Clinical Imaging Update: OCT Angiography, Fundus Autofluorescence, and Beyond

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To be discussed:

- OCT Angiography
- Technology in early glaucoma detection
  - OCT Ganglion Cell Analysis
  - 10-2 perimetry
  - OCTA and glaucoma
- Fundus autofluorescence (FAF)
- Ultra-Widefield Imaging

Financial disclosure

ALL REFERENCES TO COMMERCIALLY-AVAILABLE PRODUCTS ARE INTENDED TO BE NONBIASED AND FOR EDUCATIONAL PURPOSES.

THERE ARE NO RELEVANT FINANCIAL OR NON-FINANCIAL RELATIONSHIPS TO DISCLOSE.

OCT Angiography (OCTA): A clinical update

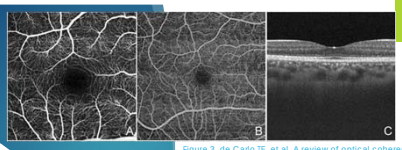
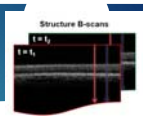


Figure 3. de Carlo TE, et al. A review of optical coherence tomography angiography (OCTA). *Int J Retina Vitreous.* 2015;1(5).

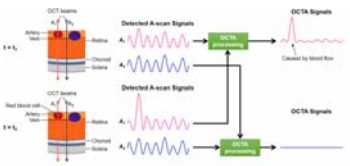
OCT Technology: A timeline

First in vitro 1991 → First in vivo 1993 → TD-OCT 1996 → SD-OCT 2006 → OCTA 2015

How does OCTA work?



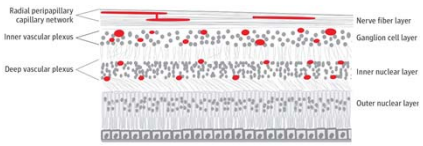
- *Motion Contrast Imaging*
  - Successive B-scans of the same area
    - Retinal tissue remains unchanged
    - Movement (flow) of erythrocytes through the retinal vasculature is detected
  - Many different algorithms exist to compute blood flow and formulate a three-dimensional image
    - Vessel density
    - Flow index



Kashani A, Chen C, Gahm J, et al. Optical coherence tomography angiography: A comprehensive review of current methods and clinical applications. *PROGRESS IN RETINAL AND EYE RESEARCH.* 2017;60:66-100.

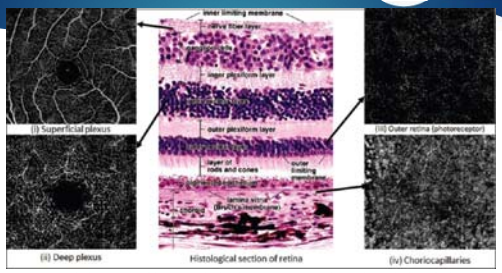
Three distinct retinal vascular layers

- Three capillary networks within the retina:
  - Radial peripapillary capillaries (NFL)
  - Inner/superficial capillary network (GCL)
  - Outer/deep capillary network (INL)



From: Retinal Vascular Layers Imaged by Fluorescein Angiography and Optical Coherence Tomography Angiography. JAMA Ophthalmol. 2015;133(1):45-50.

Vascular layers compared to histological section



From: Chalam KV, Sambhav K. Optical Coherence Tomography Angiography in Retinal Diseases. *Journal of Ophthalmic & Vision Research*. 2016;11(1):84-92.

The various OCTA platforms

- Optovue (AngioVue)
  - SSADA algorithm
- Zeiss (AngioPlex)
  - OMAG algorithm
- Not yet commercially available:
  - Nidek (AngioScan)
  - Heidelberg (Spectralis OCT2)
  - Topcon DRI OCT Triton (Swept Source)

Which system is best?

- DeVitis LA, et al. (2016)
  - **AngioPlex** (Zeiss) vs. **AngioVue** (OptoVue)
  - AngioPlex: shorter execution time, higher percentage of reliable images with fewer motion artifacts
- Munk MR, et al. (2017)
  - Compared four devices: Zeiss Cirrus, OptoVue RTVue, Topcon Triton SS-OCT, and the Heidelberg Spectralis prototype
  - No significant differences in motion artifacts
  - Overall ranking: **Zeiss (90%),** OptoVue (60%), Topcon (40%), Heidelberg (10%)
  - Rankings differed depending on parameter being evaluated
    - Each model has certain strengths

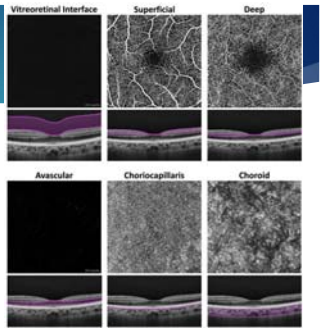
Performing OCTA

- Two scan sizes
  - 3x3 or 6x6 mm
- Angiography Analysis
  - Two en face analyses
    - **AngioPlex**
    - **Structure**
  - Cross-sectional "flow" image (raster scan)

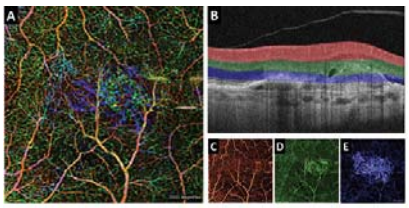
http://retinatoday.com/2017/03/a-role-for-octa-in-daily-retina-practice

En face segmented OCTA

- AngioPlex: 6 predefined angiograms
  - Vitreoretinal interface (VRI)
    - From ILM extending 300µm anteriorly
  - Superficial: NFL, GCL, and IPL
  - Deep: INL, OPL
  - Avascular: Photoreceptors, RPE
  - Choriocapillaris
    - 20µm section posterior to the RPE
  - Choroid
    - 50µm segment below the choriocapillaris



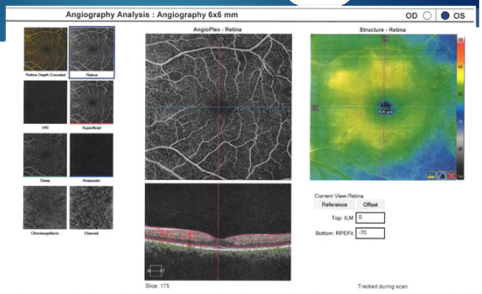
https://www.reviewofoptometry.com/article/imaging-motion-a-review-of-octa



A. Color *en face* OCTA showing a CNVM
B. Cross section with color codes
C. En face of each retinal layer inner retina → outer

Angiography Analysis

- Macula 6x6 mm



En face Analysis

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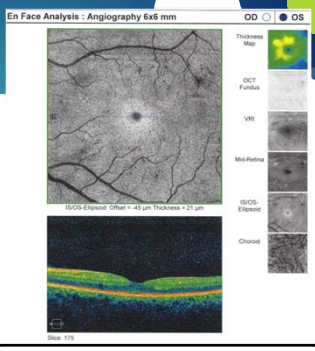
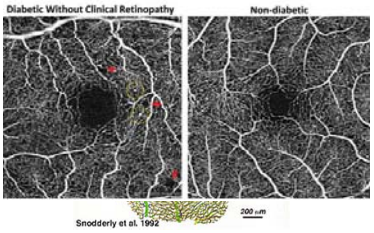


Foveal Avascular Zone (FAZ)

- Denotes the vascular-free fovea
- 400-700 µm in diameter
- Hussain *et al.*
  - 660 µm (Superficial)
  - 914 µm (Deep)
- Previously only visible with fluorescein angiography
- Enlarged in microvascular ischemic disease (ex. diabetes)



OCT Angiography

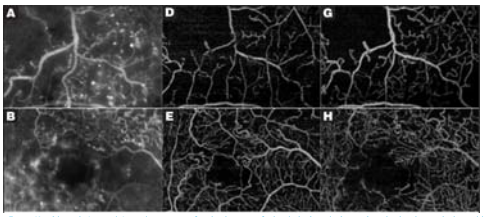
- Pros
  - *Convenience, safety*
  - *High-resolution visualization of vessel architecture, **ischemia***
  - *Isolation of specific layers for precise localization (3-D)*
  - *Ability to monitor ischemia, vessel regression with subsequent scans*
- Cons
  - *Small area analyzed*
  - *Prone to artifacts*
  - *Snapshot in time*

Fluorescein Angiography

- Pros
  - *Blood flow over time (early/late, pooling, leaking)*
  - *Better visualization in cases of very high or low flow (MA's)*
  - *Gold standard*
- Cons
  - *Potential adverse affects*
  - *Poor visualization of 2 of the 3 vascular networks (Spaide 2015)*
    - FA mainly shows the inner capillary network
    - Little to no visualization of the radial peripapillary network, deep capillary network

FA vs OCTA

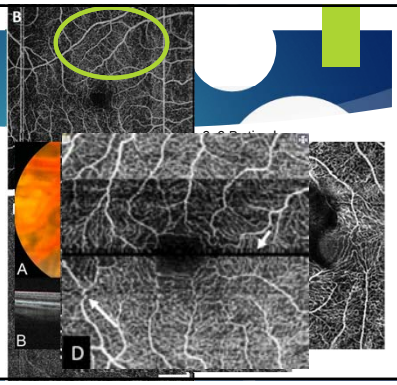
- MA's → FA
- Capillary detail, nonperfusion → OCTA



From: Kuehlewein L, et al. Imaging areas of retinal nonperfusion in ischemic branch retinal vein occlusion with swept-source OCT microangiography. Ophthalmic Surgery, Lasers and Imaging Retina. 2015;46(2):249-252

Artifacts

- Image artifacts
  - Media opacities
- Projection Artifacts
  - Vessels from above
- Motion artifacts
  - White lines
- Blink artifacts
  - Black lines



Clinical utilization of OCTA

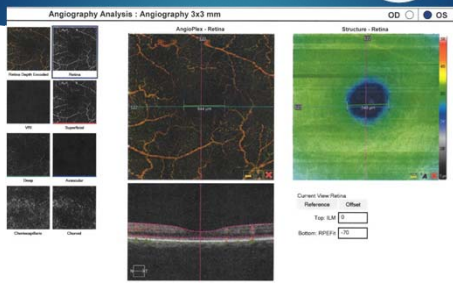
SPECIFIC OCULAR DISEASES AND CONDITIONS

CASE EXAMPLES

Diabetic evaluation & monitoring

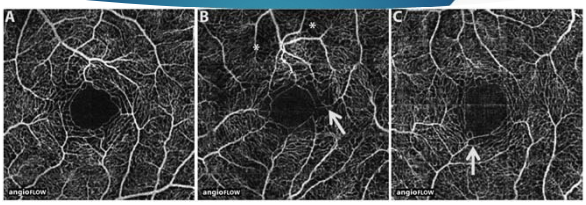
- Vascular changes may be visualized earlier than on fundus exam
- High-resolution analysis of diabetic microangiopathy
  - Capillary nonperfusion, IRMA, neovascularization
- Monitoring of disease
  - Increased FAZ
  - Macular capillary perfusion density

FAZ measurement



FAZ enlargement and vascular remodeling in a diabetic patient

From: de Carlo TE, Chin AT, Bonini Filho MA, et al. Detection of microvascular changes in eyes of patients with diabetes but not clinical diabetic retinopathy using optical coherence tomography angiography. *Retina*. 2015;35:2364-2370.



Healthy FAZ

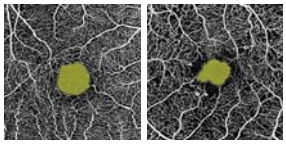
Diabetic eye with capillary nonperfusion (arrow, asterisks)

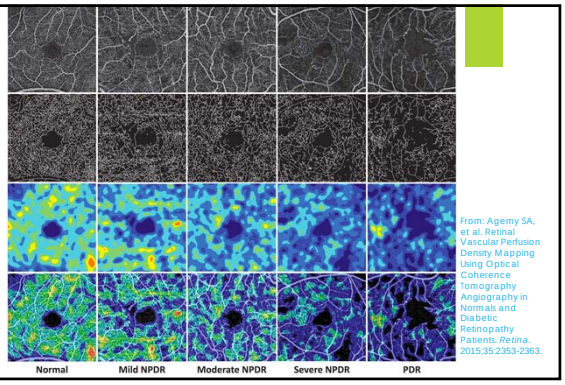
Diabetic eye with enlarged FAZ, vascular remodeling (arrow)

Quantifying microvascular change

- **AngioPlex Metrix™**
- **Identify** patients progressing in disease.
  Evaluate central microvascular perfusion changes.
  Assess changes over time.
  Visualize changes in FAZ size and geometry.

https://www.zeiss.com





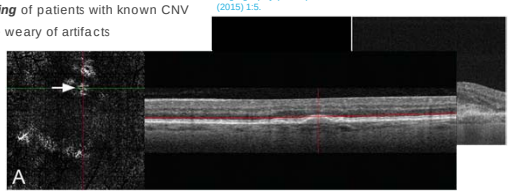
From: Agemy SA, et al. Retinal Vascular Perfusion Density Mapping Using Optical Coherence Tomography Angiography in Normals and Diabetic Retinopathy Patients. *Retina*. 2015;35:2353-2363.

Age-Related Macular Degeneration

- ***Detection*** of CNV
- ***Differentiation*** of drusenoid PED vs. CNV
- ***Monitoring*** of patients with known CNV
- Must be weary of artifacts

From: de Carlo *et al.* A review of optical coherence tomography angiography (OCTA). International Journal of Retina and Vitreous (2015) 1:5.

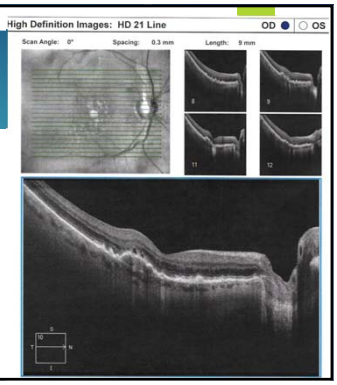
From:: Spaide RF, Fujimoto JG, Waheed NK. Image Artifacts in Optical Coherence Angiography. *Retina (Philadelphia, Pa)*. 2015;35(11):2163-2180.

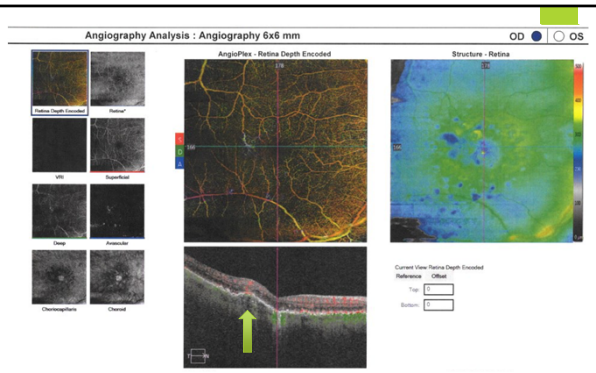


Vascular Flow Analysis

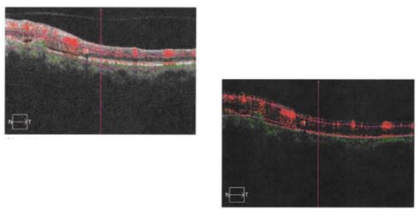
- Case example:
- 84-yr-old white male
- Dry AMD x 14 years
- Soft, coalesced drusen
- RPE pigment clumping, dropout
- BCVA 20/60- OD, 20/40- OS

- OCT HD 21 Line raster
- Confluent drusen, cystic changes
  - Dry retinal disruption or RAP lesion?





Vascular Flow Analysis



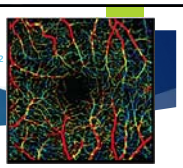
Billing & Coding for OCTA

- Currently, no billing code separate from general OCT imaging exists.
- **CPT 92134**: Scanning computerized ophthalmic diagnostic imaging, posterior segment, with interpretation and report, unilateral or bilateral; retina.
- Medicare reimbursement is the same as other OCT scans.
- Much lower reimbursement than dye-based angiography.
- But upgrade to OCTA software costs $$$$
  - And interpretation takes time!

Future applications of OCTA

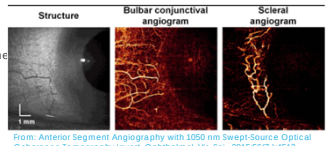
Looking ahead…

From: Arya M, Waheed NK. Upcoming Advances in Optical Coherence Tomography Angiography. *Retinal Physician*, Volume: 15, Issue: Jan/Feb 2018, page(s): 40, 42



VISTA algorithm of SS-OCT prototype shows relative flow speeds on color-coded map.

- Introduction of commercially-available swept source OCTA
  - Higher quality images, faster image acquisition
  - Swept-Source technology will likely replace SD-OCT (eventually)
- Increased development of OCTA analysis software
- Anterior segment imaging prototypes
- Many potential future implications
  - Identification of pre-clinical Alzheime



From: Anterior Segment Angiography with 1050 nm Swept-Source Optical Coherence Tomography Invest. Ophthalmol. Vis. Sci.. 2015;56(7):4512.

OCTA in summary

- OCTA, while not a replacement for FA, adds high-resolution, three-dimensional information to the clinical picture.
- OCTA allows for early detection of microvascular damage in diabetes, with increased FAZ observed in diabetics regardless of the presence of clinical retinopathy.
- Flow index, vessel density: new parameters for glaucoma dx
- Artifacts continue to pose a challenge in accurate interpretation.
- There is still a long way to go in terms of system congruity, normative database accumulation, and understanding of what it all means in the context of ocular disease.
  - But the outlook is promising!