OCT-A IN CLINICAL PRACTICE

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Financial Disclosures

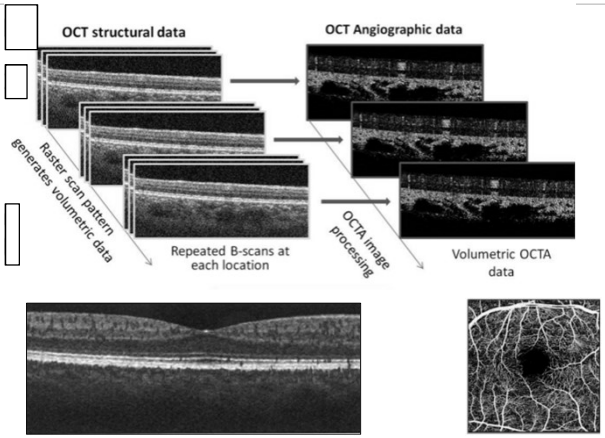
- I do not have any relevant financial relationships to disclose.
- The content and format of this course is presented without commercial bias and does not claim superiority of any commercial product or service.

Objectives

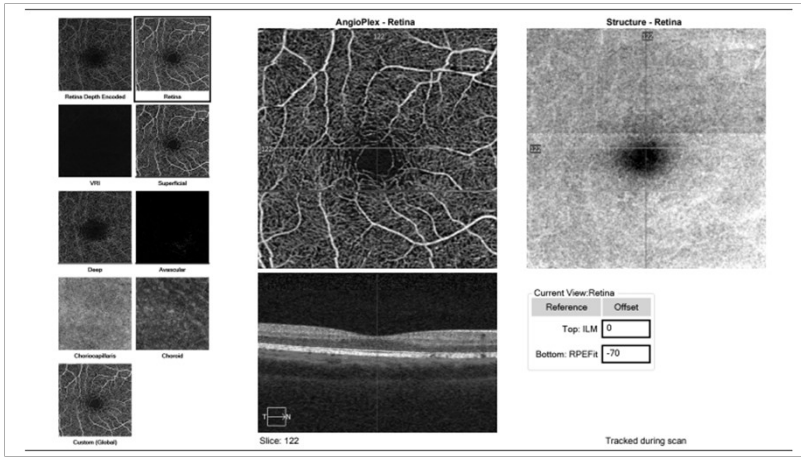
- Provide a brief overview of clinical applications of OCT-Angiography.
- Discuss expected OCT-Angiography findings in common ophthalmic conditions.
- Review literature associated with OCT-Angiography to increase clinician comfort with utilizing technology in daily practice.

OCT Angiography

- Heavily reliant on **ocular coherence tomography**
- Noninvasive method allowing for **visualization of functional blood vessels** in posterior segment
- Achieved by using **variation in OCT signal** caused by **moving erythrocytes**

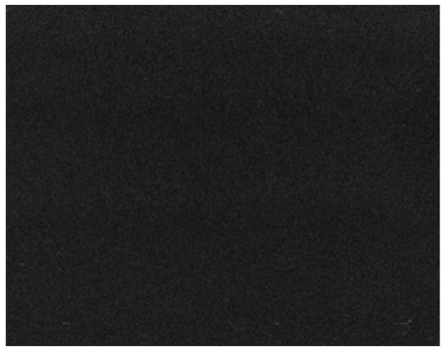


NORMATIVE SCANS



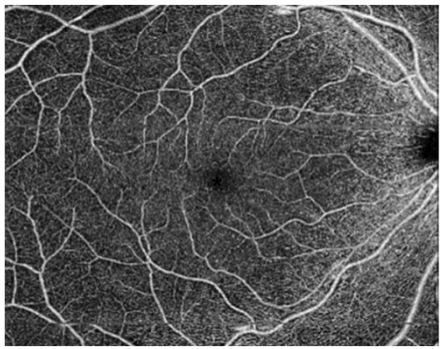
Vitreoretinal Interface (VRI)

Absence of **vascular components**



Superficial

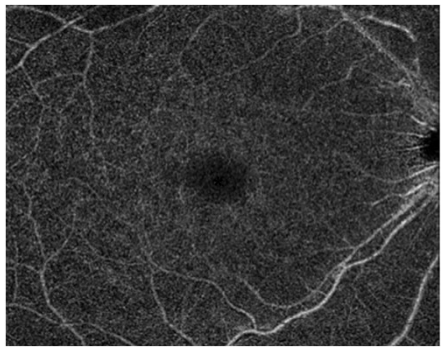
- ILM to IPL – 10 um
- Superficial vascular plexus
- Centripetal pattern



* Indicates FOVEAL AVASCULAR ZONE (FAZ)

Deep

- IPL – 10 um to OPL + 10 um
- Deep vascular complex
  - Intermediate capillary plexus
  - Deep capillary plexus



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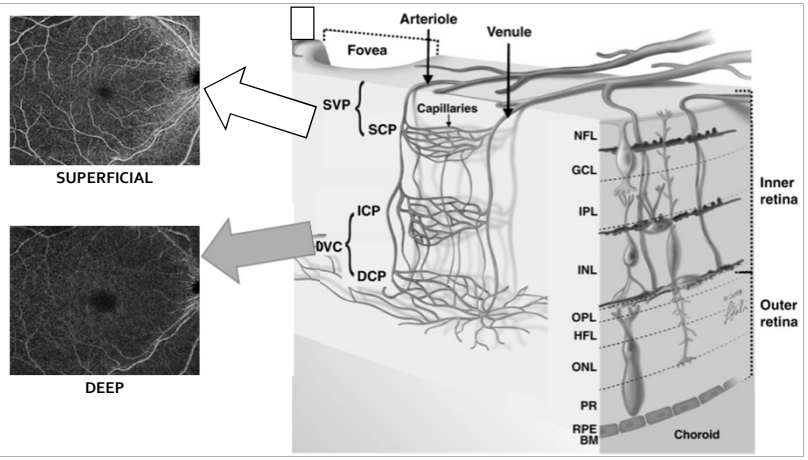
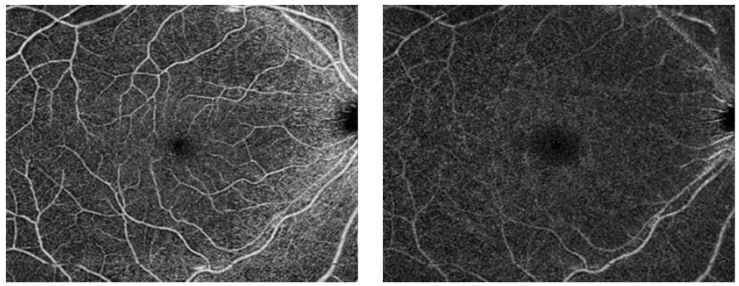
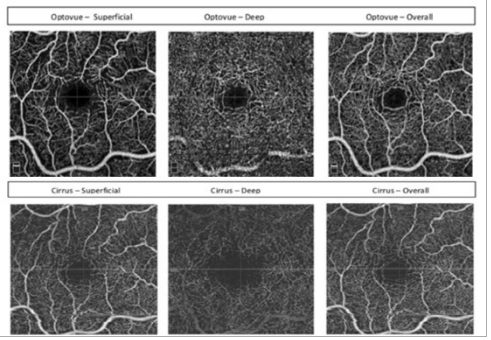


Foveal Avascular Zone*

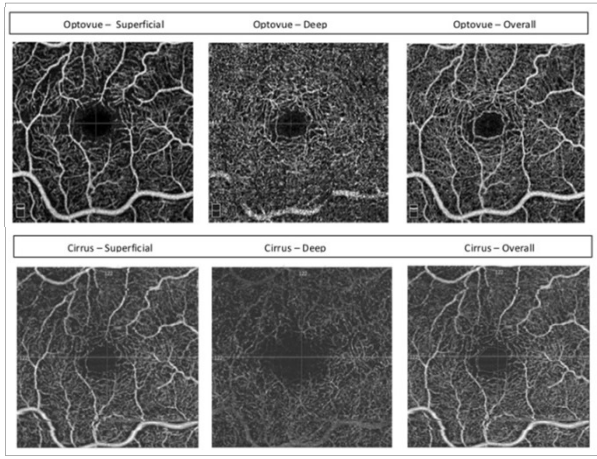


Factors Affecting Repeatability of Foveal Avascular Zone Measurement Using Optical Coherence Tomography Angiography in Pathologic Eyes

Heterogeneity among commercial OCTA segmentation software developed by various vendors can yield apparent difference in FAZ size of segmented retinal plexus layers, especially deep vascular plexus.



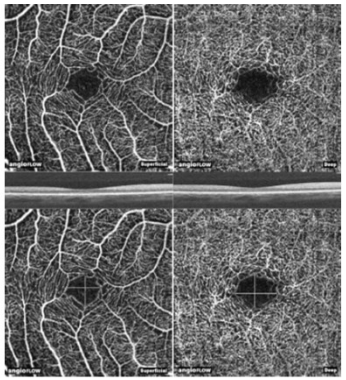
Source: Buffolino NJ, Vu AF, Amin A, De Niear M, Park SS. Factors Affecting Repeatability of Foveal Avascular Zone Measurement Using Optical Coherence Tomography Angiography in Pathologic Eyes. Clin Ophthalmol. 2020;14:1025-1033. Published 2020 Apr 5. doi:10.2147/OPTH.S247172



Source: Buffolino NJ, Vu AF, Amin A, De Niear M, Park SS. Factors Affecting Repeatability of Foveal Avascular Zone Measurement Using Optical Coherence Tomography Angiography in Pathologic Eyes. Clin Ophthalmol. 2020;14:1025-1033. Published 2020 Apr 5. doi:10.2147/OPTH.S247172

Measurement of Foveal Avascular Zone Dimensions and its Reliability in Healthy Eyes Using Optical Coherence Tomography Angiography

- Interobserver agreement re: FAZ measurements was
  - High for superficial vascular network
  - Unacceptable for deep vascular network



Source: Shahlaee A, Pefkianaki M, Hsu J, Ho AC. Measurement of Foveal Avascular Zone Dimensions and its Reliability in Healthy Eyes Using Optical Coherence Tomography Angiography. Am J Ophthalmol. 2016;161:50-5.e1. doi:10.1016/j.ajo.2015.09.026

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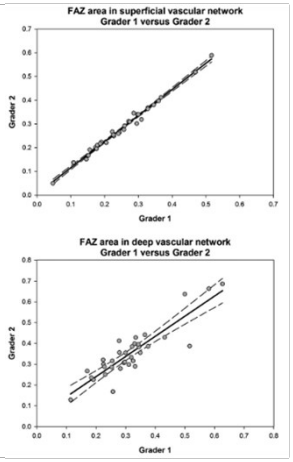
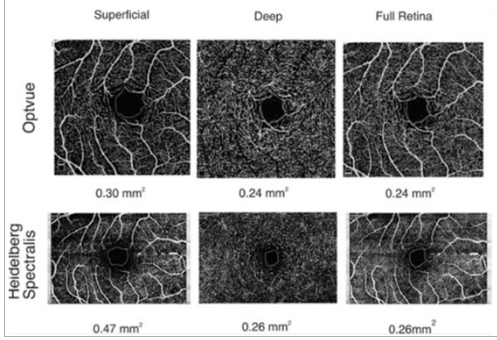


Source: Shahlaee A, Pefkianaki M, Hsu J, Ho AC. Measurement of Foveal Avascular Zone Dimensions and its Reliability in Healthy Eyes Using Optical Coherence Tomography Angiography. Am J Ophthalmol. 2016;161:50-5.e1. doi:10.1016/j.ajo.2015.09.026

Superficial and Deep Foveal Avascular Zone Area Measurement in Healthy Subjects Using Two Different Spectral Domain Optical Coherence Tomography Angiography Devices



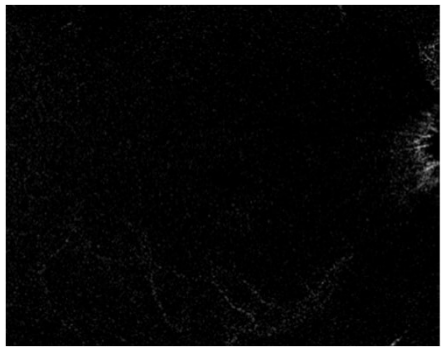
Slab	Optovue	Spectralis
Superficial capillary plexus (mm^2)	0.31 ± 0.08	0.55 ± 0.16
Deep capillary plexus (mm^2)	0.26 ± 0.08	0.36 ± 0.13
Full retina (mm^2)	0.26 ± 0.07	0.36 ± 0.10

*Paired *t*-test

Source: Anvari P, Najafi A, Mirshahi R, et al. Superficial and Deep Foveal Avascular Zone Area Measurement in Healthy Subjects Using Two Different Spectral Domain Optical Coherence Tomography Angiography Devices. J Ophthalmic Vis Res. 2020;15(4):517-523. Published 2020 Oct 15. doi:10.18502/jovr.v15i4.7791

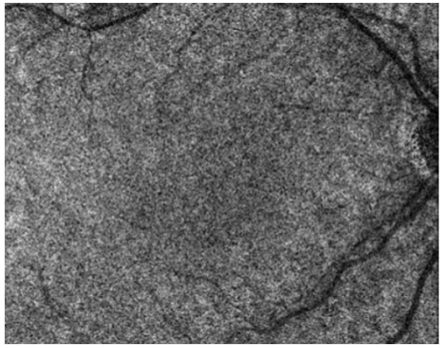
Avascular

Absence of **vascular components**



Choriocapillaris

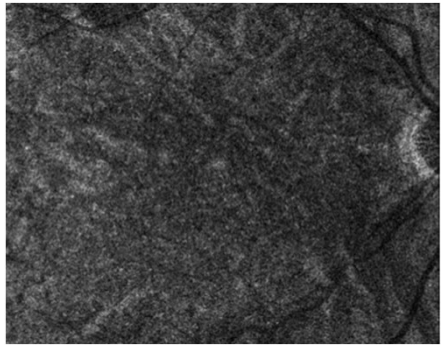
- Central macula
  - Confluent, lobular flow
- Periphery
  - More lobular
  - Less dense



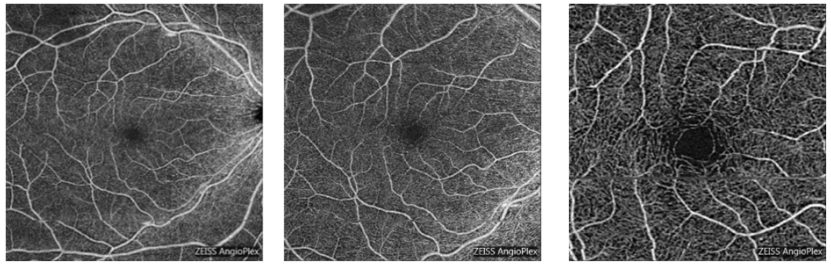
Choroid

Large vessels

Compromised visualization



Scan Size Dictates Image Resolution



8 x 8 mm | 6 x 6 mm | 3 x 3 mm

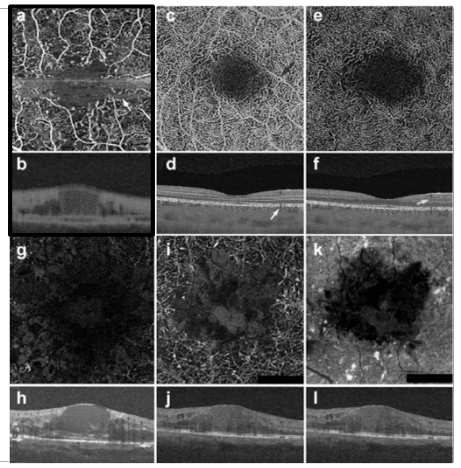
Scan Size Dictates Image Resolution

3 x 3 mm | 6 x 6 mm

COMMON OCTA ARTIFACTS

Motion Artifact

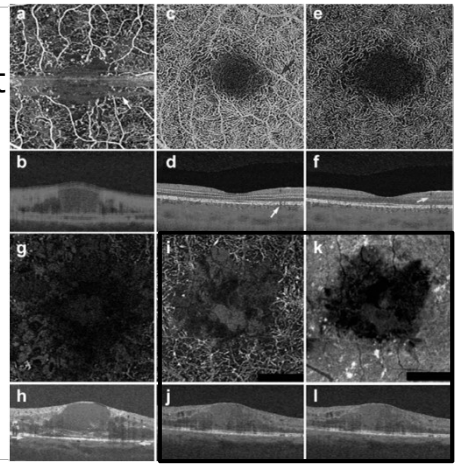
- Secondary to bulk motion
  - i.e. inappropriate patient movement
- Horizontal line through scan



Source: Greig EC, Duker JS, Waheed NK. A practical guide to optical coherence tomography angiography interpretation. Int J Retina Vitreous. 2020;6(1):55. Published 2020 Nov 13. doi:10.1186/s40942-020-00262-9

Shadowing Artifact

- OCT beam blockage
  - Drusen
  - Hemorrhage
  - Vitreous floaters
- Compromised penetration to underlying tissue



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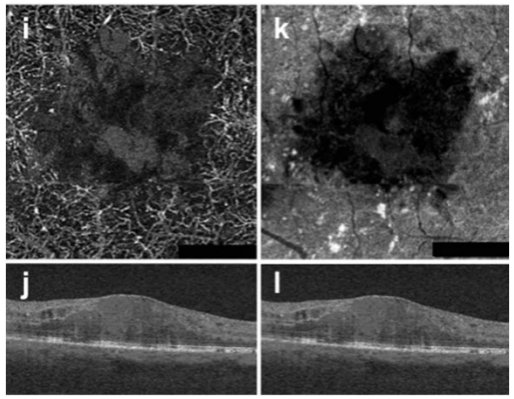

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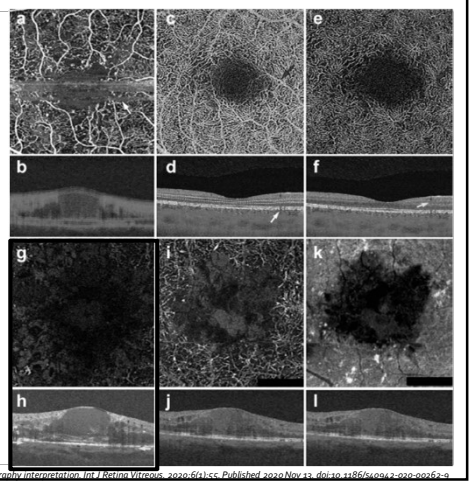
Segmentation Artifact

- Disease pathology drastically altering retinal anatomy can cause algorithms to mislabel pre-determined boundaries
  - Diabetic macula edema
  - Drusen
  - Myopia



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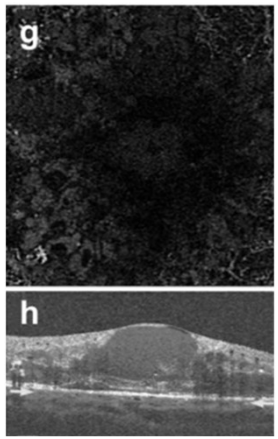

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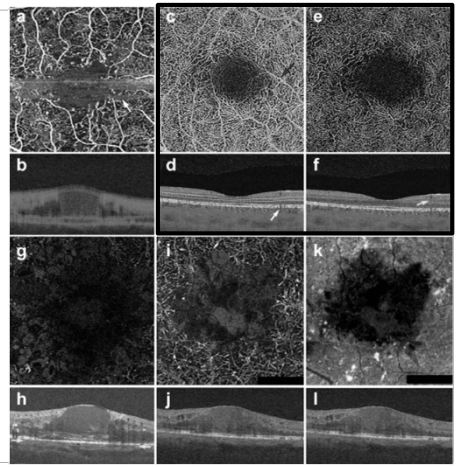
Projection Artifact

- Reflected light forms basis of OCT-A
  - Light reflected back from SVP forms image of that plexus
- Phase of light passing through a superficial layer is changed, and once reflected back by a layer below will still give off appearance of blood flow from superficial layer



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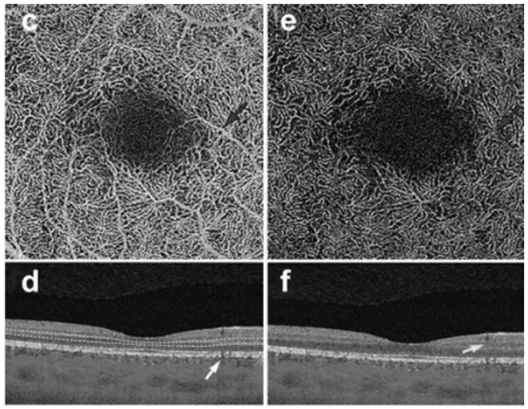

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OCT-ANGIOGRAPHY

CAN BE UTILIZED IN MANY CONDITIONS

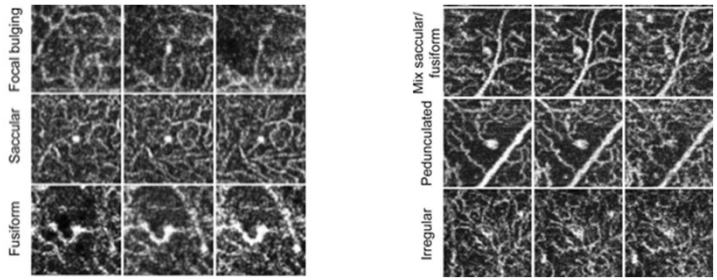
Common Clinical Considerations for Angiography Acquisition

- Diabetic Retinopathy
  - Non-Proliferative
  - Proliferative
- Macular Degeneration
- Vascular Occlusive Events
- Glaucoma

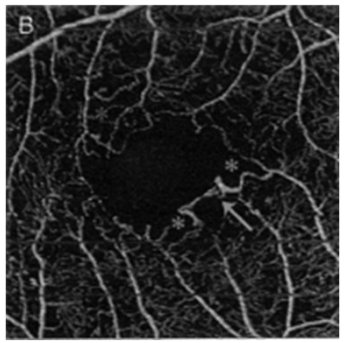
OCTA Imaging: Nonproliferative Diabetic Retinopathy

- Identify retinal vascular abnormalities:
  - Microaneurysm formation
  - Capillary dilation
  - Clustering
  - Tortuosity
  - Microaneurysm formation
  - Areas of nonperfusion

NPDR: Microaneurysms



Source: Schreur V, Domanian A, Liefers B, *et al.* Morphological and topographical appearance of microaneurysms on optical coherence tomography angiography. *British Journal of Ophthalmology* 2019;**103**:630-635



* Indicates enlargement and irregularity of foveal avascular zone

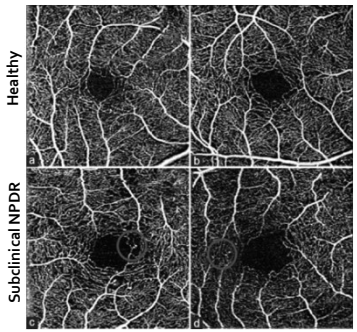
* Indicates capillary nonperfusion

← Indicates cluster of abnormally dilated and tortuous parafoveal capillaries

Source: OCT and OCTA in Retinal Disorders

Role of optical coherence tomography-angiography in diabetes mellitus: Utility in diabetic retinopathy and a comparison with fluorescein angiography in vision threatening diabetic retinopathy

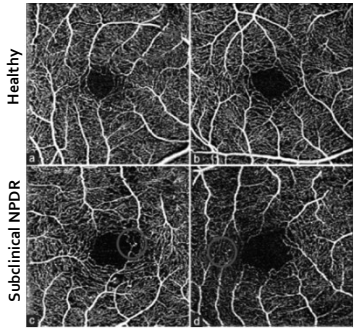
- Microaneurysms
  - Cardinal sign → DR onset
  - Clinically detectable >30 microns
- Study revealed subclinical microaneurysms
  - <30 microns
  - Not detectable
- Suggestive of positively impacting early diagnosis of DR



Source: Shaikh NF, Vohra R, Balaji A, et al. Role of optical coherence tomography-angiography in diabetes mellitus: Utility in diabetic retinopathy and a comparison with fluorescein angiography in vision threatening diabetic retinopathy. *Indian J Ophthalmol.* 2021;69(11):3218-3224. doi:10.4103/ijo.IJO_1267_21

Role of optical coherence tomography-angiography in diabetes mellitus: Utility in diabetic retinopathy and a comparison with fluorescein angiography in vision threatening diabetic retinopathy

- Quantification of vascular changes also considered
- Negative correlation between diabetic retinopathy severity and
  - Vessel density
  - Perfusion density



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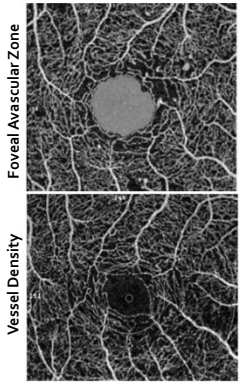
Evaluation of Foveal Avascular Zone and Capillary Plexuses in Diabetic Patients by Optical Coherence Tomography Angiography

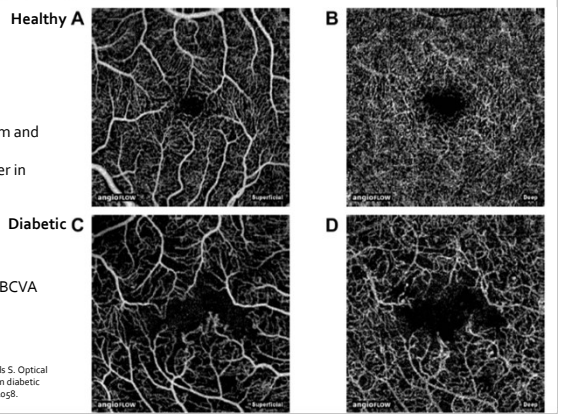
- Confirmed that diabetic disease severity had:
  - Positive correlation with
    - Foveal AVZ
  - Negative correlation with
    - Parafoveal vessel density in SCP & DCP
    - Foveal vessel density in SCP & DCP



Source: Ciloglu E, Unal F, Sukgen EA, Koçluk Y. Evaluation of Foveal Avascular Zone and Capillary Plexuses in Diabetic Patients by Optical Coherence Tomography Angiography. Korean J Ophthalmol. 2019;33(4):359-365. doi:10.3341/kjo.2018.0025

Optical coherence tomography angiography of the foveal avascular zone in diabetic retinopathy

- Mean horizontal, vertical, maximum and the diameter at 90 degrees to the maximum FAZ diameter were larger in diabetic eyes than healthy eyes
  - Superficial layer
  - Deep layer
- Correlation of FAZ dimensions wit BCVA found to be statistically significant

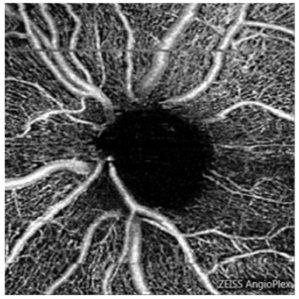


Source: Freiberg FJ, Pfau M, Wons J, Wirth MA, Becker MD, Michels S. Optical coherence tomography angiography of the foveal avascular zone in diabetic retinopathy. *Graefes Arch Clin Exp Ophthalmol.* 2016;254(6):1051-1058. doi:10.1007/s00417-015-3148-2

OCTA Imaging: Proliferative Diabetic Retinopathy

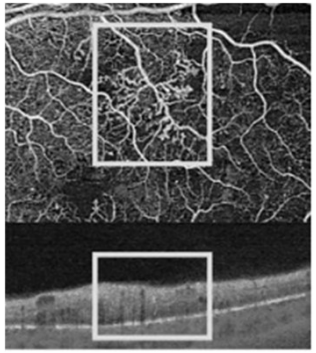
- Neovascularization
  - Disc
  - Everywhere
- Extensive capillary nonperfusion

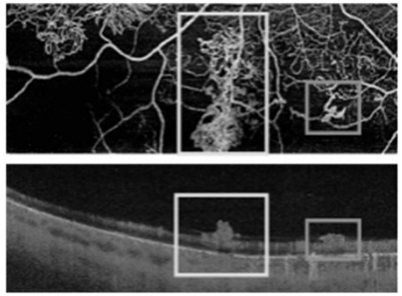
Neovascularization of the Disc



Source: Vaz-Pereira, S., Morais-Sarmento, T. & Esteves Marques, R. Optical coherence tomography features of neovascularization in proliferative diabetic retinopathy: a systematic review. Int J Retin Vitr **6**, 26 (2020). https://doi.org/10.1186/s40942-020-00230-3

IRMA vs. NEO ELSEWHERE



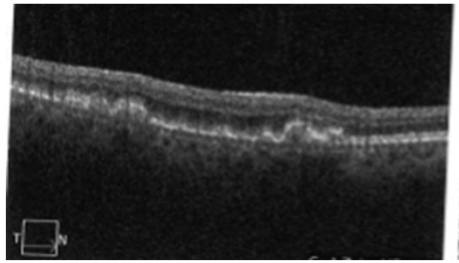


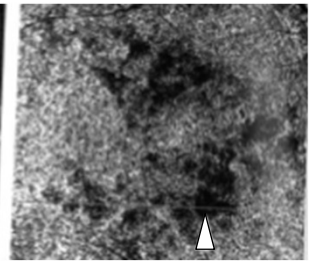
Source: Arya M, Sorour O, Chaudhri J, et al. DISTINGUISHING INTRARETINAL MICROVASCULAR ABNORMALITIES FROM RETINAL NEOVASCULARIZATION USING OPTICAL COHERENCE TOMOGRAPHY ANGIOGRAPHY. Retina. 2020;40(9):1686-1695. doi:10.1097/IAE.0000000000002671

OCTA Imaging: Dry Macular Degeneration

- Confirm absence of CNVMs
- Demonstrate loss of choriocapillaris

OCTA Imaging: Dry Macular Degenerative



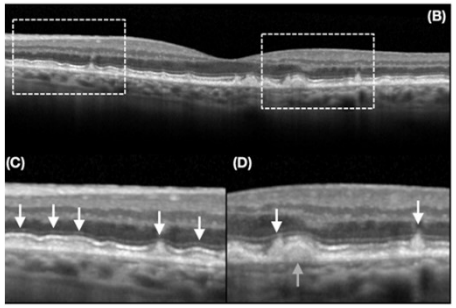


Flow Voids

Source: OCT and OCTA in Retinal Disorders

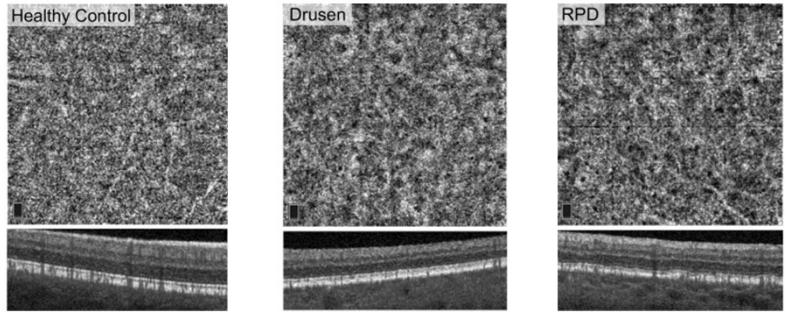
Choriocapillaris Nonperfusion is Associated With Poor Visual Acuity in Eyes With Reticular Pseudodrusen

- **Study Purpose**
  - Reticular pseudodrusen vs. Drusen
    - Differences on OCT-A?
    - Correlation to visual acuity?



Source: Nesper PL, Soetikno BT, Fawzi AA. Choriocapillaris Nonperfusion is Associated With Poor Visual Acuity in Eyes With Reticular Pseudodrusen. Am J Ophthalmol. 2017;174:42-55. doi:10.1016/j.ajo.2016.10.005

Choriocapillaris Nonperfusion is Associated With Poor Visual Acuity in Eyes With Reticular Pseudodrusen



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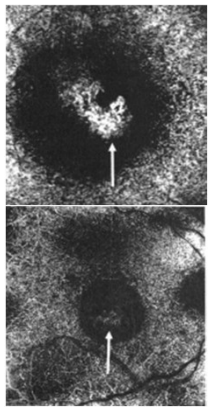
OCTA Imaging: Exudative Macular Degenerative

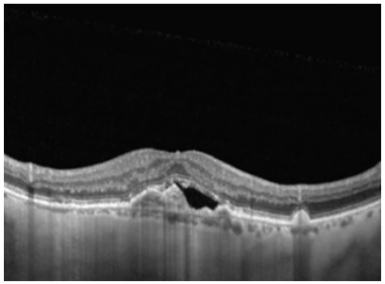
- Choroidal Neovascular Membrane
  - Surrounded by "dark halo"
  - Appearance varies on underlying type
    - Type 1
    - Type 2
    - Type 3



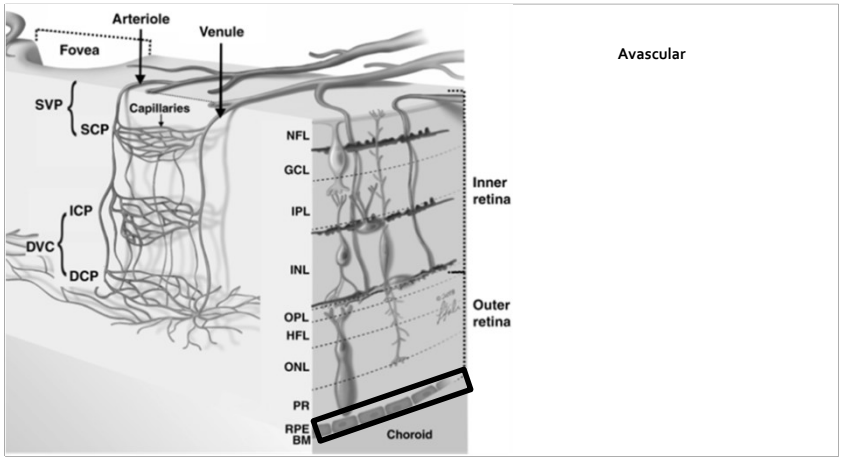
Source: OCT and OCTA in Retinal Disorders

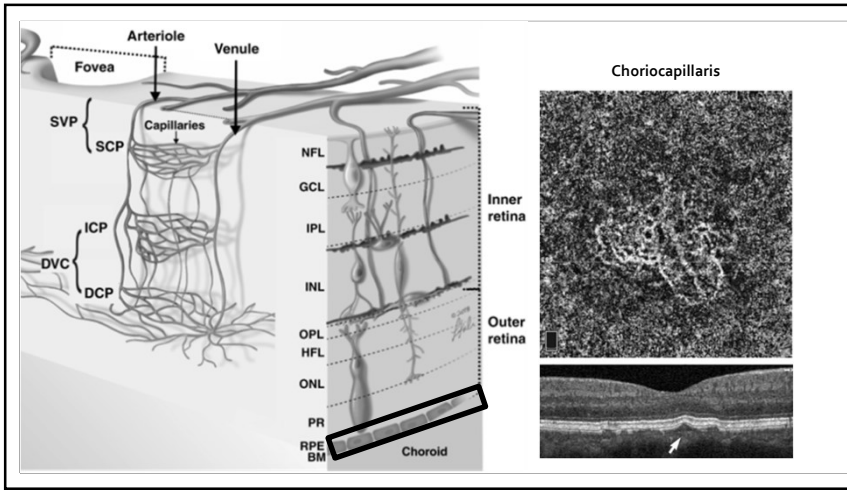
OCTA Imaging: Type 1 CNV

- Characterized by pathologic angiogenesis occurring between the RPE and its basal lamina and the remainder of Bruch's membrane
- Most common subtype of nAMD

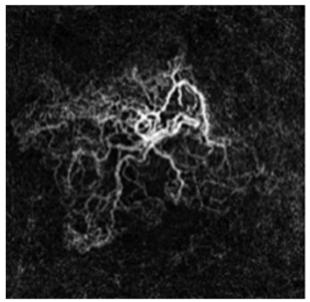


Source: Ryan's Retina





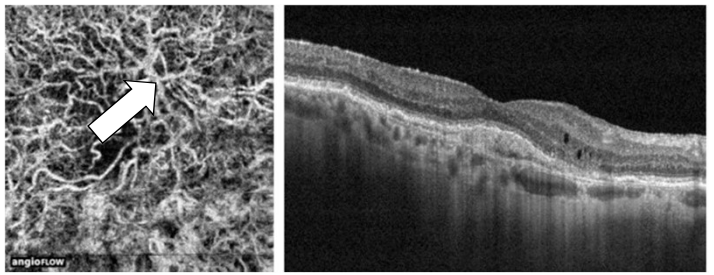
TYPE 1 CNV → "Medusa" Configuration



- Large main central vessel trunk
- Vessels radiating in branching pattern in all directions from lesion center

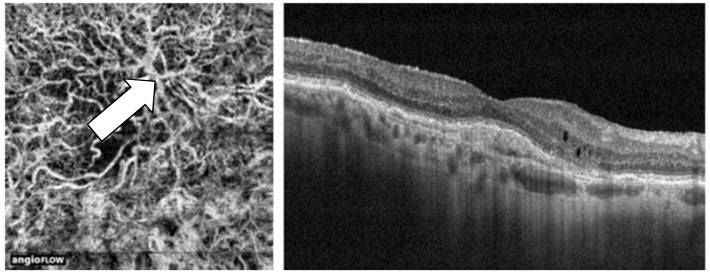
Source: Choi M, Kim SW, Yun C, Oh J. OCT Angiography Features of Neovascularization as Predictive Factors for Frequent Recurrence in Age-Related Macular Degeneration. Am J Ophthalmol. 2020;213:109-119. doi:10.1016/j.ajo.2020.01.012

TYPE 1 CNV → "Medusa" Configuration



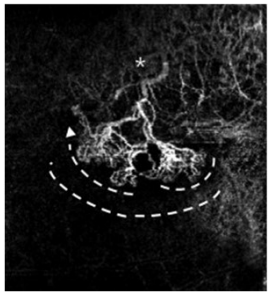
Source: Iafe NA, Phasukkijwatana N, Sarraf D. Optical Coherence Tomography Angiography of Type 1 Neovascularization in Age-Related Macular Degeneration. Dev Ophthalmol. 2016;56:45-51. doi:10.1159/000442776

TYPE 1 CNV → "Medusa" Configuration



Source: Iafe NA, Phasukkijwatana N, Sarraf D. Optical Coherence Tomography Angiography of Type 1 Neovascularization in Age-Related Macular Degeneration. Dev Ophthalmol. 2016;56:45-51. doi:10.1159/000442776

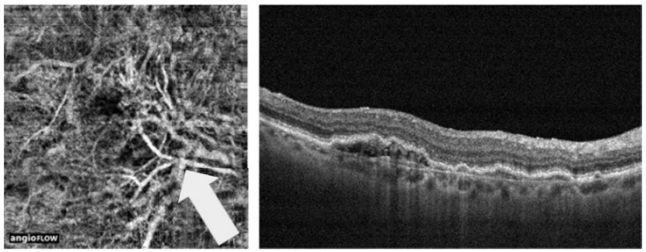
TYPE 1 CNV → "Sea Fan" Configuration



- Large main central vessel trunk
- Vessels radiating from one side of the lesion

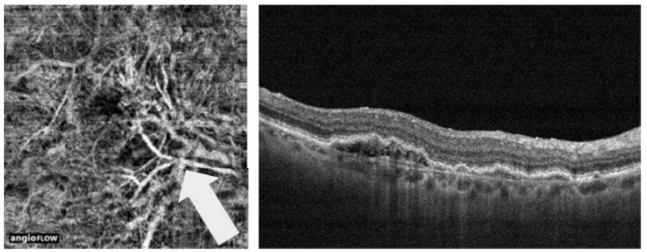
Source: Choi M, Kim SW, Yun C, Oh J. OCT Angiography Features of Neovascularization as Predictive Factors for Frequent Recurrence in Age-Related Macular Degeneration. Am J Ophthalmol. 2020;213:109-119. doi:10.1016/j.ajo.2020.01.012

TYPE 1 CNV → "Seafan" Configuration



Source: Iafe NA, Phasukkijwatana N, Sarraf D. Optical Coherence Tomography Angiography of Type 1 Neovascularization in Age-Related Macular Degeneration. Dev Ophthalmol. 2016;56:45-51. doi:10.1159/000442776

TYPE 1 CNV → "Seafan" Configuration

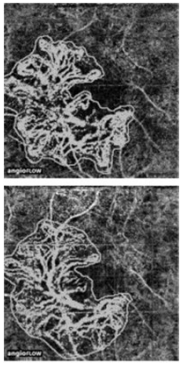


Source: Iafe NA, Phasukkijwatana N, Sarraf D. Optical Coherence Tomography Angiography of Type 1 Neovascularization in Age-Related Macular Degeneration. Dev Ophthalmol. 2016;56:45-51. doi:10.1159/000442776

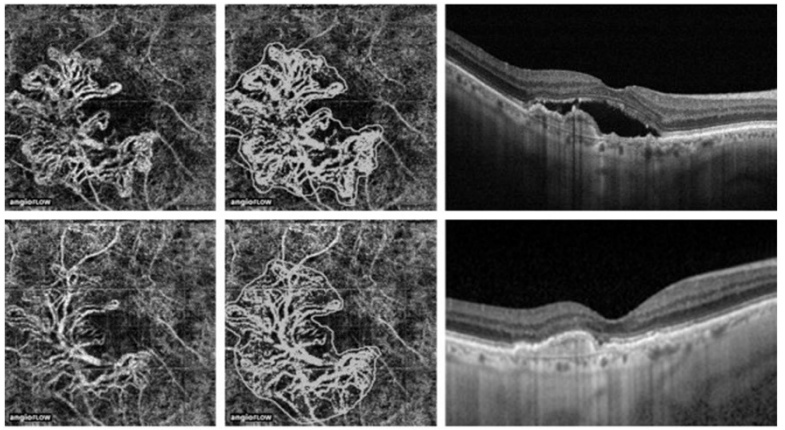
Optical Coherence Tomography Angiography ofType 1 Neovascularization in Age-Related Macular Degeneration

Purpose: To analyze type 1 neovascular membranes in AMD using OCTA, to correlate morphological characteristics with imaging and clinical criteria, and to analyze structural features of type 1 neovascularization sequentially after anti-VEGF therapy.

Results: Lesion area and vessel density remained unchanged, even after anti-VEGF therapy, indicating a more mature longstanding neovascular complex resistant to anti-VEGF therapy.



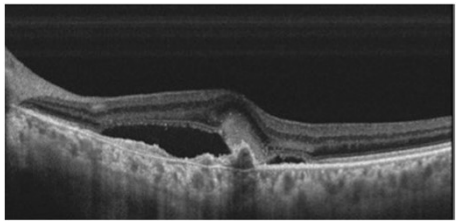
Source: Kuehlewein L, Bansal M, Lenis TL, et al. Optical Coherence Tomography Angiography of Type 1 Neovascularization in Age-Related Macular Degeneration. Am J Ophthalmol. 2015;160(4):739-48.e2. doi:10.1016/j.ajo.2015.06.030



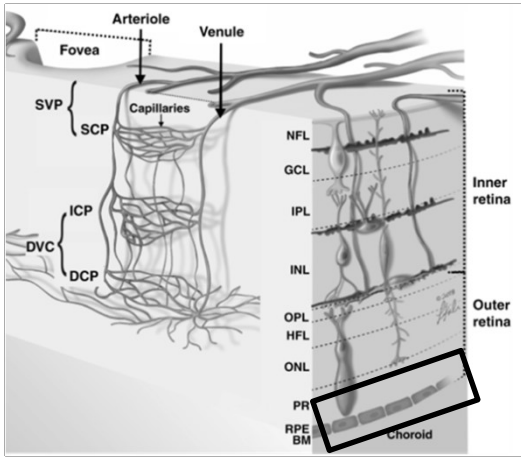
Source: Kuehlewein L, Bansal M, Lenis TL, et al. Optical Coherence Tomography Angiography of Type 1 Neovascularization in Age-Related Macular Degeneration. Am J Ophthalmol. 2015;160(4):739-48.e2. doi:10.1016/j.ajo.2015.06.030

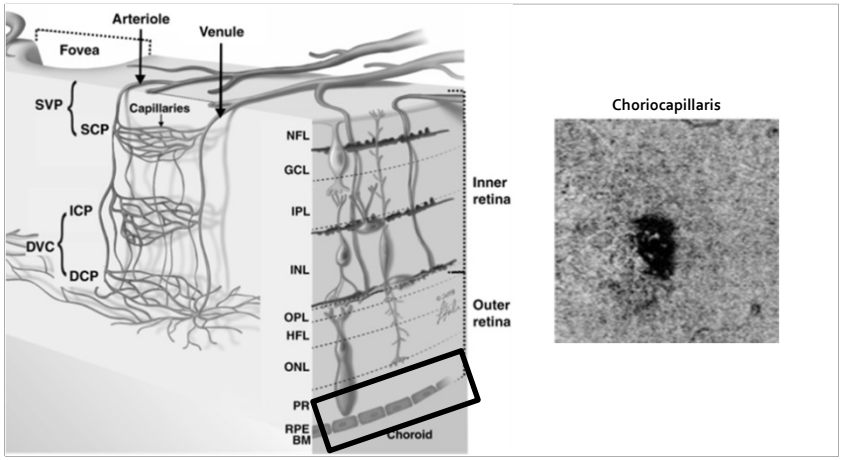
OCTA Imaging: Type 2 CNV

- Characterized by pathologic choroidal vessels in subretinal space
- Least frequent phenotype



Source: Ryan's Retina

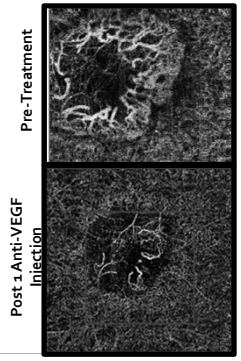




[Changes in OCT Angiography of Type 2 CNV in Neovascular AMD during Anti-VEGF Treatment]

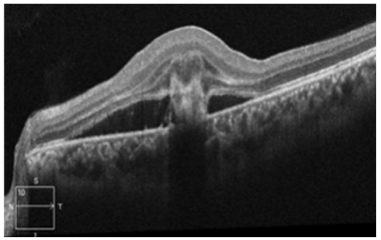
Purpose: Better characterize type 2 CNVMs based on OCT-A segmentation and structures as well as investigate changes during anti-VEGF treatment..

Results: Significant reduction in the size of CNVM as well as flow area within the membrane and flow index following anti-VEGF treatment with most significant reduction occurring at the level of the RPE.

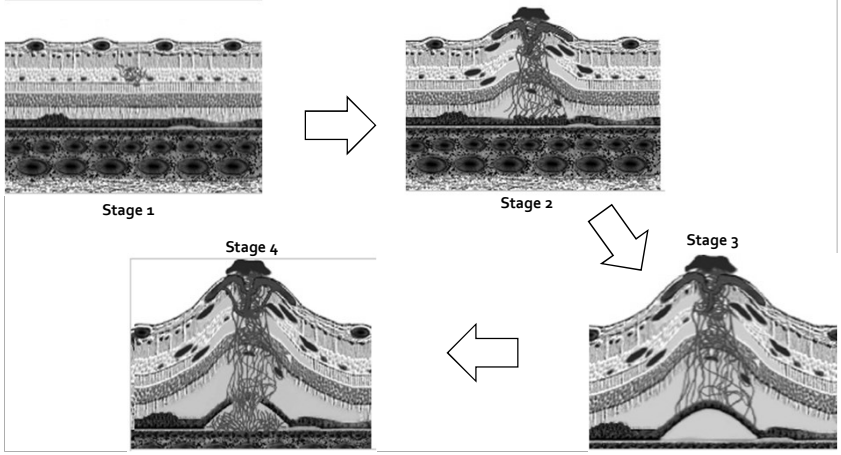


OCTA Imaging: Type 3 CNV

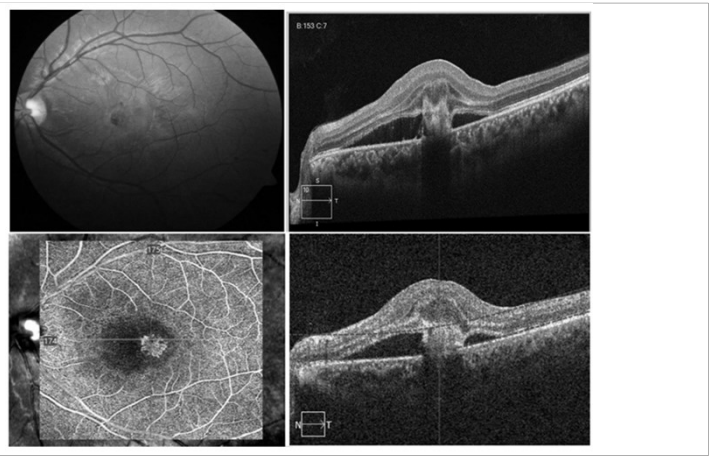
- Characterized by proliferation of new vessels within neurosensory retina rather than in subretinal or sub-RPE spaces
- i.e. Retinal Angiomatous Proliferation



Source: Retina Image Bank

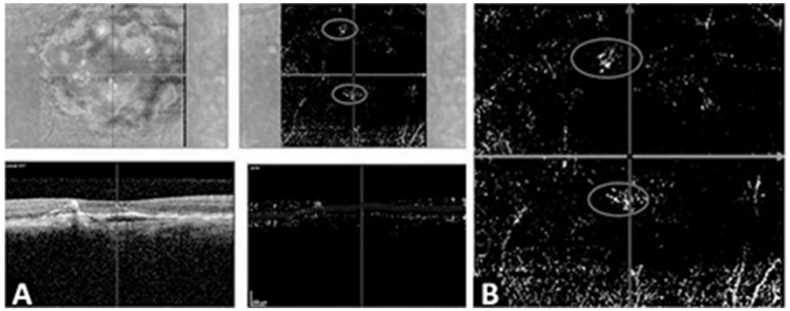


Source: Lawrence A. Yannuzzi, MD



Source: Retina Image Bank

Retinal Angiomatous Proliferation: Multimodal Imaging Characteristics and Follow-up with Eye-Tracked Spectral Domain Optical Coherence Tomography of Precursor Lesions



Source: Öztaş Z, Menteş J. Retinal Angiomatous Proliferation: Multimodal Imaging Characteristics and Follow-up with Eye-Tracked Spectral Domain Optical Coherence Tomography of Precursor Lesions. Turk J Ophthalmol. 2018;48(2):66-69. doi:10.4274/tjo.03780

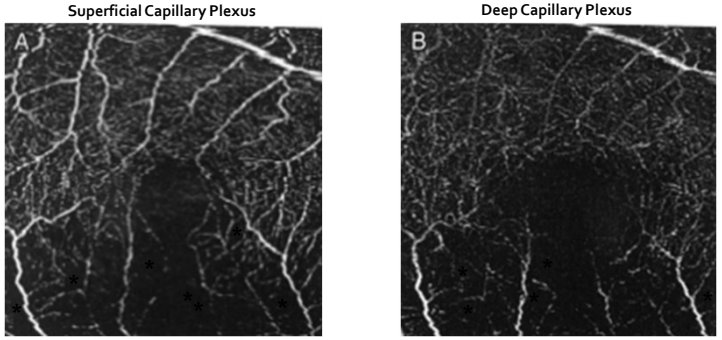
OCTA Imaging: Vascular Occlusions

- **Branch Retinal Artery Occlusions**
  - Easily identify
    - Retinal non-perfusion areas
    - Localize foci of retinal ischemia
      - i.e. flow voids
  - Quantify alterations in vascular density
    - Superficial capillary plexus
    - Deep capillary plexus

OCTA Imaging: Branch Retinal Artery Occlusions

Superficial Capillary Plexus

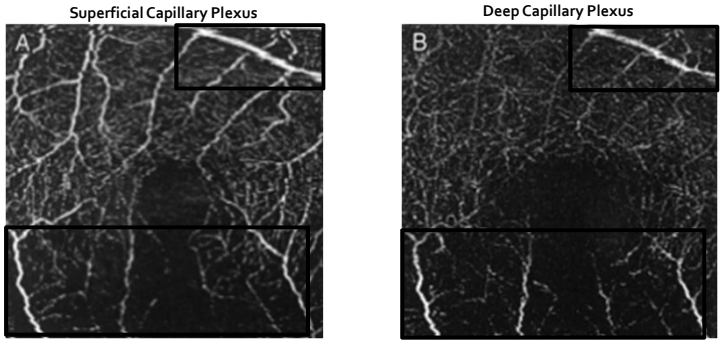
Deep Capillary Plexus



* Indicates capillary nonperfusion

Source: OCT and OCTA in Retinal Disorders

OCTA Imaging: Branch Retinal Artery Occlusions

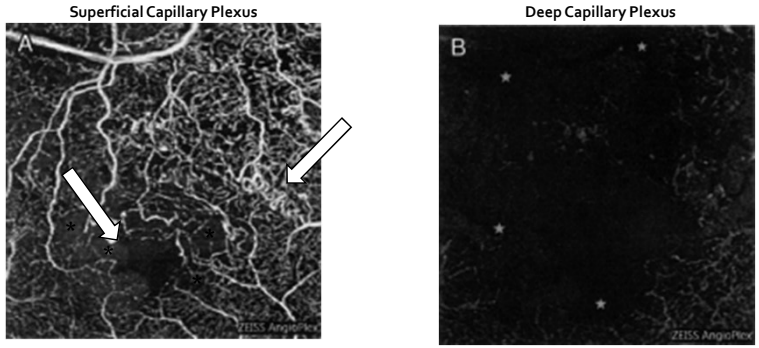


Source: OCT and OCTA in Retinal Disorders

OCTA Imaging: Vascular Occlusions

- **Branch Retinal Vein Occlusions**
  - Vascular abnormalities
    - Decreased capillary density
    - Capillary nonperfusion
    - Enlargement of FAZ
    - Venous dilation
  - Collateral formation
    - Parafoveally
    - Raphe crossing

OCTA Imaging: Branch Retinal Vein Occlusions



* Indicates capillary nonperfusion ; *Indicates vascular dropout ; green arrow indicates fusiform MA ; teal arrow indicates collateral

Source: OCT and OCTA in Retinal Disorders

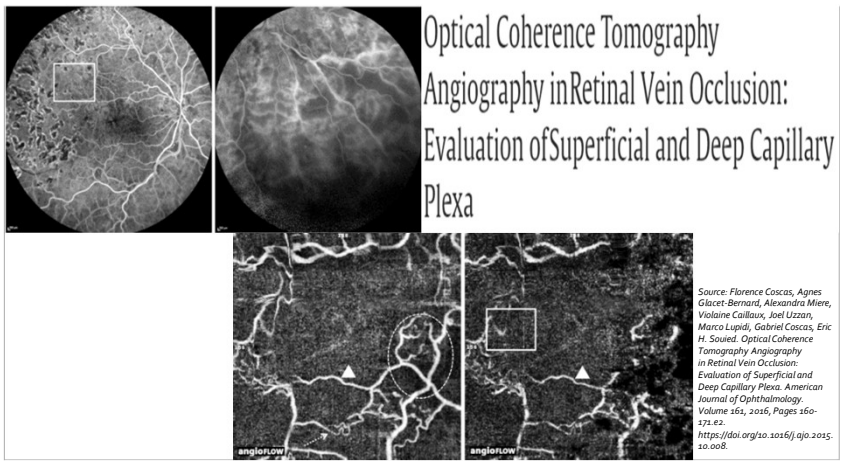
Optical Coherence Tomography Angiography in Retinal Vein Occlusion: Evaluation of Superficial and Deep Capillary Plexa

Purpose: Compare OCT-A appearance of superficial and deep capillary plexus characteristics to those found with FA and OCT

Results:
Deep capillary plexus more severely affected than superficial

Perifoveal capillary arcade disruption on OCT angiography was found to have positive correlation with peripheral ischemia on fluorescein angiography

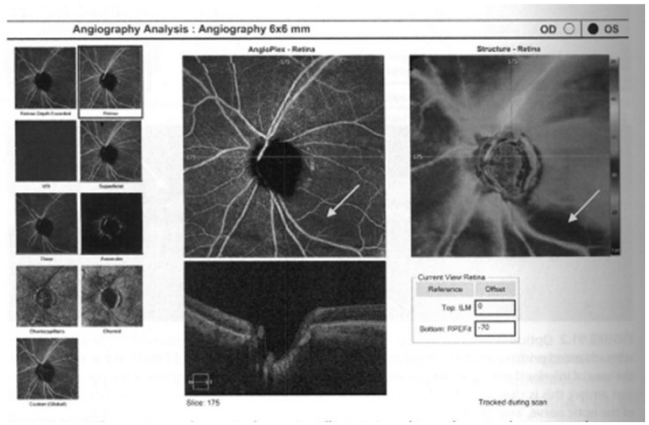
Source: Florence Coscas, Agnes Glacet-Bernard, Alexandra Miere, Violaine Caillaux, Joel Uzzan, Marco Lupidi, Gabriel Coscas, Eric H. Souied. Optical Coherence Tomography Angiography in Retinal Vein Occlusion: Evaluation of Superficial and Deep Capillary Plexa. American Journal of Ophthalmology. Volume 161, 2016, Pages 160-171.e2. https://doi.org/10.1016/j.ajo.2015.10.008.



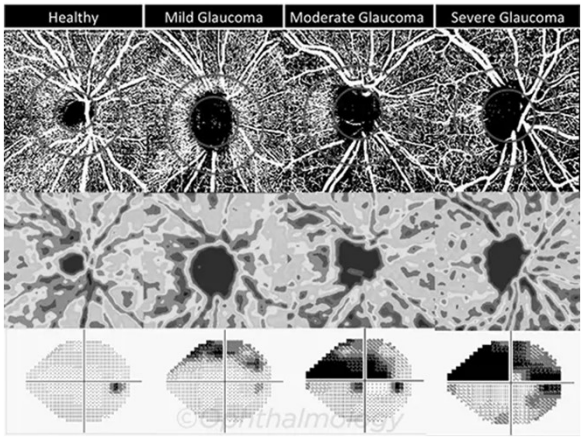
Source: Florence Coscas, Agnes Glacet-Bernard, Alexandra Miere, Violaine Caillaux, Joel Uzzan, Marco Lupidi, Gabriel Coscas, Eric H. Souied. Optical Coherence Tomography Angiography in Retinal Vein Occlusion: Evaluation of Superficial and Deep Capillary Plexa. American Journal of Ophthalmology. Volume 161, 2016, Pages 160-171.e2. https://doi.org/10.1016/j.ajo.2015.10.008.

OCTA Imaging: Glaucoma

- Decreased
  - Peripapillary vessel density
  - Flow indices
    - Optic nerve head
    - Peripapillary retina



Source: OCT and OCT-A in Retinal Disorders

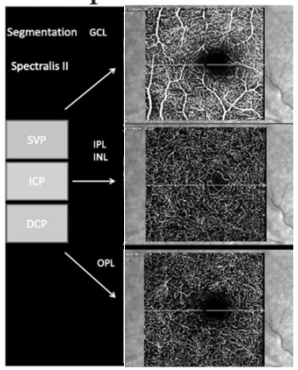


Source: American Academy of Ophthalmology

OCT-angiography: Regional reduced macula microcirculation in ocular hypertensive and pre-perimetric glaucoma patients

Purpose: Investigate regional macular vascular characteristics in patients with ocular hypertension, pre-perimetric primary open angle glaucoma and age based control subjects.

Measurements Acquired:
Retinal nerve fiber layer
Retinal ganglion cell layer
Inner nuclear layer
Bruch's Membrane Opening- Minimum Rim Width
Macular vessel density
Foveal avascular zone

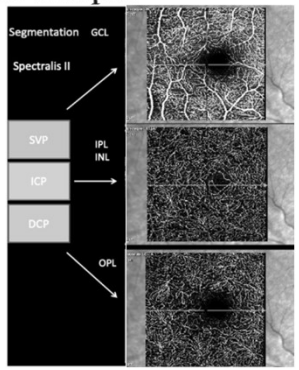


Source: Hohberger B, Lucio M, Schlick S, Wollborn A, Hosari S, Mardin C. OCT-angiography: Regional reduced macula microcirculation in ocular hypertensive and pre-perimetric glaucoma patients. PLoS One. 2021;16(2):e0246469. Published 2021 Feb 11. doi:10.1371/journal.pone.0246469

OCT-angiography: Regional reduced macula microcirculation in ocular hypertensive and pre-perimetric glaucoma patients

Results: Reduced macula vessel density observed in all three retinal vascular layers in OHT and pre-POAG vs. controls

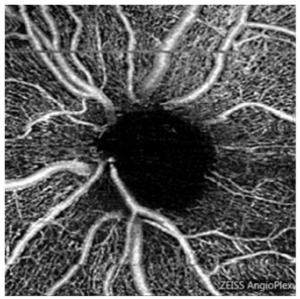
Conclusion: Localized microvascular change is early marker in glaucoma pathogenesis



Source: Hohberger B, Lucio M, Schlick S, Wollborn A, Hosari S, Mardin C. OCT-angiography: Regional reduced macula microcirculation in ocular hypertensive and pre-perimetric glaucoma patients. PLoS One. 2021;16(2):e0246469. Published 2021 Feb 11. doi:10.1371/journal.pone.0246469

Effect of Testing Frequency on the Time to Detect Glaucoma Progression With Optical Coherence Tomography (OCT) and OCT Angiography

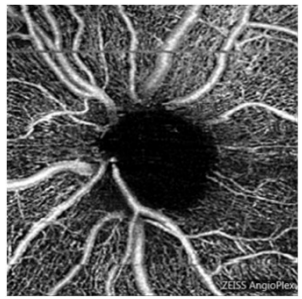
Purpose: Determine how frequency of testing affects the time required to detect statistically significant glaucoma progression for cpRNFL with OCT and cpCD with OCT-A



Source: Mahmoudinezhad G, Moghimi S, Proudfoot JA, et al. Effect of Testing Frequency on the Time to Detect Glaucoma Progression With Optical Coherence Tomography (OCT) and OCT Angiography. Am J Ophthalmol. 2023;245:184-192. doi:10.1016/j.ajo.2022.08.030

Effect of Testing Frequency on the Time to Detect Glaucoma Progression With Optical Coherence Tomography (OCT) and OCT Angiography

Results: cpCD detected progression slightly sooner than cpRNFL. With both tests, two visits per year were found to be sufficient.



Source: Mahmoudinezhad G, Moghimi S, Proudfoot JA, et al. Effect of Testing Frequency on the Time to Detect Glaucoma Progression With Optical Coherence Tomography (OCT) and OCT Angiography. Am J Ophthalmol. 2023;245:184-192. doi:10.1016/j.ajo.2022.08.030

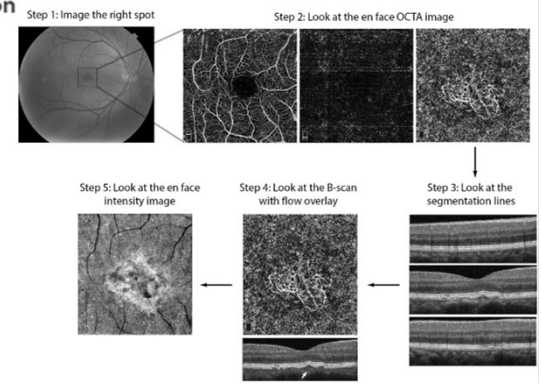
WHAT NEXT?

Increase Comfort Level With In Office Machine

- Understand imaging options
  - AngioMac scans only?
    - Sizes
  - AngioMac and Angio ONH?
    - Sizes
- Determine segmentation
  - 2 vascular plexi vs. 3 vascular plexi
- Identify expected normative findings
  - **Literature search**

Review | Open Access | Published: 13 November 2020

A practical guide to optical coherence tomography angiography interpretation



Source: Greig EC, Duker JS, Waheed NK. A practical guide to optical coherence tomography angiography interpretation. Int J Retina Vitreous. 2020;6(1):55. Published 2020 Nov 13. doi:10.1186/s40942-020-00262-9

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