT VASCULAR ABNORMALITIES
Central Serous Chorioretinopathy

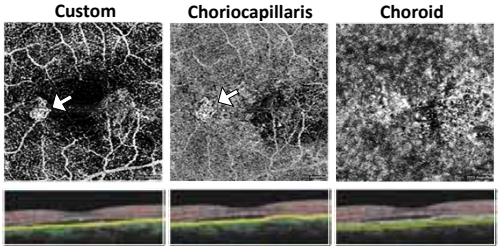
58yo Hispanic male

- Recurrent bouts of CSCR OS
- VAs: OD 20/20, OS 20/60



23

HIGHLIGHT VASCULAR ABNORMALITIES
Central Serous Chorioretinopathy



~1/3rd of CSCR eyes have abnormal choroidal vessels, of which 2/3rds are confirmed CNV membranes.

Costanzo et al. OCTA in CSCR. J Ophthalmol 2015.

24

SUBCLINICAL DISEASE DETECTION

39yo American Indian female – Presents for routine diabetic exam

- Oc Hx: Unremarkable, LEE 1 year ago
- Med Hx:
  - **DM Type 2 x 2 yrs**, last HbA1C 5.8%
  - HTN, dyslipidemia, IBS
- BCVAs @dist:
  - OD -1.75 -1.00 x 011 **20/40 PHNI**
  - OS -1.75 -1.50 x 004 **20/30 PHNI**
- Entrance testing: WNL
- SLE: Trace NS cat OU
- BP: 145/81

OD 1 year ago (20/30)

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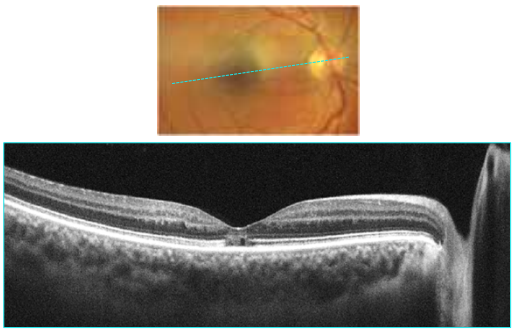
SUBCLINICAL DISEASE DETECTION



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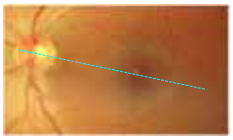
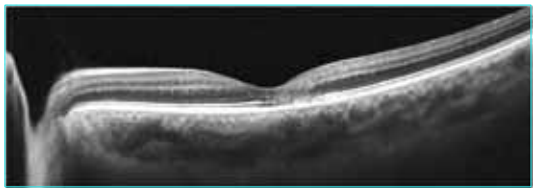
SUBCLINICAL DISEASE DETECTION





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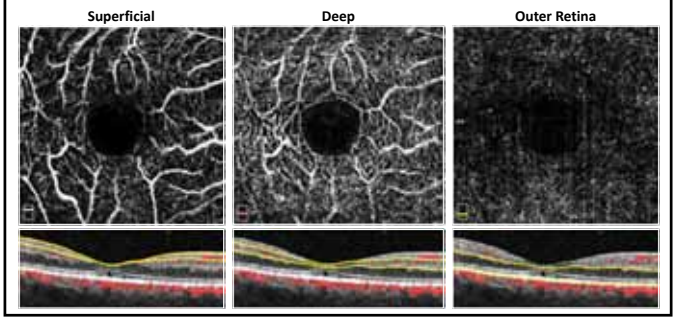
SUBCLINICAL DISEASE DETECTION

OCTA 3mm Macula OD



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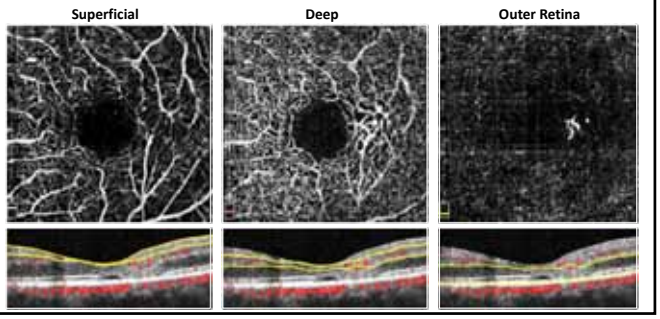
SUBCLINICAL DISEASE DETECTION

OCTA 3mm Macula OS



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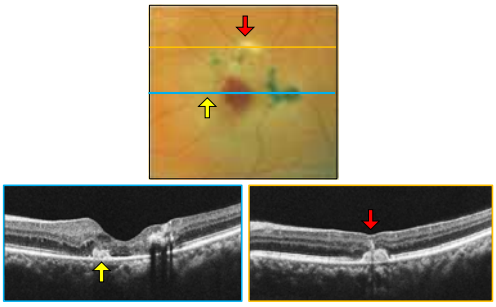
Macular Telangiectasia Type 2

Proliferative (Subretinal neovascularization)



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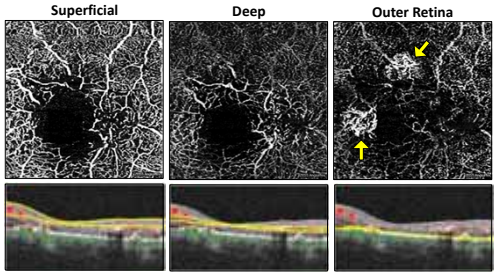
Macular Telangiectasia Type 2

Proliferative (Subretinal neovascularization)

OCTA 3mm OCTA Macula OS



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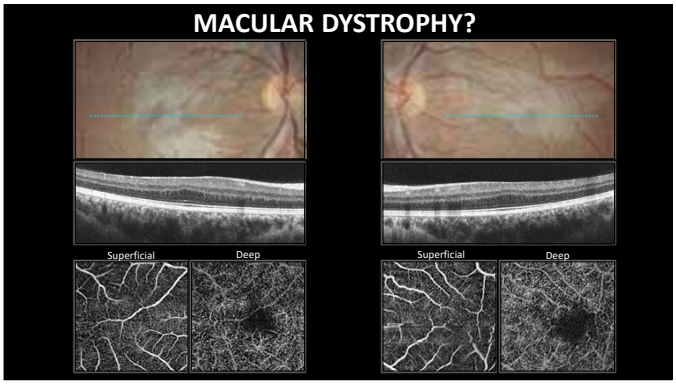
MACULAR DYSTROPHY?



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OCTA Clinical Applications

Nonperfusion

Detecting, localizing, and quantifying nonperfusion

- Retinal
  - Diabetic retinopathy
    - Risk of progression to PDR?
  - Venous occlusion
    - Ischemic vs nonischemic?
    - NVG risk?
  - Macular ischemia/detailed evaluation of the foveal avascular zone (FAZ)
- Choroidal
  - AMD, peripapillary atrophy, giant cell arteritis, ocular ischemic syndrome
  - Neovascular/geographic atrophy precursor?
- Disc/radial peripapillary capillaries
  - Glaucoma
  - Neuropathy

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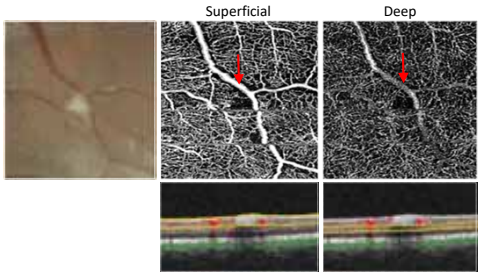
RETINAL NONPERFUSION

Cotton Wool Spot



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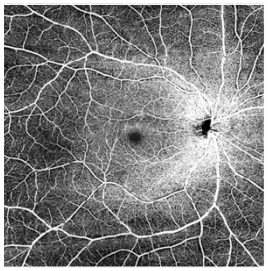
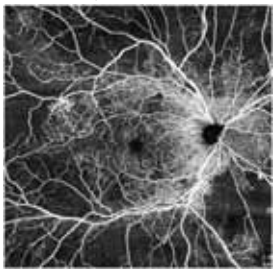
RETINAL NONPERFUSION- DIABETIC RETINOPATHY

Normal



Very Severe NPDR



- Increased risk for progression to PDR
- Consider early anti-VEGF/PRP treatment

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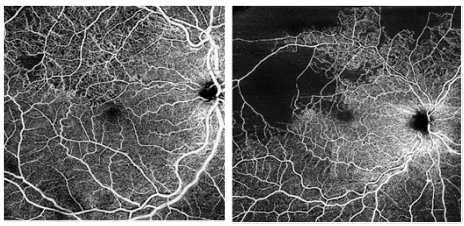
RETINAL NONPERFUSION- VENOUS OCCLUSION

Non -ischemic BRVO

Ischemic BRVO



- Estimate the degree of NP and classify as ischemic or nonischemic
  - CRVO → ant seg neo
  - BRVO → post seg neo

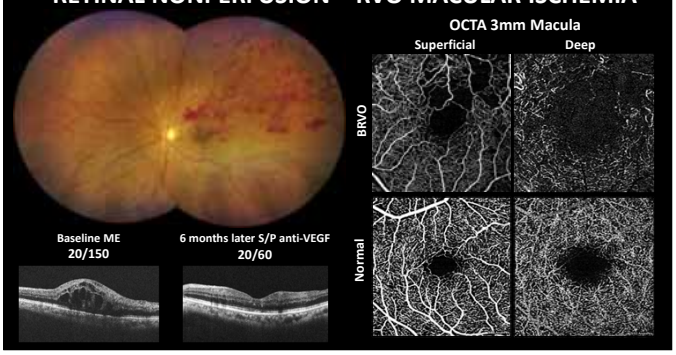
Predictive Value of Retinal NP!!!

BVS 50/50/50 rule: ~ 50% of eyes with ischemic BRVO will develop NVD/NVE

Branch Vein Occlusion Study Grp. Argon laser scatter photocoagulation for prevention of neovascularization and vit heme in BVO. A RCT. Arch Ophthalmol. 1986.

36

RETINAL NONPERFUSION – RVO MACULAR ISCHEMIA



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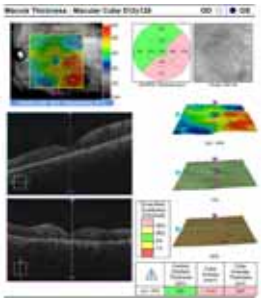
THE CASE OF THE FORLORN FOVEA

61yo Hispanic Male
- DM type 2 x 27 years
- OS VA 20/100



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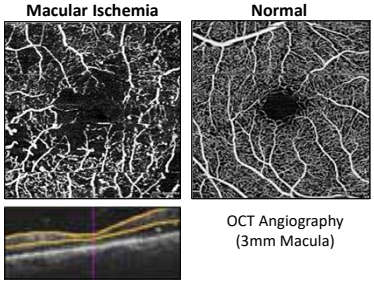
THE CASE OF THE FORLORN FOVEA

OCTA- Identify Macular Ischemia

Macular Ischemia **Normal**



OCT Angiography
(3mm Macula)

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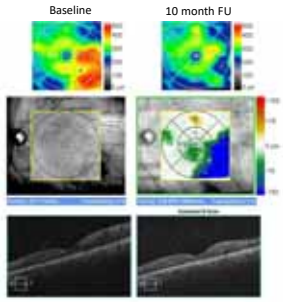
THE CASE OF THE FORLORN FOVEA

OCTA Identification of Macular Ischemia

Change after 10 months, observation only

20/100 to 20/60



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RETINAL NONPERFUSION

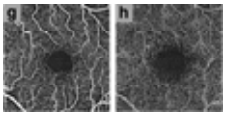
Alzheimer Disease

Jiang H, et al. J Neurooph 2018.
- Decreased macular vascular density (superficial and deep) in AD compared to controls

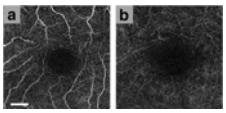
Den Haan J, et al. ARVO 2018.
- Decreased macular vascular density in late onset AD compared to early onset AD and controls
- No diff between early onset AD and controls

Shen M et al. ARVO 2018.
- Decreased macular capillary density (superificial and deep) in mild AD compared to controls
- Lower macular capillary density correlates with cognitive performance

Normal



Alzheimer Disease



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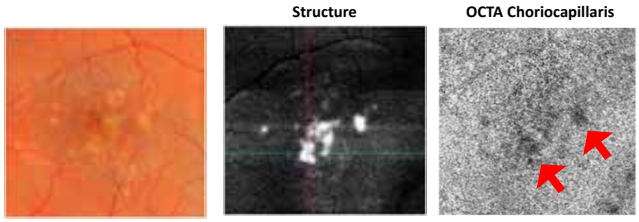
CHOROIDAL NONPERFUSION

Nonexudative AMD



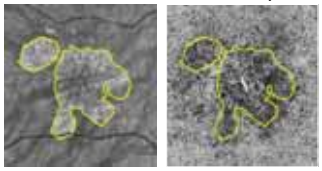
Zhang Q, et al. A Novel Strategy for Quantifying CC Flow Voids Using SS-OCTA. IOVS. 2018.

42

CHOROIDAL NONPERFUSION
AMD Geographic Atrophy

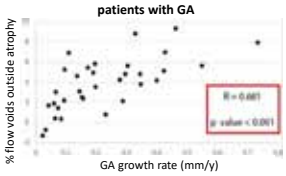
- Impairment of choriocapillaris flow is present immediately surrounding GA lesions
- **↑ degree of choriocapillaris flow impairment = faster GA enlargement!!**

Structural EnFace **OCTA Choriocapillaris**



Nassisi M, et al. Choriocapillaris impairment around the atrophic lesions in patients with GA: a SS-OCTA study. Br J Oph. 2018.

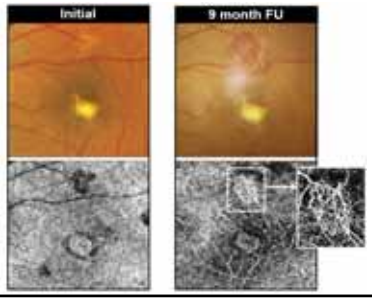
Correlation between CC flow impairment around atrophic lesions and yearly growth rate in patients with GA



Nassisi M, et al. Choriocapillaris flow impairment surrounding GA correlates with disease progression. PLoS One 2019.

43

CHOROIDAL NONPERFUSION
A predictor for CNV development in adult-onset foveomacular vitelliform dystrophy



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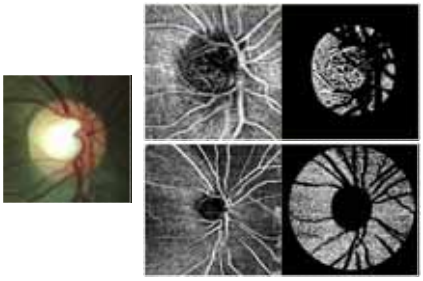
DISC/RPC NONPERFUSION
Glaucoma

Decreased perfusion of the ONH, radial peripapillary capillaries, and macula all well evidenced



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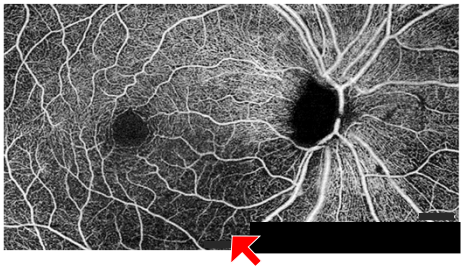
DISC/RPC NONPERFUSION
Glaucoma

Decreased perfusion of the ONH, radial peripapillary capillaries, and macula all well evidenced



46

GLAUCOMA

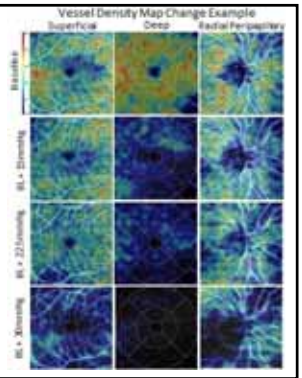
More longitudinal studies PLEASE!!

47

GLAUCOMA

Majcher C, Trevino R, Sponsel W. Effect of Transient IOP elevation on OCTA macular and peripapillary vessel density. ARVO 2020.

https://iovs.arvojournals.org/article.aspx?articleid=2769852



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OCTA Clinical Applications
Neovascularization

- **Detecting, localizing, and defining neovascularization**
  - Preretinal
    - Early detection of PDR
      - Differentiate IRMA from early NVE
    - Differentiate collaterals from NVD
  - Choroidal
    - Early detection of CNV
    - Detection/monitoring nonexudative CNV
- **Monitoring regression/progression**
- **Determining level of exudative activity based on membrane morphology**
  - Assess need for retreatment

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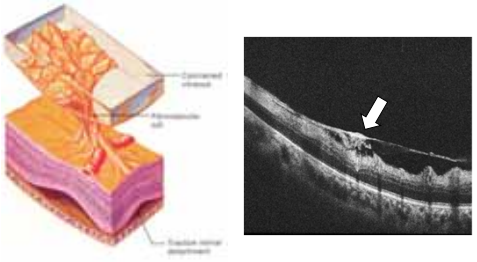
PRERETINAL NEOVASCULARIZATION

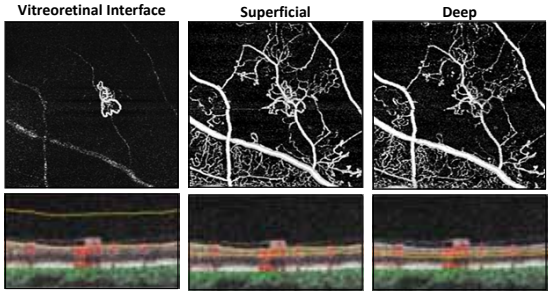


Most often characterized by new blood vessel growth located between the ILM and the posterior hyaloid

50

PRERETINAL NEOVASCULARIZATION - DR

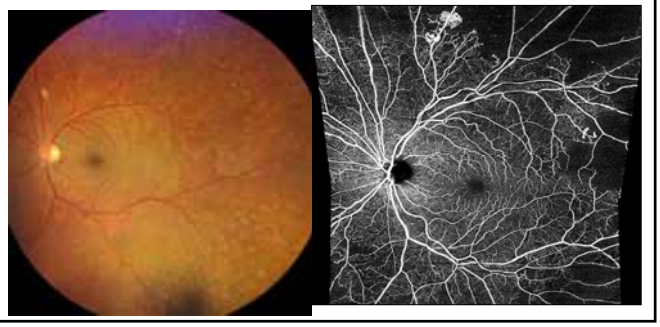
IRMA or early NVE???



51

PRERETINAL NEOVASCULARIZATION - DR

OCTA Enhanced Visualization of NVE



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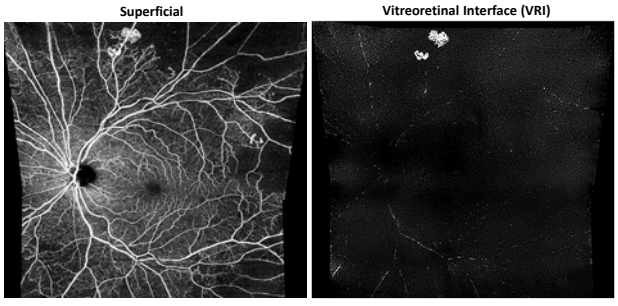
PRERETINAL NEOVASCULARIZATION - DR

OCTA Enhanced Visualization of NVE



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PROLIFERATIVE OR NONPROLIFERATIVE?

You QS et al. Detection of Clinically Unsuspected Retinal Neovascularization with Wide-field OCTA. 2019

- Performed wide-field OCTA on 27 eyes with NPDR via DFE & color fundus photography
- Of the 7 eyes originally graded as severe NPDR, wide field OCTA detected neovascularization in 4 eyes (57%)
  - 2 of these eyes would have been missed with 6x6mm scan alone

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OCTA DETECTION/MONITORING OF NEO IN RVO

65yo American Indian female

- **BRVO OD with sectoral PRP approx. 5 years ago**
- BCVA OS 20/50
- CVF OS: superior nasal restriction

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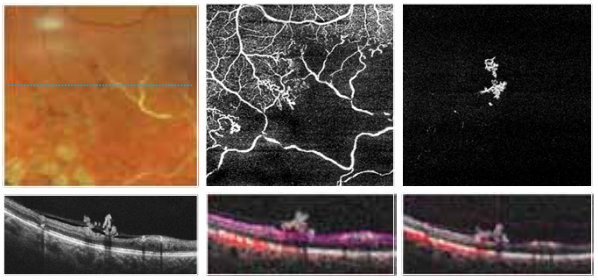
OCTA DETECTION/MONITORING OF NEO IN RVO

6mm OCTA

Superficial **Vitreoretinal Interface**



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PRERETINAL NEOVASCULARIZATION - NVD

50yo American Indian male

- CC: Decreased vision
- **Oc Hx: Severe NPDR OU at LEE 2 yrs ago**
- Med Hx:
  - **Type 2 DM x 11 years, last A1C 11.8%**, admits poor compliance and has been out of meds x 1 wk
  - HTN, ↑chol, sleep apnea
- BCVA
  - **OD 20/20**

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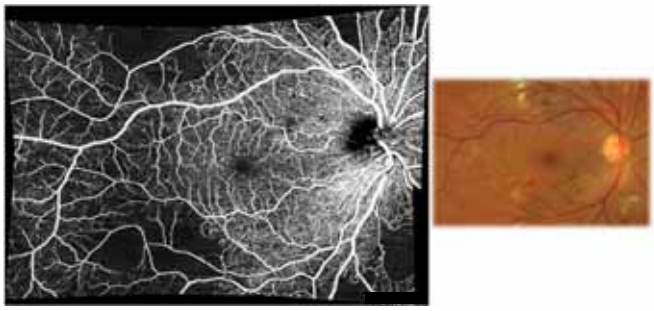
PRERETINAL NEOVASCULARIZATION - NVD



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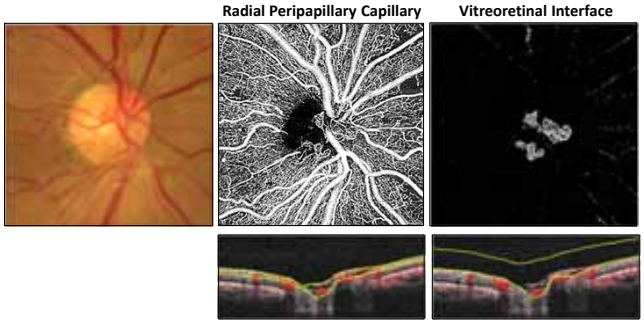
OCTA 4.5mm Optic Nerve

Radial Peripapillary Capillary **Vitreoretinal Interface**



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PRERETINAL NEOVASCULARIZATION - NVD

Follow-up

- Sees retina within 6 weeks, diagnosed with severe NPDR OU → observe in 6 months
- 6 months later- PD → recommend PR

Baseline **1 year later-still 20/20!**

60

A MORE EXTERME CASE…

29yo American Indian male – Presents for routine DM exam, needs gls

- POH: Severe NPDR OU at LEE 5 yrs ago
- MH:
  - DM Type 2 x 20 yrs, last HbA1C 8.2%
  - 2 toes amputated recently due to DM ulcer
- BCVAs @dist:
  - OD 20/30
  - OS 20/30^{-2}
- Entrance testing: WNL
- External exam: Normal OU

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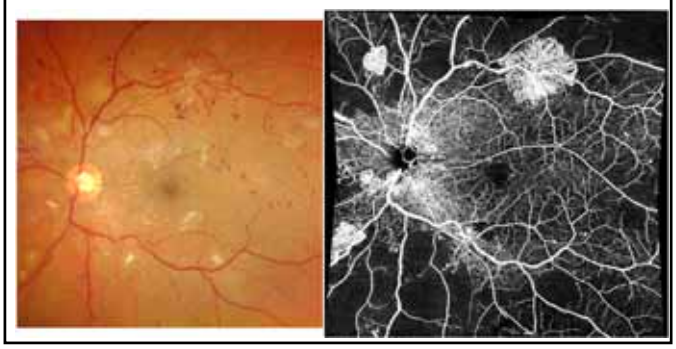
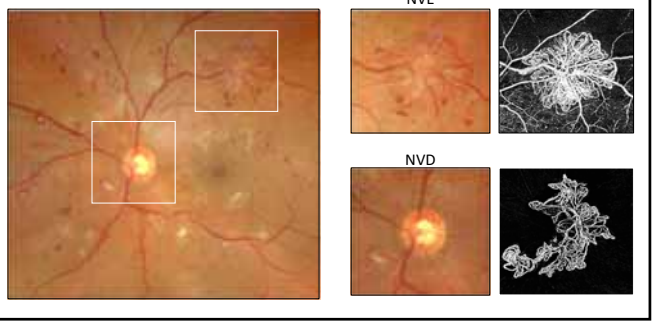
PRERETINAL NEO - A MORE EXTERME CASE…



62

PRERETINAL NEO - A MORE EXTERME CASE…



63

A MORE EXTREME CASE……1 YEAR FOLLOW-UP

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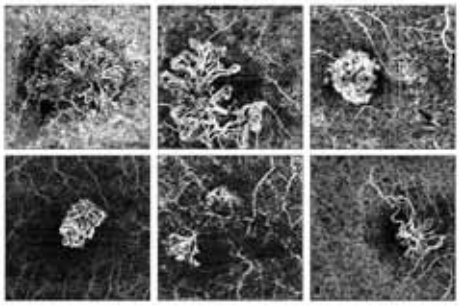
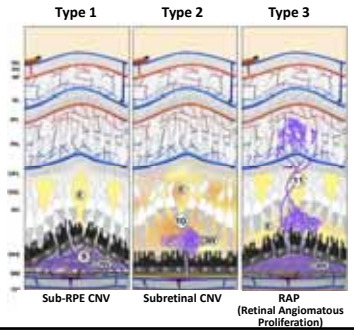
CHOROIDAL NEOVASCULARIZATION



65

CHOROIDAL NEOVASCULARIZATION



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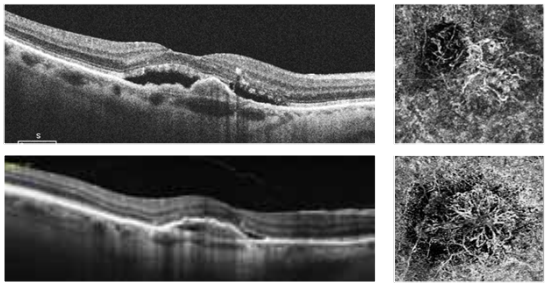
Choroidal Neovascularization

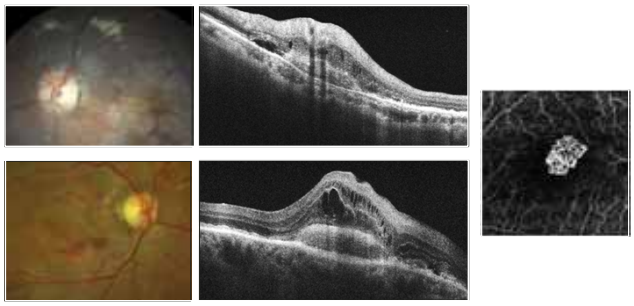
Type 1 (SubRPE, Occult)



67

Choroidal Neovascularization

Type 2 (Subretinal, Classic)



68

COVID CASUALTY

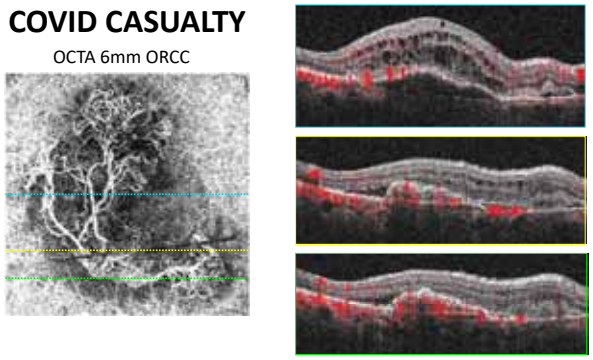
73yo American Indian female

- **Decreased vision OD x 6 months**, dark spots and grayish vision esp when reading
- **Dry AMD x 7 yrs taking AREDS 2**
- LEE approx. 15 months ago
- VA OD: **20/100 PHNI** (was 20/20 15 months ago)

69

COVID CASUALTY

OCTA 6mm ORCC

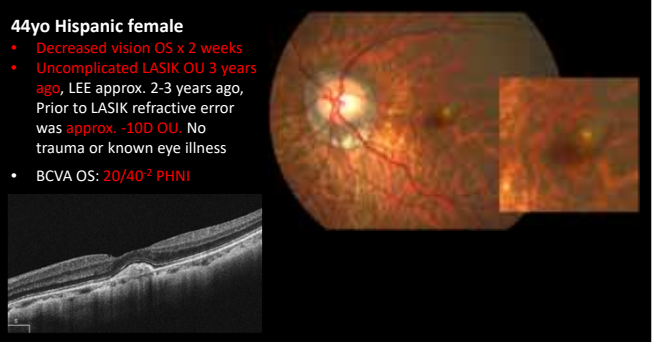


70

SUBRETINAL HEME VS MYOPIC CNV?

44yo Hispanic female

- Decreased vision OS x 2 weeks
- Uncomplicated LASIK OU 3 years ago, LEE approx. 2-3 years ago, Prior to LASIK refractive error was approx. -10D OU. No trauma or known eye illness
- BCVA OS: $20/40^{-2}$ PHNI



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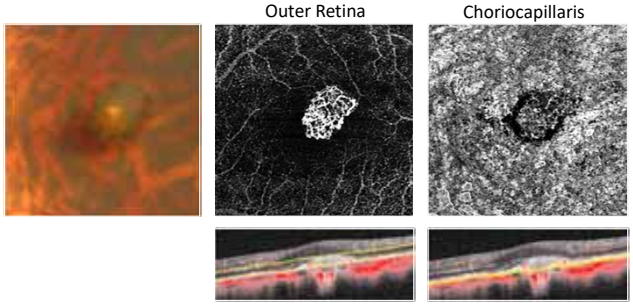
CHOROIDAL NEOVASCULARIZATION

Myopia - Type 2

Outer Retina | Choriocapillaris



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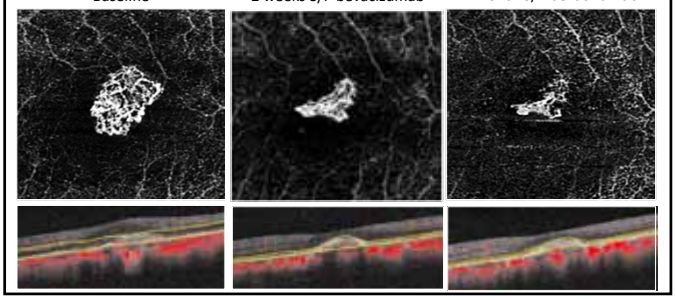
CHOROIDAL NEOVASCULARIZATION

Myopia - Type 2

Baseline | 2 weeks S/P bevacizumab | 1 month S/P bevacizumab



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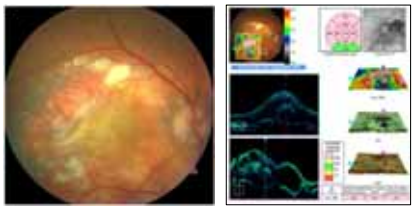
CHOROIDAL NEOVASCULARIZATION

Right Eye

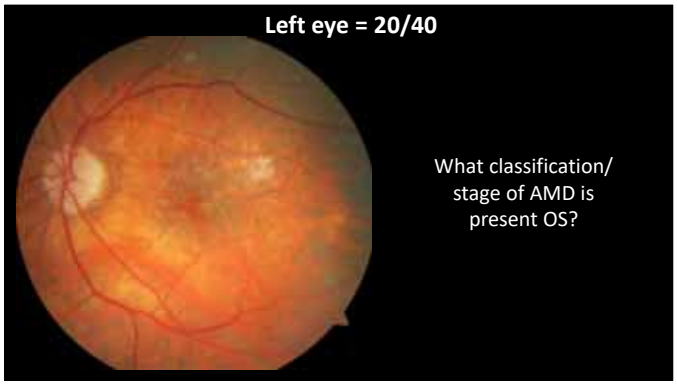
87yo Hispanic female

- History of exudative AMD OD S/P 12 Lucentis injections- wants a second opinion of whether or not she should continue injections OD
- Med HX remarkable for DM type 2
- VAs OD HM, OS 20/40



74

Left eye = 20/40



What classification/ stage of AMD is present OS?

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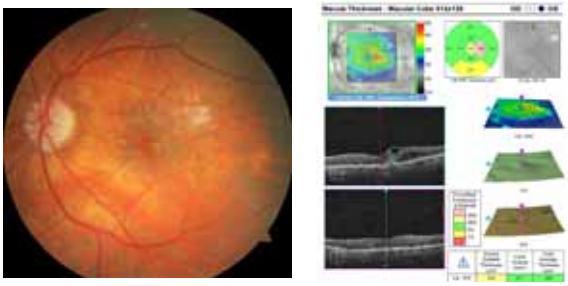
CHOROIDAL NEOVASCULARIZATION

Type 3 RAP



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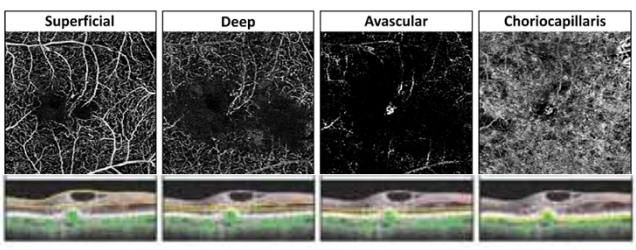
CHOROIDAL NEOVASCULARIZATION

AMD- Type 3 RAP (Retinal Angiomatous Proliferation)

Superficial | Deep | Avascular | Choriocapillaris



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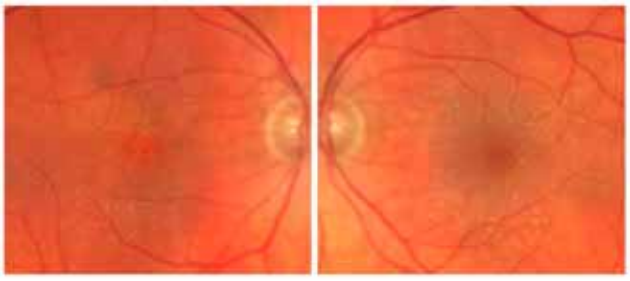
"DON'T WAKE THE SLEEPING DRAGON"

64yo American Indian male

- Routine exam, Dry AMD x 5 yrs OU, former smoker, 20/20 OD & OS



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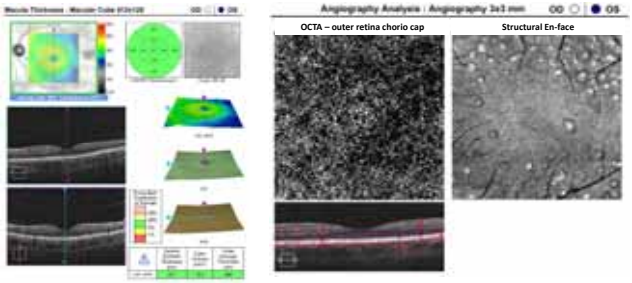
"DON'T WAKE THE SLEEPING DRAGON"



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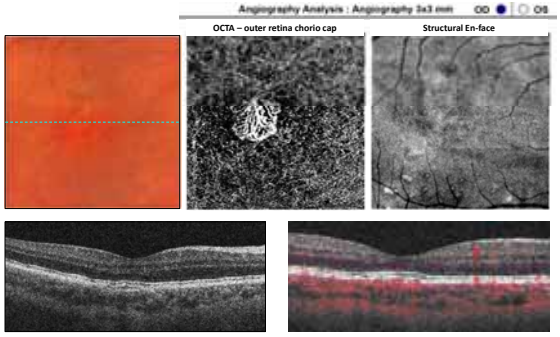
"DON'T WAKE THE SLEEPING DRAGON"



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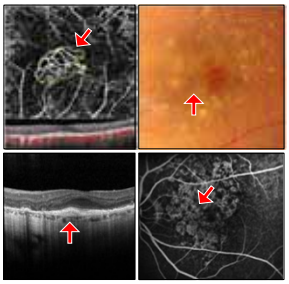
NEW!

OCTA DETECTION OF NONEXUDATIVE CNV



Carnevali A, et al. OCTA: A Useful Tool for Diagnosis of Treatment-Naïve Quiescent CNV. Am J Ophth. 2016.

1. Well-defined neovascular complex via OCTA
2. No signs of exudation via ophthalmoscopy such as exudate or blood
3. No fluid via structural OCT
4. No leakage with IVFA

Present in approx. 10% of high risk AMD eyes (intermediate AMD, exudative fellow eye)

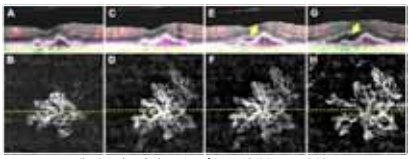
Or C, et al. Incidence of Vascularized Drusen in Non-Exudative ARMD using SD-OCTA. ARVO 2018.

81

NONEXUDATIVE CNV

Prognosis

- Rate of future exudation, eyes with nonexudative CNV vs eyes without nonexudative CNV
  - **Bailey S ARVO 2017.** 60% vs 4% (5 months)
  - **De Oliveira Dias J Ophthal 2018.** 21% vs 4% (12 months)
    - 15x greater risk of exudation after detection of nonexudative CNV



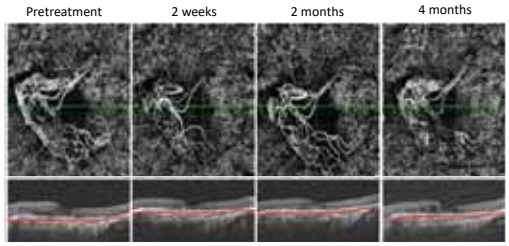
Bailey S et al. Early detection of CNV with OCTA. ARVO 2017.
De Oliveira Dias JR, et al. Natural History of Subclinical Neovascularization in Nonexudative ARMD Using SS-OCTA. Ophthalmol 2018.

EYES WITH NONEXUDATIVE CNV ARE AT HIGH RISK FOR EXUDATIVE CONVERSION!

82

NEOVASCULAR REGRESSION

AMD When to retreat?



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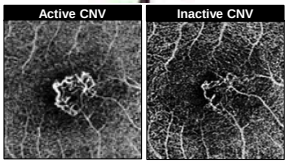
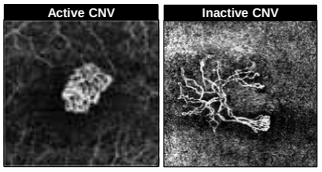
NEOVASCULAR ACTIVITY

OCTA morphologic features of CNV associated with disease activity

- Peripheral arcade of anastomosing capillaries vs dead tree



- "Lacy wheel" vs long filamentous linear vessels
- Numerous tiny capillaries vs large mature vessels



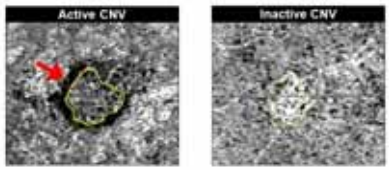
Coscas GJ. OCTA vs traditional multimodal imaging in assessing the activity of exudative ARMD: A new diagnostic challenge. Retina 2015.

84

NEOVASCULAR ACTIVITY

OCTA morphologic features of CNV associated with disease activity

- Perilesional hypointense halo



Coscas GJ. OCTA vs traditional multimodal imaging in assessing the activity of exudative ARMD: A new diagnostic challenge. Retina 2015.

85

THE "*TAKE HOME*" MESSAGE

- Non-invasive method of visualizing RBC motion
- Many advantages over IVFA
- Good for highlighting and localizing subtle vascular abnormalities
- Detection of subclinical DR
- Better detection of non-perfusion in DR, venous occlusive disease, AMD, and glaucoma
- Earlier detection of pre-retinal and choroidal neovascularization
- Improved visualization of CNV and precursors (nonexudative CNV)

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THANK YOU!

Majcher@nsuok.edu

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