HOW OCT FOREVER CHANGED RETINA

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Financial Disclosures

Honoraria
- Review of Optometry
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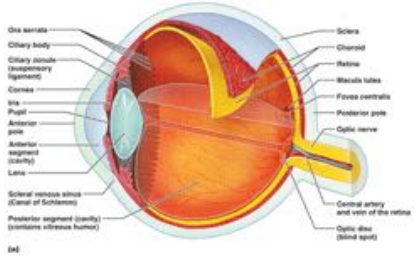


FINANCIAL DISCLOSURES

- Proprietary Interests
  - None
- Stockholder: Zeavision
- CE Companies
  - CEinItaly.com Europe
  - EyeSkiUtah.com Park City
  - AllThingsOCT.com Multiple locations and online

DISCLAIMER #1

This is a clinical course focusing on the technology and its use in patient care. While I may briefly discuss some practice management aspects, this is not a billing and coding seminar. Many other meetings provide education in those areas.

DISCLAIMER #2

You will view many scans obtained with several OCT instruments made by multiple manufacturers. Neither I nor ATOCT endorse any one OCT company, brand or model.

Q & A WINE MOMENT

- allthingsoct@gmail.com

"Drinking good wine with good food in good company is one of life's most civilized pleasures."

Michael Broadbent

FOR COLOR PPT NOTES…

Available at

- https://tinyurl.com/JJPVEE

Problems downloading? Send an email request for the handouts to allthingsoct@gmail.com.

COURSE GOAL

- To provide clinically relevant information about OCT in retinal and macular disease.
  - Case examples
  - Interpretation and clinical use

STATEMENT OF THE PROBLEM

Diseases of the posterior segment are among the leading causes of vision loss worldwide.

The new frontier:

Optometrists have now begun to fully embrace vitreoretinal care.

"Most major advances in the understanding of retinal diseases have been preceded by advances in imaging."

Richard Spaide, MD
NY Retina Consultants

Invasive

- Fluorescein angiography (FA)
- Indocyanine green angiography (ICGA)

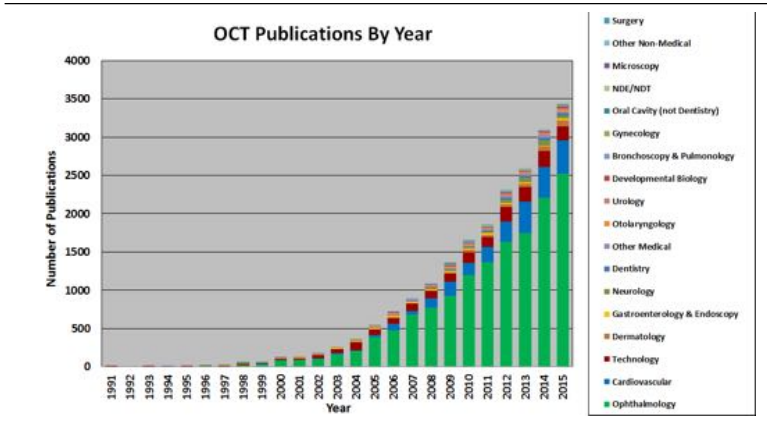
Non-invasive

- Optical coherence tomography (OCT)
- A/B scan ultrasonography
- Fundus photography
- Wide field and UWF imaging
- Fundus autofluorescence (FAF)
- Multi-color (multichannel) imaging

Milestones in Retinal Imaging

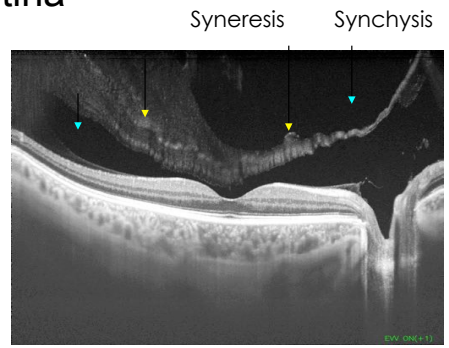
Fundus Photography	1920s
Fluorescein Angiography	1950s
A/B-Scan Ultrasound	1970s
ICG Angiography (Digital)	1980s
CSLO (HRT), SLP (GDX)	1990s
OCT first demonstrated	1991
Time Domain (TD-OCT)	2001
Fourier (Spectral) Domain (SD-OCT)	2006
OCT Angiography (OCTA)	2015
Swept-Source (SS-OCT)	2016

30 Years of OCT



Posterior Segment Applications

- Vitreous/Vitreoretinal Interface
- Neurosensory Retina
- RPE/Bruch's
- Choriocapillaris
- Deeper Choroid
- Optic Nerve
  - RNFL
  - GCL/GCC



WHAT IS OCT?

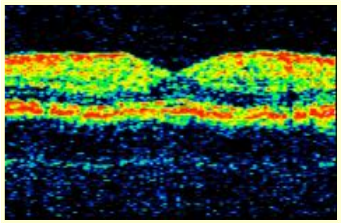
Massachusetts Institute of Technology

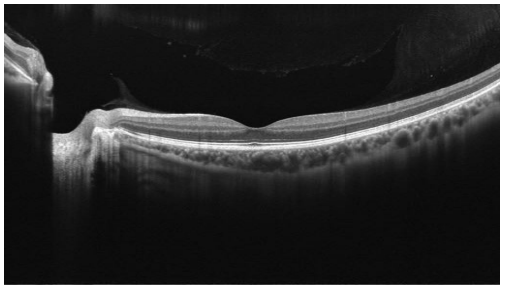
Milestones in OCT Imaging

- OCT was first demonstrated in 1991.
  - Huang D, Swanson EA, Lin CP, Schuman JS, Stinson WG, Chang W, Hee MR, Flotte T, Gregory K, Puliafito CA, Fujimoto JG. Optical coherence tomography. Science. 1991;254:1178–1181.
- The first *in vivo* tomograms of the human optic disc and macula were demonstrated in 1993.
  - Swanson EA, Izatt JA, Hee MR, Huang D, Lin CP, Schuman JS, Puliafito CA, Fujimoto JG. *In vivo*retinal imaging by optical coherence tomography. Opt Lett. 1993;18:1864–1866.
- Original research instrument performed 400 A-scans/second.
- Current OCT instruments have imaging speeds upwards of 100,000 A-scans/second!

29 years of OCT

Then and.....Now





OCT IS…

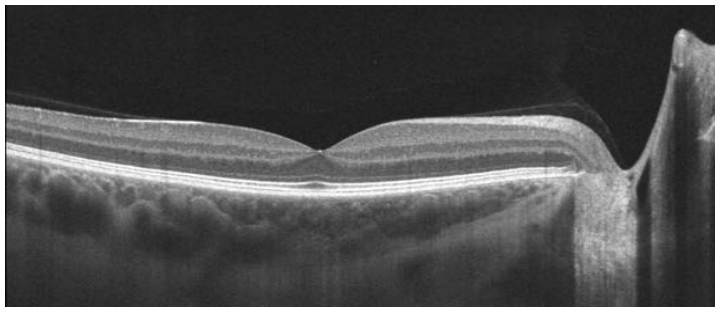
An optical imaging modality that performs high-resolution, cross-sectional (A-scan) tomographic imaging of the internal microstructure in materials and biologic systems by measuring back-scattered or back-reflected light. OCT images are two-dimensional data sets (B-scans) which represent the optical backscattering in a cross-sectional plane through the tissue.

-Dr. James Fujimoto (2000)

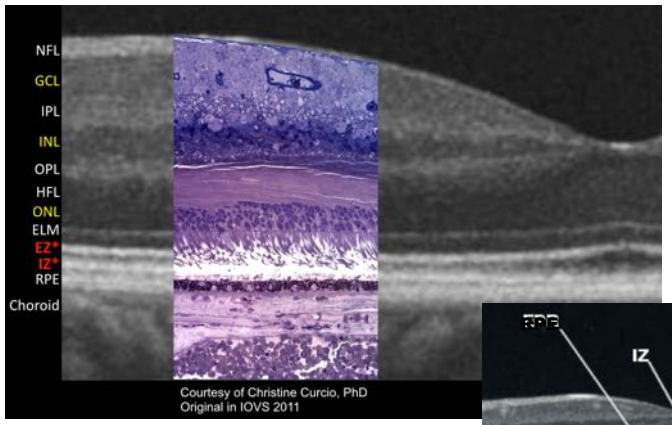
THE B-SCAN

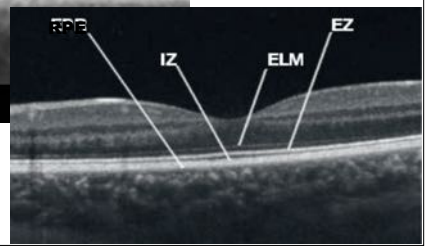
Two-dimensional, cross-sectional single cut.

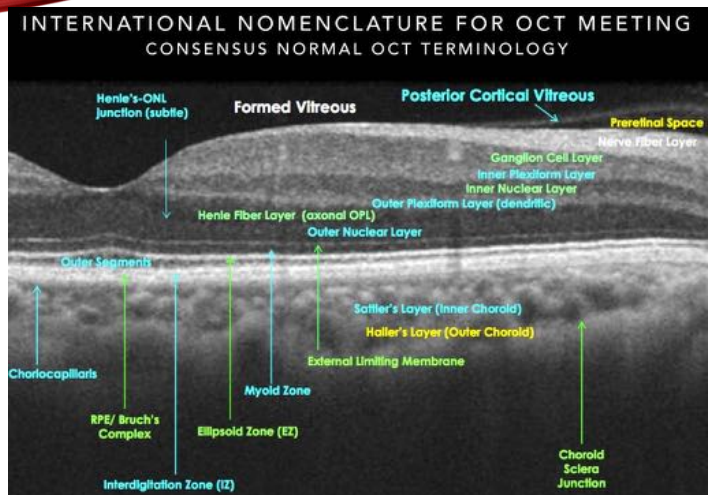
Used for qualitative and quantitative analysis.



RETINAL ANATOMIC CORRELATES

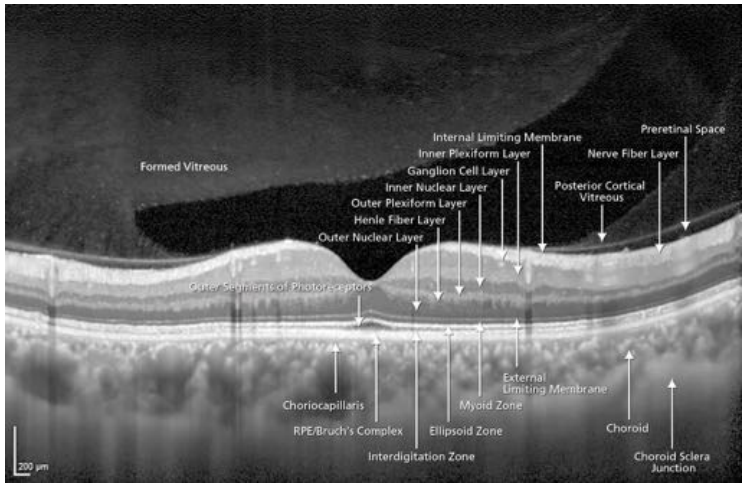






1. Staurenghi G, Sadda S, Chakravarthy U, Spaide RF, International Nomenclature for Optical Coherence Tomography (IN*OCT) Panel, Proposed lexicon for anatomic landmarks in normal posterior segment spectral-domain optical coherence tomography: The IN*OCT consensus, Ophthalmology, 2014;121:1572–8.

Anatomic Correlates



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WHAT IS OCT?

OPTICAL

OCT is an imaging technology that is based on principles of physics, specifically optics.

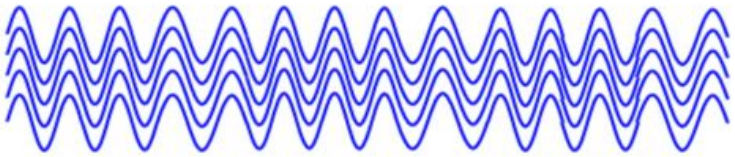
WHAT IS OCT?

COHERENCE

Coherent light is used in OCT imaging.

COHERENT LIGHT

- Light in which the photons are all in step.
  - The change of phase within the beam occurs for all the photons at the same time.
  - There are no abrupt phase changes within the beam.
  - Light produced by lasers is both coherent and monochromatic (of one color).



WHAT IS OCT?

TOMOGRAPHY

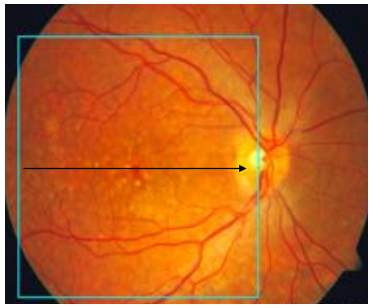
A technique used for displaying a representation of a cross section through a human body or a tissue.

Color Photo of Multiple Drusen/RPEDs
Simultaneous SD-OCT confirms confluent pattern
EZ band absent, c/w VA

69 yo WF

VA = 20/50

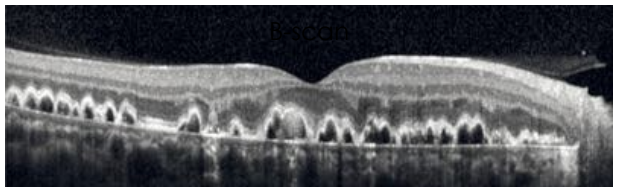
Intermediate Dry AMD



Plan:

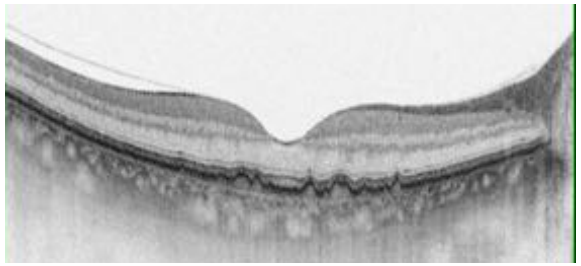
AREDS-2

RTC 3 mon



B-scan

Foveal Drusen on B-scan "Negative"
VA = 20/20. Note normal foveal contour, intact EZ band



The B-scan represents a single "slice" through a specific anatomic location.

WHAT IS OCT?

Optical coherence tomography is a technology that uses coherent light to produce cross-sectional images.

-Pizzimenti (2018)

VOLUMETRIC SCAN

AKA 3D scan or Cube scan.

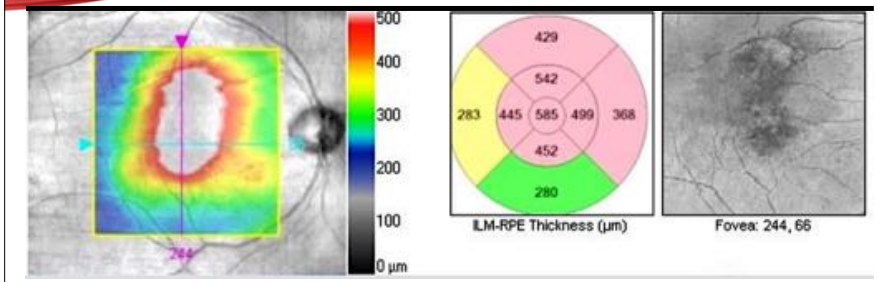
Consists of a number of line scans (B-scans) composing a rectangular data box.

Generates a 3D view of the image, which enables advanced visualization and complex analysis, for example:

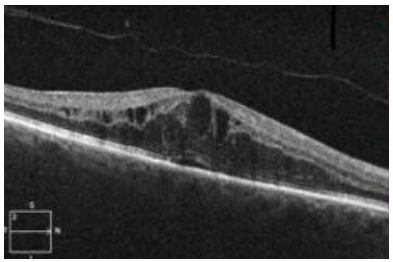
- C-scan (en face) OCT images
- Thickness maps and 3-D renderings
- Segmentation of layers
  - RNFL, Ganglion cell analysis

OCT has forever changed the classification and management of DR, and especially DME.

VOLUMETRIC "CUBE" SCAN

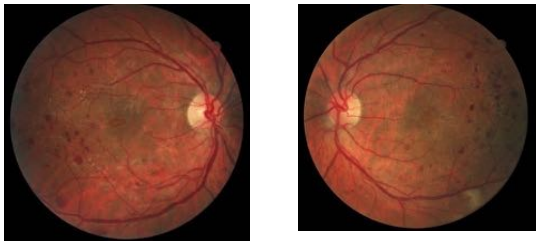


Center-involved DME: note central sub-field thickness on 9-zone ETDRS grid.



Temporal-to-nasal B-scan through foveal center shows Cystoid DME.

Diabetic Retinopathy--ME may occur at ANY stage!

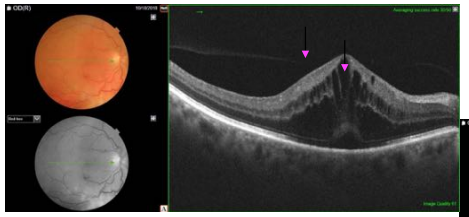


CYSTIC DME AND ANTI-VEGF TREATMENT

Large, cystoid spaces in inner retina at baseline appears to be more frequent in non responders to treatment.

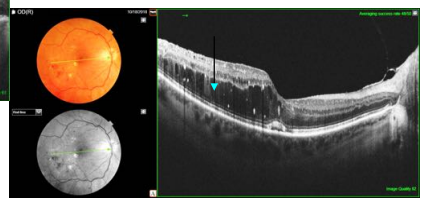
This may be a predictor of worse response to anti-VEGF treatment, while diffuse macular edema without cystoid spaces appears to be associated with good response to treatment.

Investigative Ophthalmology & Visual Science March 2012, Vol.53, 411.



cystoid spaces

diffuse ME

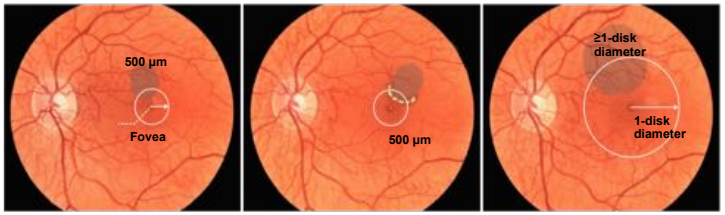


Clinically Significant Diabetic Macular Edema

Retinal thickening within 500 µm

Hard exudates within 500 µm of the center of the macula if associated with thickening of the adjacent retina

Retinal thickening of >1-disk area in size, any part of which is located within 1-disk diameter of the center of the macula



CSME = clinically significant macular edema.
ETDRS Research Group. *Arch Ophthalmol.* 1985;103:1796-1806; Bandello F, et al. *Eye (Lond).* 2012;26:485-493.

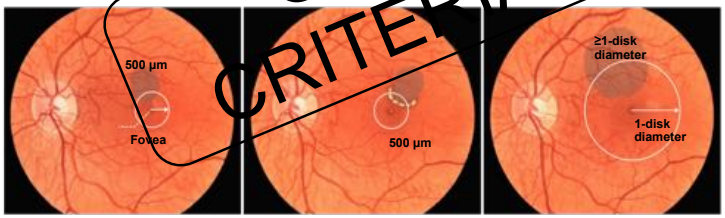
Clinically Significant Diabetic Macular Edema

OLD CRITERIA

Retinal thickening within 500 µm

Hard exudates within 500 µm of the center of the macula if associated with thickening of the adjacent retina

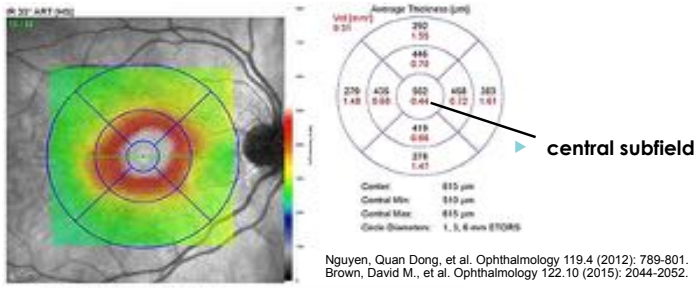
Retinal thickening of >1-disk area in size, any part of which is located within 1-disk diameter of the center of the macula



CSME = clinically significant macular edema.
ETDRS Research Group. *Arch Ophthalmol.* 1985;103:1796-1806; Bandello F, et al. *Eye (Lond).* 2012;26:485-493.

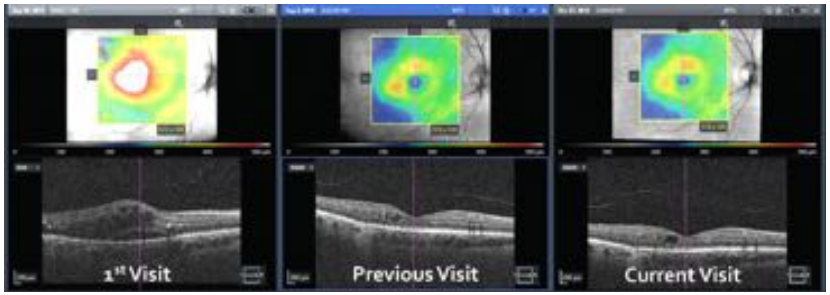
DME Classification & Management: Center Involved or Not?

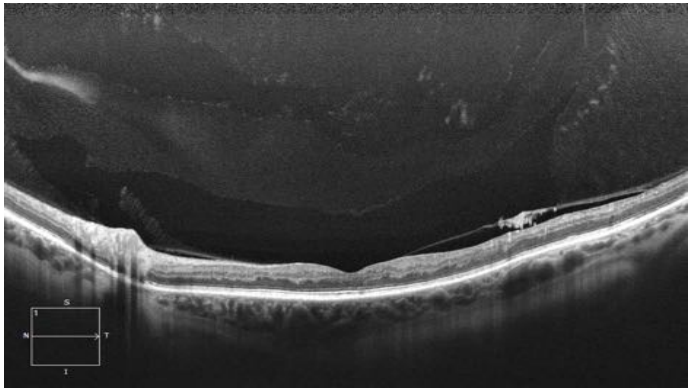
- Randomized clinical trials of anti-VEGF agents used the presence of DME in **OCT central subfield.**
- Older ETDRS definition of "clinically significant macular edema" modified in era of OCT.



Nguyen, Quan Dong, et al. Ophthalmology 119.4 (2012): 789-801.
Brown, David M., et al. Ophthalmology 122.10 (2015): 2044-2052.

IS THE TREATMENT WORKING?

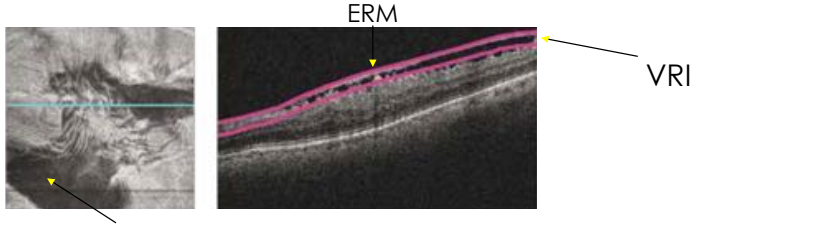




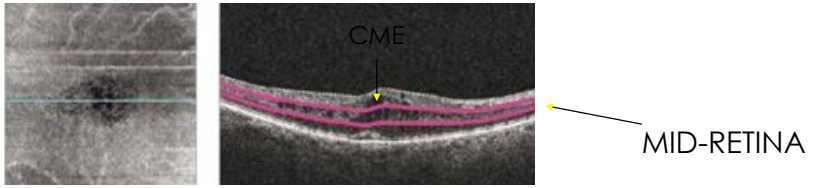
NVE

12 mm
HD 1 Line Raster
(100x Averaged)

THE CORONAL SCAN
C-SCAN: EN FACE SLICES



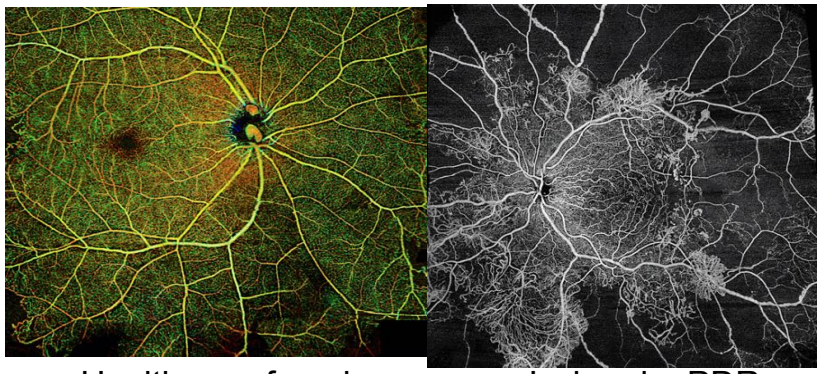
Dark areas on C-scan (L) indicate non-adherence of ERM.



6 wks post-op CME. On C-scan, note petaloid appearance.

C-SCAN ENABLES OCTA

2015-2020 En face OCT angiograms



Healthy, perfused Ischemia, PDR

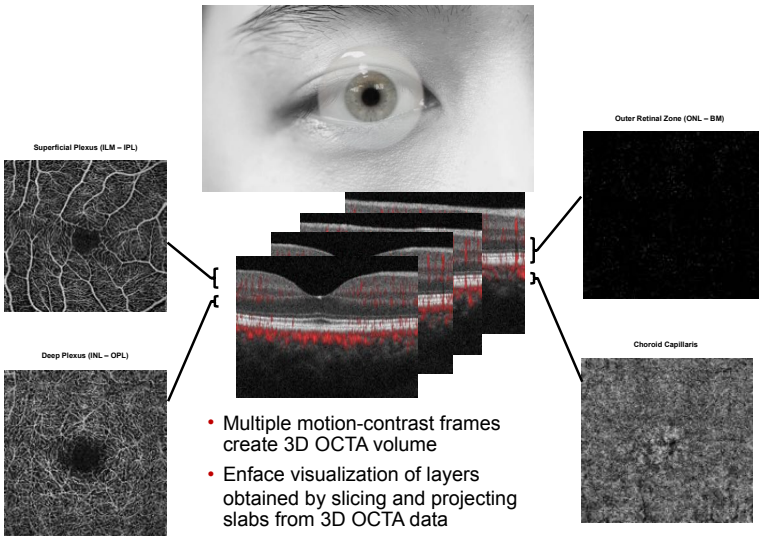
WHAT IS OCT-ANGIOGRAPHY?

OCTA is an extension of OCT that provides 3D angiograms of retinal and choroidal blood vessels, as well as ON vasculature.

Unlike IV Angio, OCTA is noninvasive and allows for rapid image acquisition.

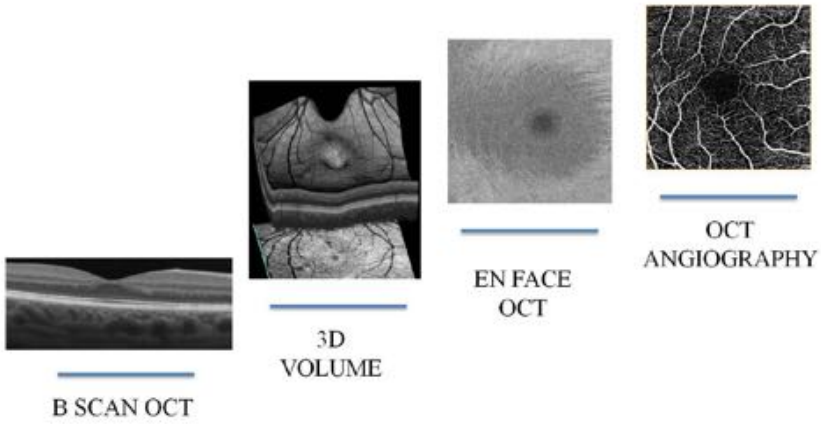
The clinician can assess blood flow layer by layer, allowing a separated evaluation of the retinal and choroidal plexuses, which cannot be separately visualized by other techniques.

How is an OCT Angiogram Acquired?

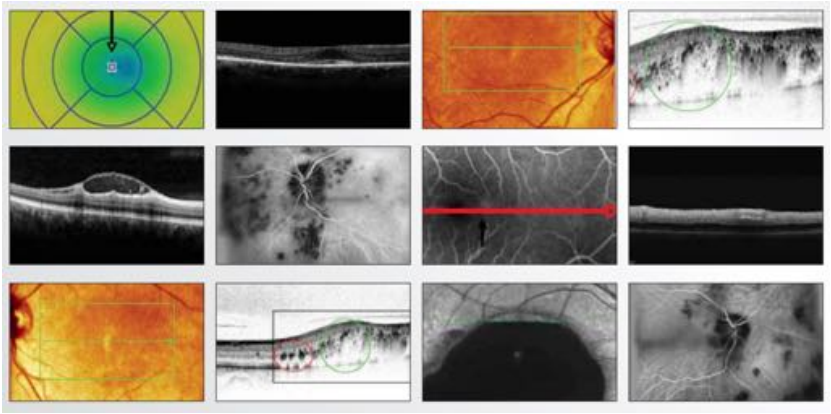


- Multiple motion-contrast frames create 3D OCTA volume
- Enface visualization of layers obtained by slicing and projecting slabs from 3D OCTA data

OCT AND OCTA



Multimodal Imaging



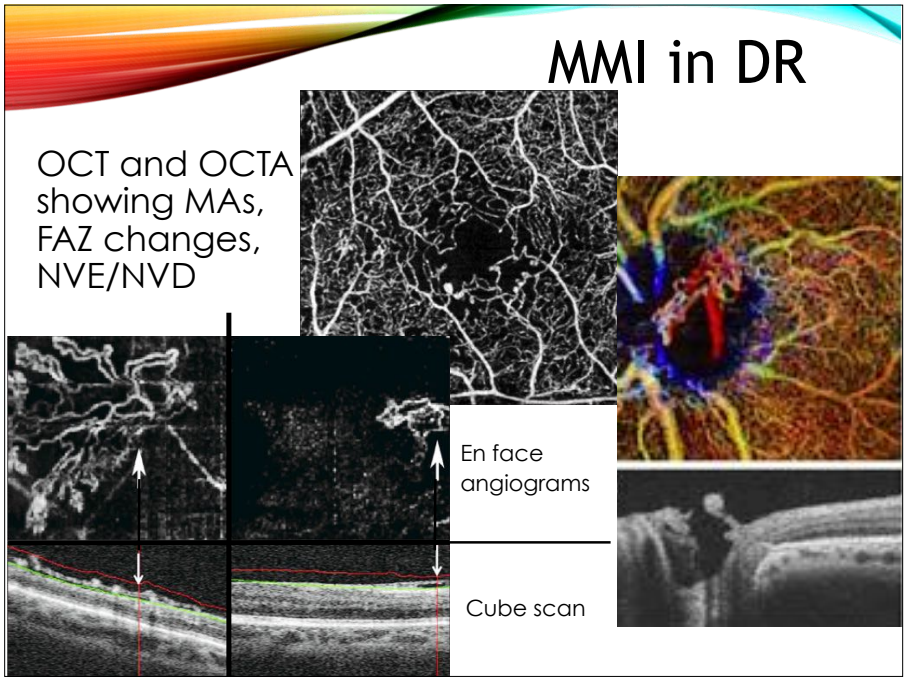
What is multimodal imaging (MMI)?

- The use of multiple technological systems to acquire images.
- May also include hybrid devices that simultaneously perform 2 or more imaging modalities.
- Images acquired by MMI complement one another clinically.

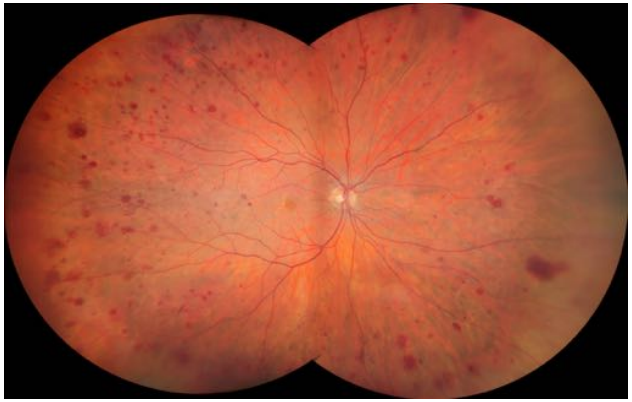
MMI

- Common modalities include:
  - Color/multicolor fundus imaging
  - Near-infrared reflectance (NIR)
  - Fundus autofluorescence (FAF)
  - OCT
  - Echography (A-scan and B-mode)

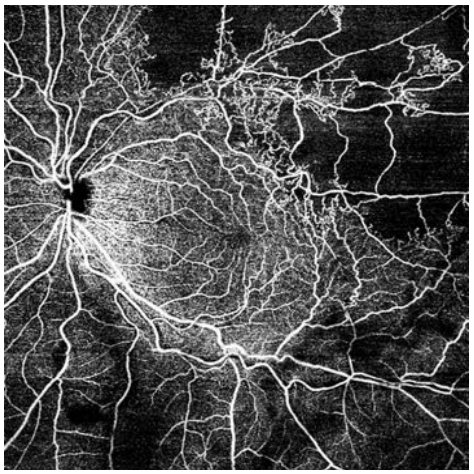
MMI in DR



DR is NOT exclusive to the central retina.



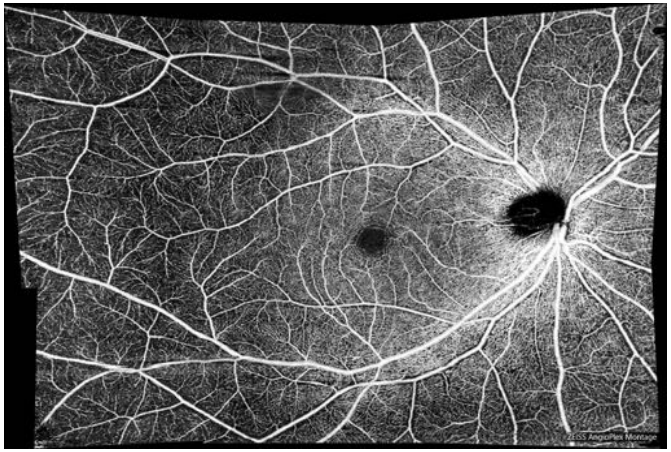
Beyond the Posterior Pole



OCT Angiography (OCTA)

Vitreoretinal Interface (VRI)

Montage feature extends the reach of OCTA.



Q & A WINE MOMENT

- allthingsoct@gmail.com

76 Y/O WM

CC: Worsening central vision OS x 4 wks

Oc Hx: POAG OU

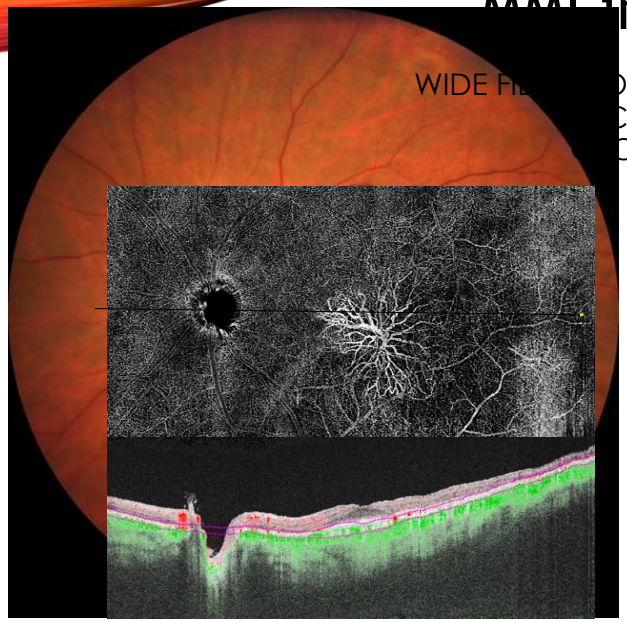
- S/p SLT OS x 6 mon, SLT OD x 9 mon
- Intermed Dry AMD OU
- Taking ARED2 Plus supplements

VA:

- OD 20/30 PHNI
- OS 20/40 PHNI, down from 20/25 four mon prior

IOP: 14 OD/13 OS

MMI in AMD

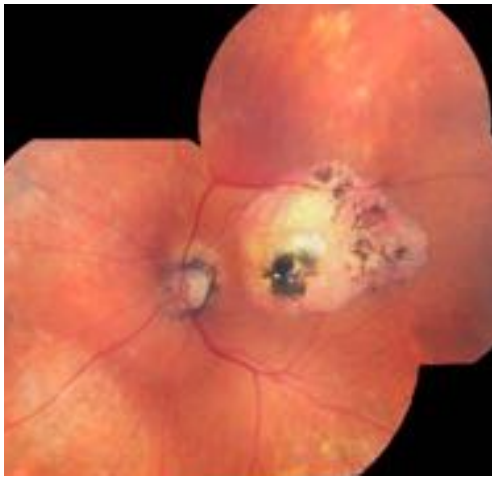


WIDE FI… …LOR FUNDUS
…T AND OCTA
…C + WET AMD

MMI in CNV

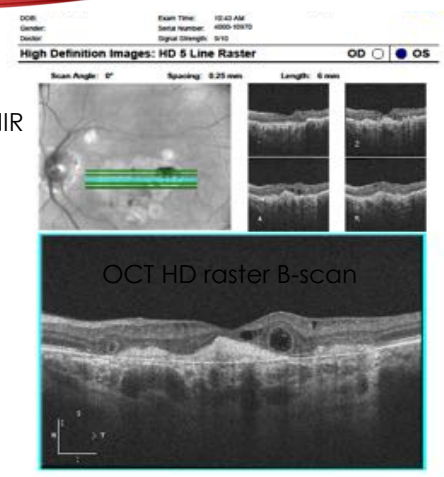
Causes of CNV

- AMD
- Angioid streaks
- OHS
- High Myopia
- Choroidal rupture
- CSC



MMI in CNV

NIR



OUTER RETINAL TUBULATION IN CNV (OHS)

ORT is a feature of photoreceptor rearrangement after outer retinal insult (CNV scar).

Multimodal imaging with NIR and SD-OCT.

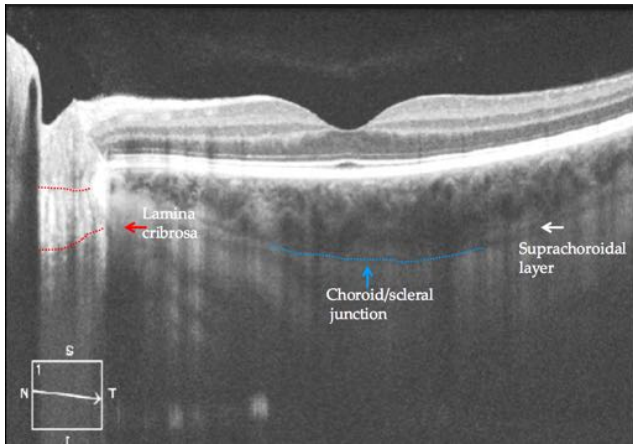
Image credit: Brad Sutton, OD

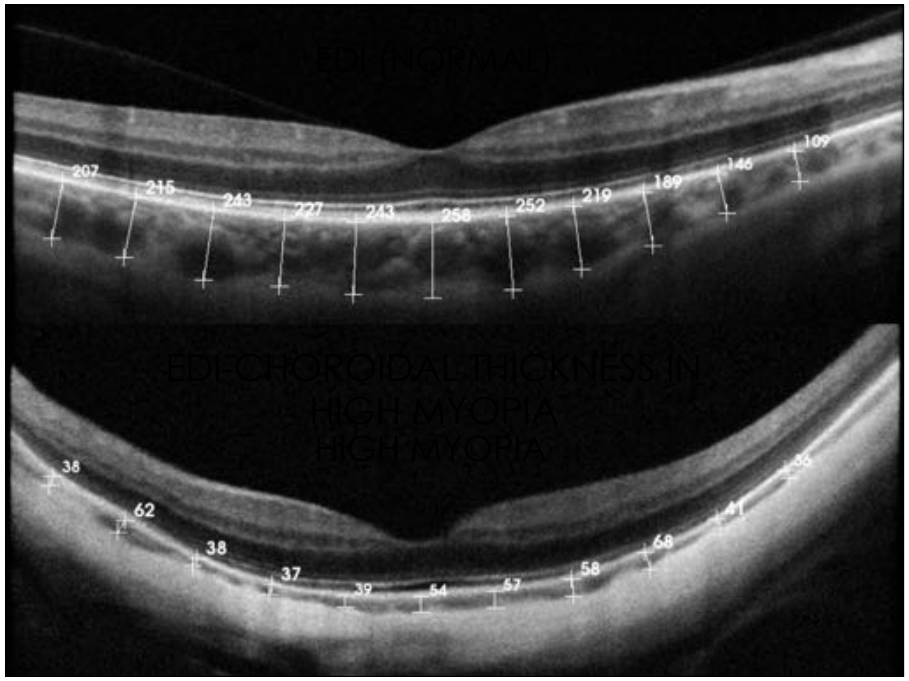
WHAT IS ENHANCED DEPTH OCT IMAGING?

EDI-OCT

Enhanced-depth imaging (EDI) OCT modifies the standard technique of image acquisition to better reveal the structural details of the choroid.

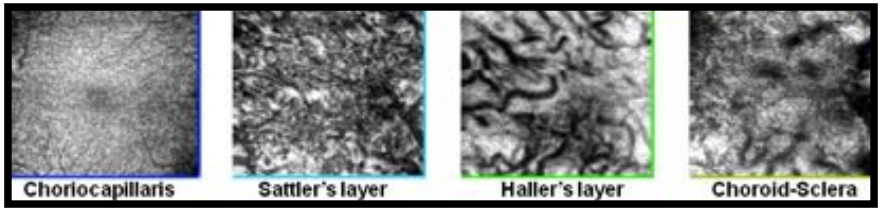
EDI SHOWS DEEPER INTRAORBITAL ON, LAMINA, C/S JXN





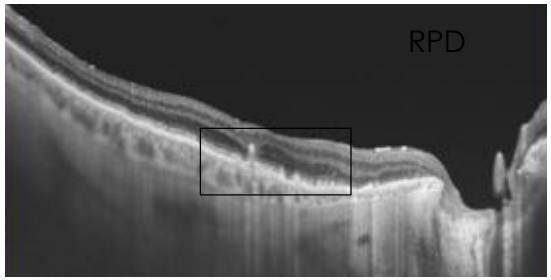
Posterior Segment Applications

- Vitreous/Vitreoretinal Interface
- Neurosensory retina, RPE
- Choroid
- Optic Nerve/NFLA



AMD, HD Raster Scan w/EDI

Suspect Reticular Pseudodrusen

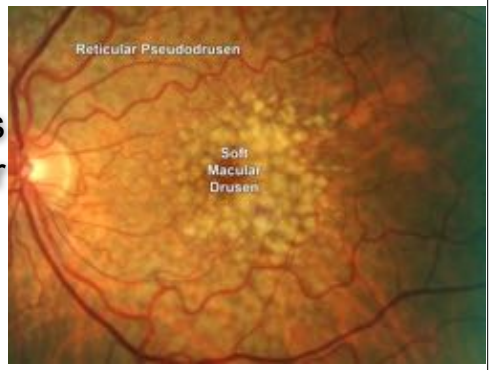


Unfavorable prognostic signs leading to CNVM, GA

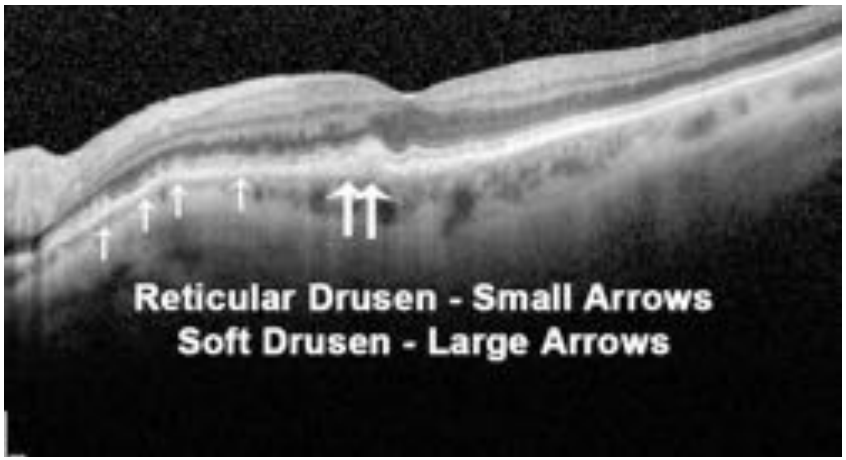
- Soft, large, confluent drusen
- Reticular (pseudo) drusen*
- Focal hyperpigmentation
- Disciform lesion in the fellow eye
- Older age
- Poor dark adaptation*

Reticular (Pseudo)drusen (RPD)

- Seen as a reticular pattern of small yellow-white lesions often in the superior macula, RPD are a high-risk sign for advanced AMD.

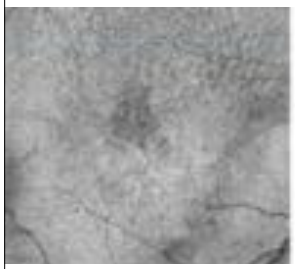


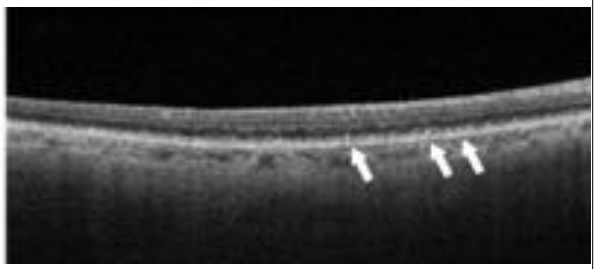
Reticular (Pseudo)drusen



Reticular (Pseudo)drusen

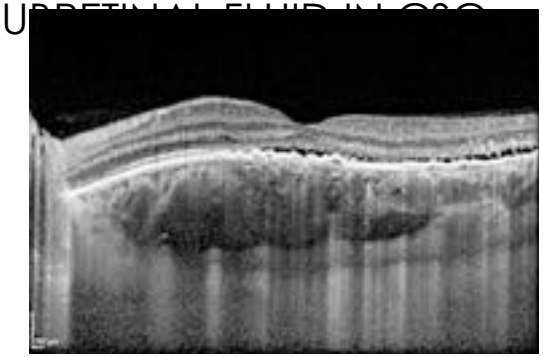
- Presence of RPD is a consistent risk factor for progression to both atrophy and CNV
- IS/OS C-scan B-scan





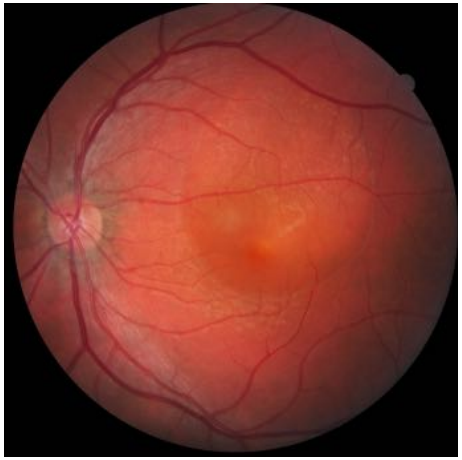
IMAGING THE CHOROID

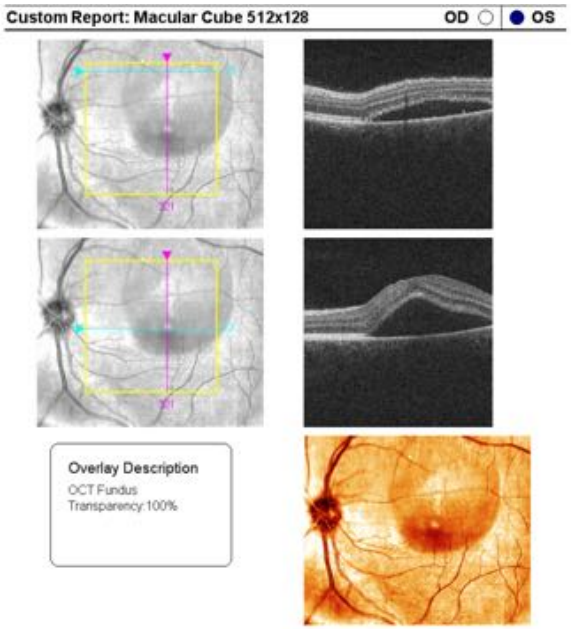
PACHYCHOROID
AND SU



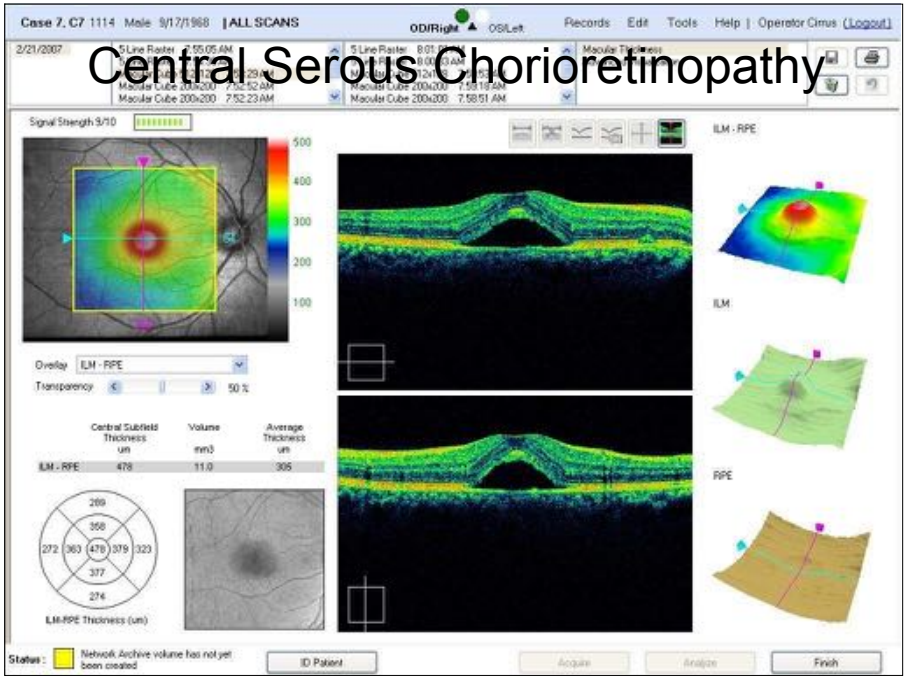
Central Serous Chorioretinopathy

- 36 y/o WM
- CC: Sudden central blur OS
- VA OD 20/20
- VA OS 20/200

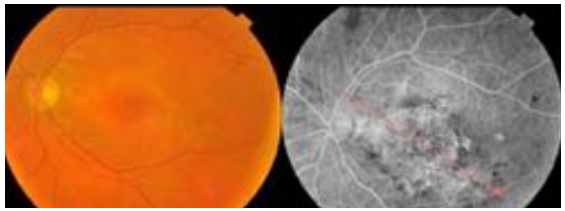


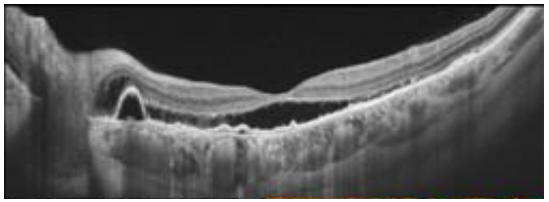


Central Serous Chorioretinopathy



PACHYCHOROID
CNV IN CSC
EDI-OCT AND IVFA





Q & A WINE MOMENT

- pizzimen@uiwtx.edu

OCT has forever changed screening protocols for drug toxicity.

HYDROXYCHLOROQUINE
HCQ: TRADE NAME, PLAQUENIL

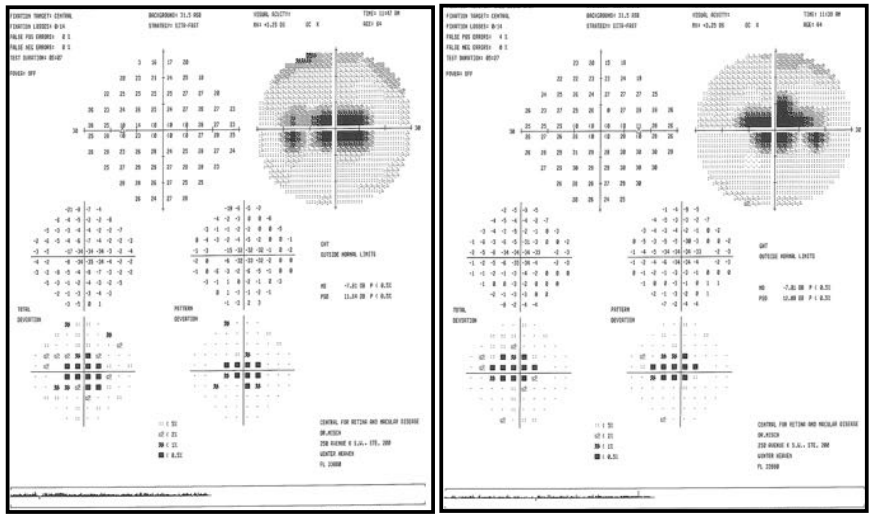
CHLOROQUINE
CQ: TRADE NAME, ARALEN

HCQ TOXICITY

Perform DFE annually.

What additional testing/ work-up is appropriate?

Patient Case: VY 65 y/o Asian Female
Central Threshold Perimetry: Why 30-2?



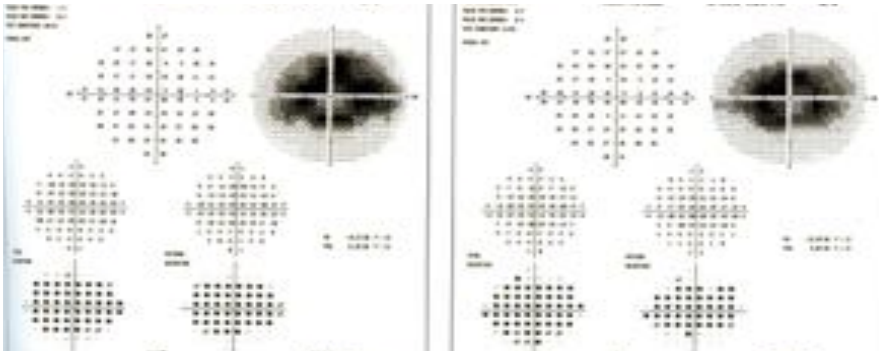
AMERICAN ACADEMY OF OPHTHALMOLOGY
The Eye M.D. Association

Pericentral Retinopathy and Racial Differences in Hydroxychloroquine Toxicity

Ronald B. Melles, MD,[1] Michael F. Marmor, MD[2]

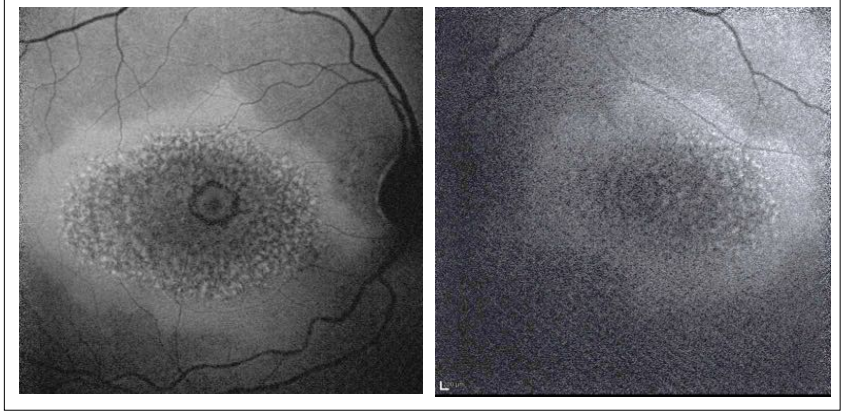
Melles RB, Marmor MF. Pericentral retinopathy and racial differences in hydroxychloroquine toxicity. Ophthalmology 2015; 122: 110–116.

Patient Case: VY
Central 10-2 VF



Fundus Auto-fluorescence (FAF): Case VY

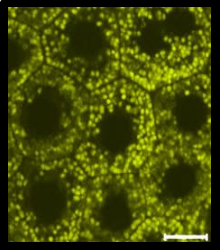
OD OS



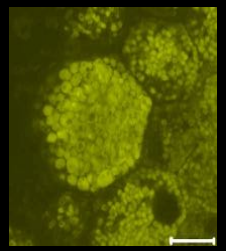
Imaging Technologies: FAF

What is autofluorescence in the retina?

- It is the fluorescence of the lipofuscin molecule within the RPE cell layer that fluoresces with a certain wavelength.



19 years



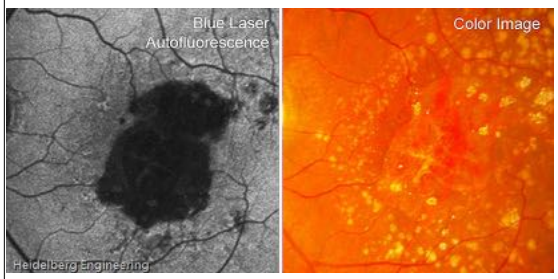
64 years

MULTIMODAL IMAGING:

FUNDUS AUTOFLUORESCENCE

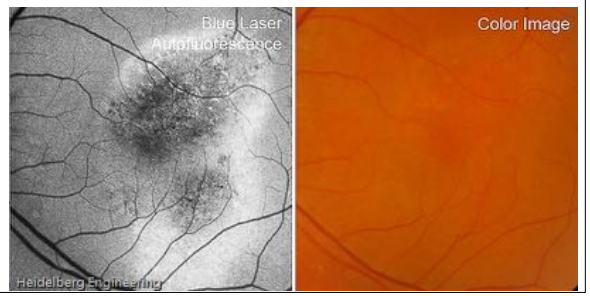
While OCT assesses structure, and IVFA assesses BRB integrity, FAF captures **metabolic activity.**

Additional Clinical Value of FAF

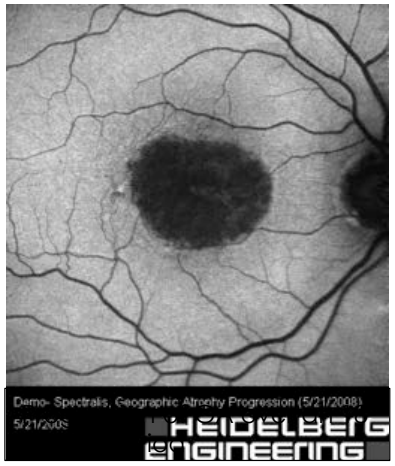


Advanced atrophic AMD

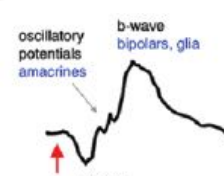
CSC

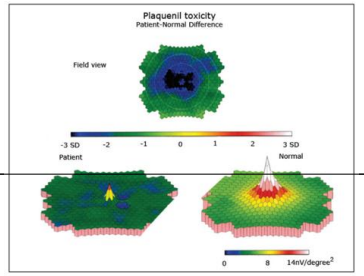


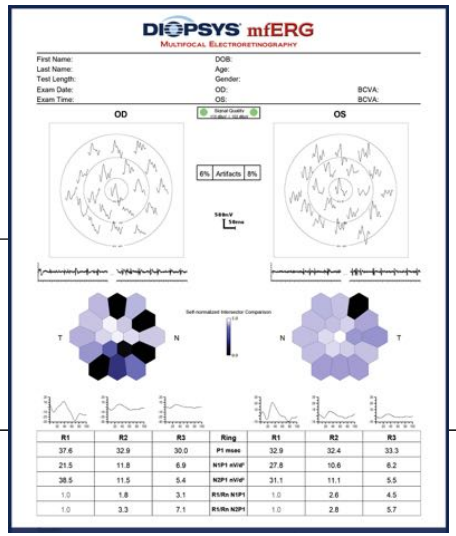
FAF and Progression-Geographic Atrophy



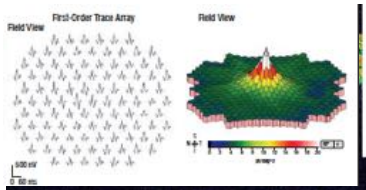
PLAQUENIL AND MF-ERG



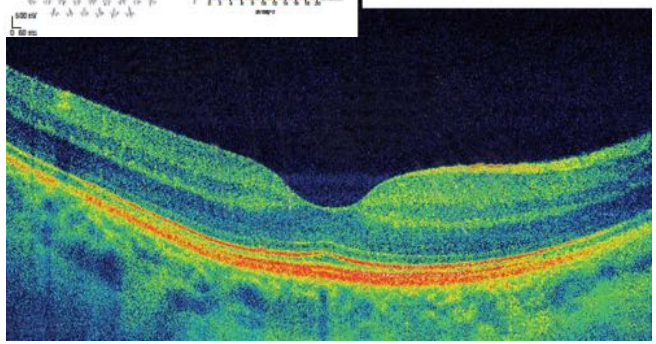




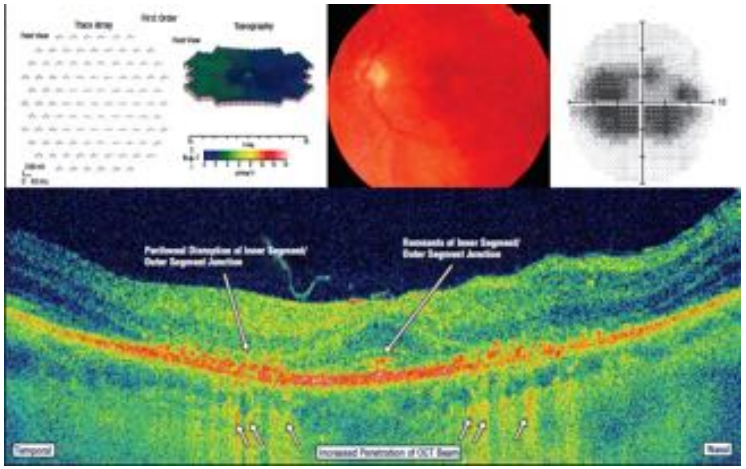
Another Patient on Plaquenil



200 mg/day x 5 yrs
no toxicity

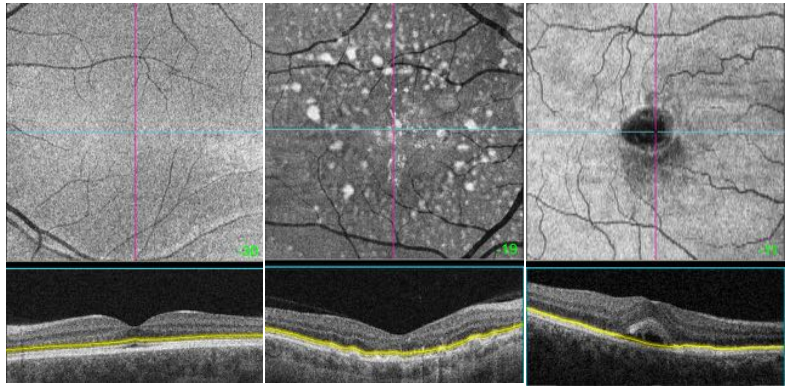


Plaquenil Toxicity- mfERG



Plaquenil Toxicity

- By the time “flying saucer” or “bullseye” is detected, significant toxic damage has occurred.
- May progresses even if drug is stopped.
- Ganglion cell analysis and en face OCT may offer early detection.



What is the recommended maximum HCQ dose ?

Calculate Max Dose in mg/day

2.3 x weight (in lbs.) = Max dose

At recommended dose, risk of toxicity is < 1% after 5 years, < 2% after 10 yrs.

- Risk rises to almost 20% after 20 years. **
  - Our patient VY (~110-120 lbs) was taking 400 mg/d for 20 yrs

Risk for HCQ maculopathy depends on daily dose, duration of use

AMERICAN ACADEMY™ OF OPHTHALMOLOGY

American Academy of Ophthalmology Statement

Recommendations on Screening for Chloroquine and Hydroxychloroquine Retinopathy (2016 Revision)

Michael F. Marmor, MD,[1] Ulrich Kellner, MD,[2] Timothy Y.Y. Lai, MD, FRCOphth,[3] Ronald B. Melles, MD,[4] William F. Mieler, MD,[5] for the American Academy of Ophthalmology

Background: The American Academy of Ophthalmology recommendations on screening for chloroquine (CQ) and hydroxychloroquine (HCQ) retinopathy are revised in light of new information about the prevalence of toxicity, risk factors, fundus distribution, and effectiveness of screening tools.

Pattern of Retinopathy: Although the locus of toxic damage is parafoveal in many eyes, Asian patients often show an extramacular pattern of damage.

Dose: We recommend a maximum daily HCQ use of ≤5.0 mg/kg real weight, which correlates better with risk than ideal weight. There are no similar demographic data for CQ, but dose comparisons in older literature suggest using ≤2.3 mg/kg real weight.

Risk of Toxicity: The risk of toxicity is dependent on daily dose and duration of use. At recommended doses, the risk of toxicity up to 5 years is under 1% and up to 10 years is under 2%, but it rises to almost 20% after 20 years. However, even after 20 years, a patient without toxicity has only a 4% risk of converting in the subsequent year.

HCQ SCREENING FREQUENCY

Baseline: DFE within 1 year of starting HCQ

Visual field and SD-OCT if macular abnormalities are present at baseline

Annual screening: Begin after 5 years of use

Sooner in presence of "major risk factors"

AMERICAN ACADEMY OF OPHTHALMOLOGY

American Academy of Ophthalmology Statement

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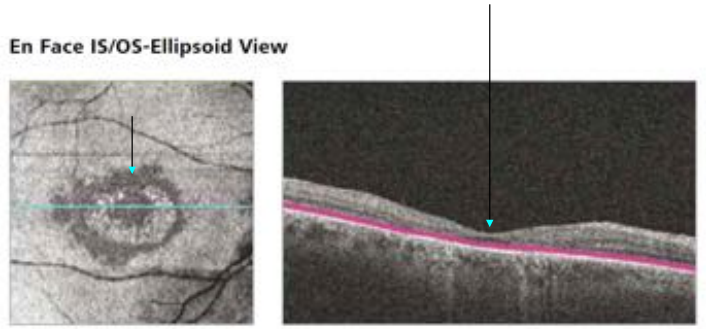
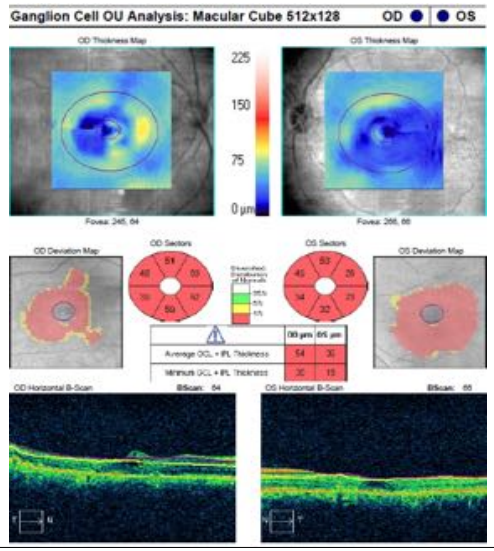
PLAQUENIL MACULOPATHY WITH CLASSIC BULL'S EYE DUE TO ANNULAR FOVEAL ATROPHY



GCL + IPL loss in HCQ maculopathy



Expanded spectral domain-OCT findings in the early detection of hydroxychloroquine retinopathy and changes following drug cessation

David R. Lally, Jeffrey S. Heier, Caroline Baumal, Andre J. Witkin, Steven Maler, Chirag P. Shah, Elias Reichel, Nadia K. Waheed, Igor Bussel, Adam Rogers and Jay S. Duker

International Journal of Retina and Vitreous 2016 2:18
https://doi.org/10.1186/s40942-016-0042-y
Received: 8 April 2016 | **Accepted:** 21 June 2016 | **Published:** 18 July 2016

The Journal of Rheumatology

The Journal of Rheumatology Volume 46, no. 12

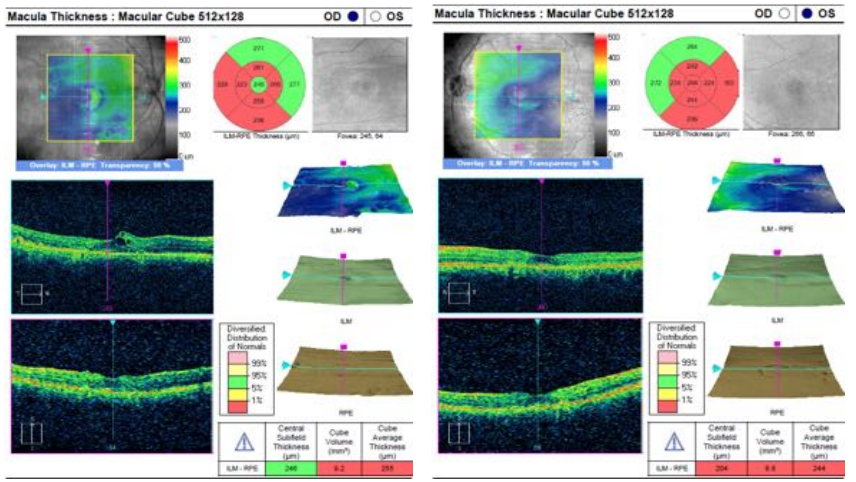
Hydroxychloroquine Ocular Toxicity: Lessons Learned

JEFF C. RABIN and KIRSTI RAMIREZ

J Rheumatol 2019;46;1640-1641
http://www.jrheum.org/content/46/12/1640

Acknowledgement: Drs. K. Ramirez and J. Rabin, UIWRSO VNS clinic

Note significantly thin maculae and cystic retinal changes



Acknowledgement: Drs. K. Ramirez and J. Rabin, UIWRSO VNS clinic

FROM THE AUTHORS

"(Real) weight-based dosage and early screening (DFE, central fields, OCT, FAF, mfERG) are essential to prevent HCQ toxicity,

particularly with certain risk factors: small stature, high total dosage, diminished renal function, concomitant tamoxifen use, and/or existing retinal/ macular disease.

Interprofessional collaboration to optimize patient outcomes."

The Journal of Rheumatology

The Journal of Rheumatology Volume 46, no. 12

Hydroxychloroquine Ocular Toxicity: Lessons Learned

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Visual Neurophysiology Service
UNIVERSITY OF THE INCARNATE WORD
ROSENBERG SCHOOL of OPTOMETRY

Plaquenil Maculopathy

- Testing for patients on Plaquenil
  - DFE
  - VF 10-2 W/W (add 24-2 or 30-2 in Asians)
  - SD or SS-OCT: raster and cube scans
  - FAF
  - mfERG
- Increase frequency of monitoring (2+ visits per year) w/degree of pathophysiology.

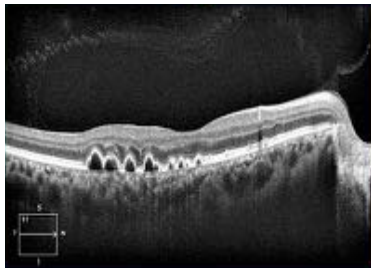
Summary and Case Outcome

- MMI and other diagnostics are essential in evaluation of patients using CQ or HCQ on a chronic basis.
- Co-management team includes:
  - Optometry
  - Rheumatology
    - Other therapies: methotrexate, TNF inhibitors (our patient VY was switched to this drug class)

Q & A WINE MOMENT

- allthingsoct@gmail.com

Tiny Bubbles



Joseph J. Pizzimenti, OD, FAAO

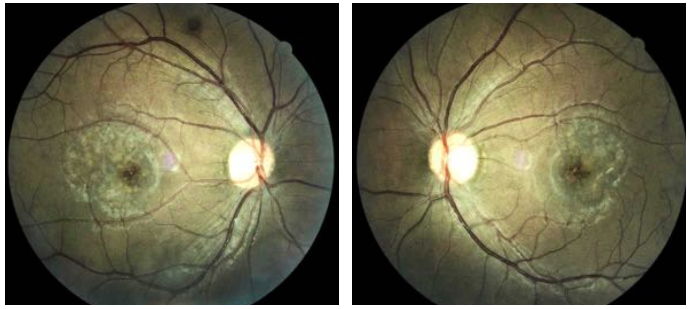
Case History and Clinical Findings

- A 30-year-old male presented with a chief complaint of mild, bilateral central blur of one year's duration.
- Health history was positive for type 2 diabetes.
- Best corrected visual acuities were 20/25 at distance and 20/20 at near for both eyes.
- Amsler testing revealed central metamorphopsia in each eye.

Additional Clinical Findings

- Dilated funduscopy showed a honeycomb pattern of pigment epithelial changes within each central retina that resembled small, translucent bubbles.
- Mod NPDR OD, Mild NPDR OS without macula edema.
- Peripheral retina intact and unremarkable OU

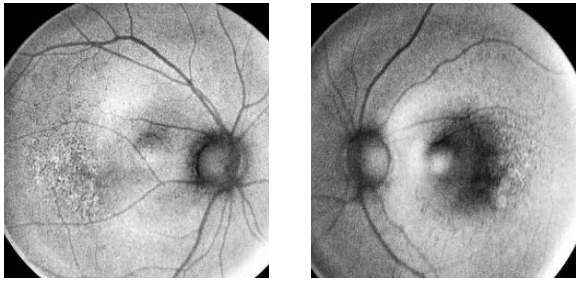
Color Fundus Photography



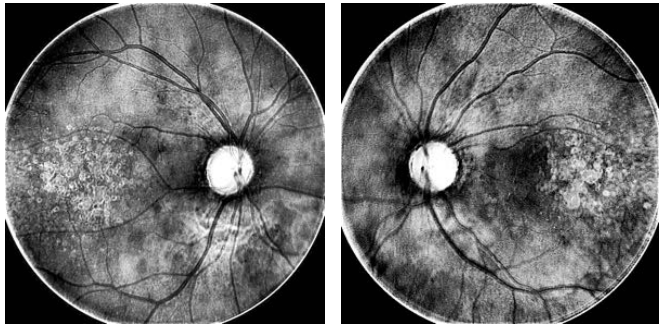
Special Testing

- Further investigation through multimodal imaging with fundus autofluorescence and OCT confirmed multiple serous RPEDs of various sizes in both eyes spanning 2.5 DD centered around the fovea.
- Differential Diagnosis
  - Pattern Dystrophy of RPE
  - Central Serous Chorioretinopathy
  - Bilateral Idiopathic Multiple RPE Detachment

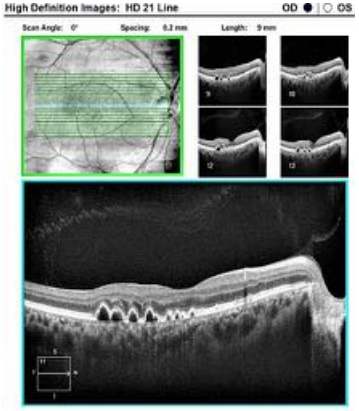
FAF



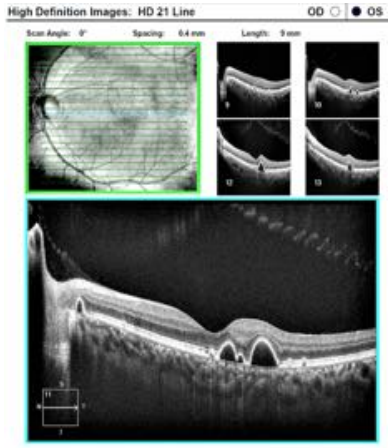
Near-IR



OCT-OD: Multiple RPEDs of Varied Size

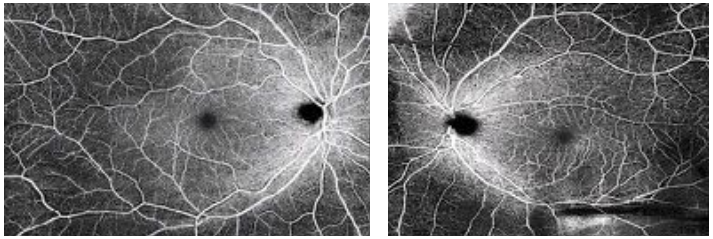


OCT OS: Multiple RPEDs of Varied Size, Note Choroidal Thickness

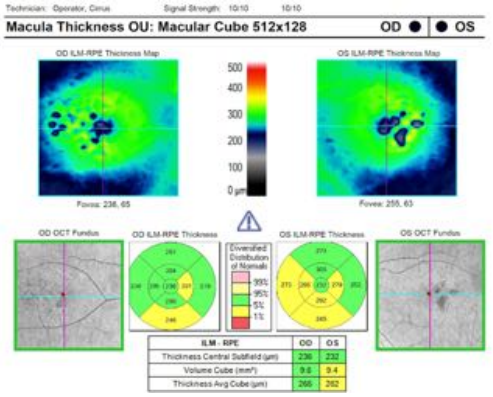


En Face OCT Showing “Tiny Bubbles”

Angioplex OCTA



Retinal thickness maps show pattern of RPEDs. Sub-RPE fluid is underneath the dark blue areas.



Discussion

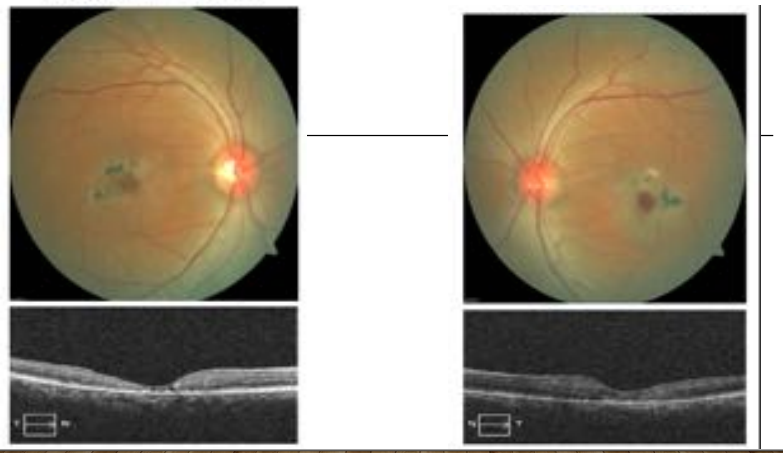
- Bilateral Idiopathic Multiple RPED is a rare condition that may represent an atypical form of CSC or a pachychoroid syndrome.
- There is currently no preferred treatment, besides observation, as visual prognosis is typically good.

Conclusion

- Multimodal ophthalmic imaging is useful in ruling out various differential diagnoses, as well as monitoring for progressive changes such as serous RD and choroidal neovascularization.
- MMI was a difference maker in revealing the diagnosis of this case.

CASE HISTORY

A 57-year-old HF presented with a chief complaint of gradual-onset bilateral blur that was slowly worsening. BCVAs were 20/100 OD and 20/150 OS. A temporal paracentral scotoma OS was detected on Amsler. Biomicroscopy showed 2+ cortical cataracts OD/OS; IOPs were 20mmHg OD/OS. Ophthalmoscopy revealed healthy nerves. Both maculae demonstrated a reddish “pseudo-lamellar hole” appearance, w/ perifoveal hyperpigmentation, and scattered crystalline deposits.

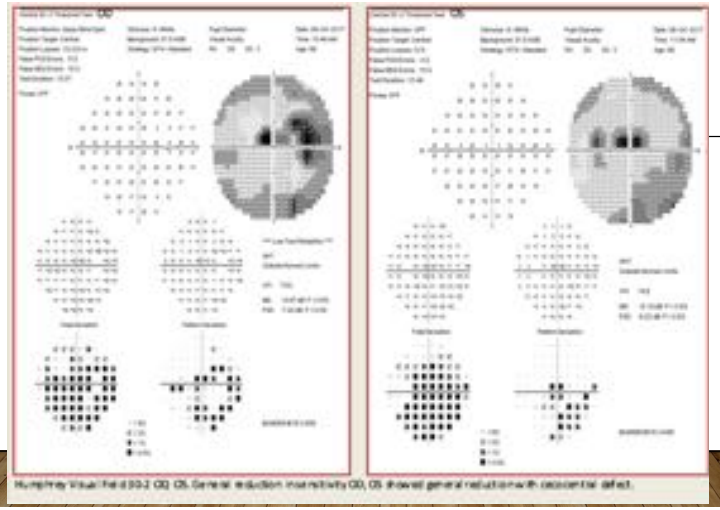


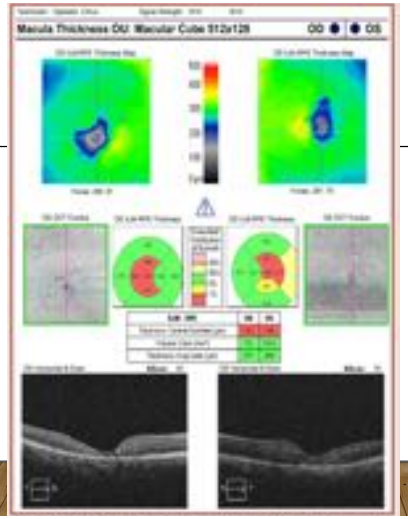
DIFFERENTIAL DIAGNOSES

- Macular Telangiectasia (Type 2)
- Age related macular degeneration (AMD)—only 57 y/o

- Previous Branch Retinal Vein Occlusion (BRVO) w/old ME
- Diabetic Retinopathy w/old ME, now mac ischemia
- Previous Central Serous Chorioretinopathy (CSC)

- Pattern Dystrophy of the RPE

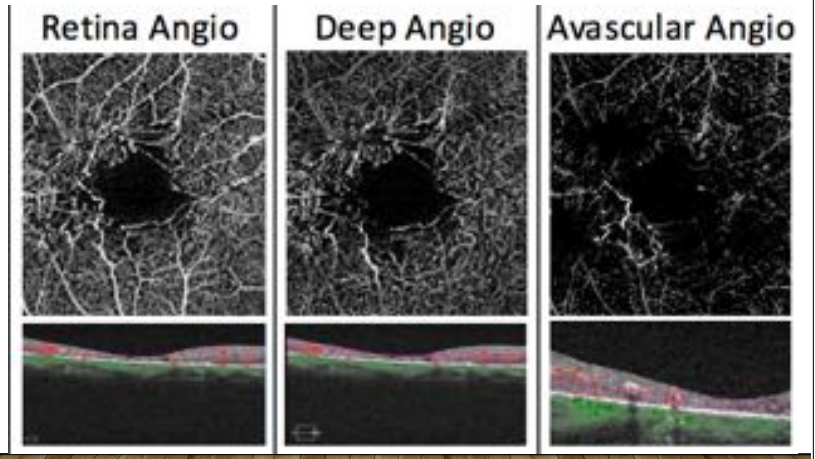




OCTA- OD

- OCT-Angiography of OD highlights temporal perifoveal telangiectasias in the superficial, deep, and even avascular layers of the retina.
- These particular telangectatic vessels appear deeper than usual.

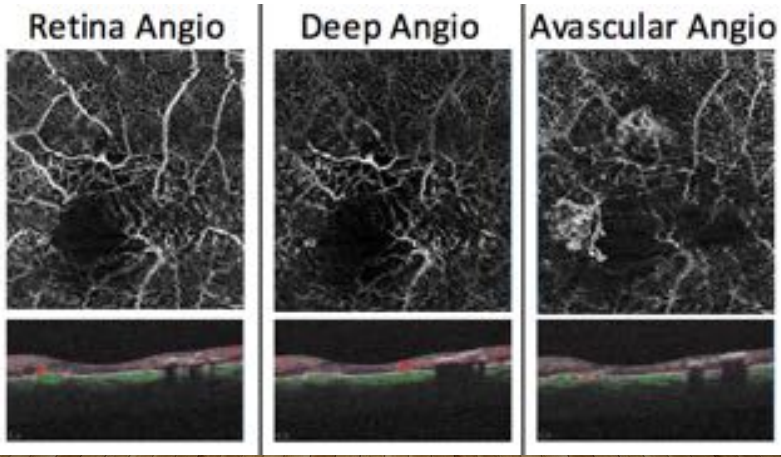
OD



OCTA- OS

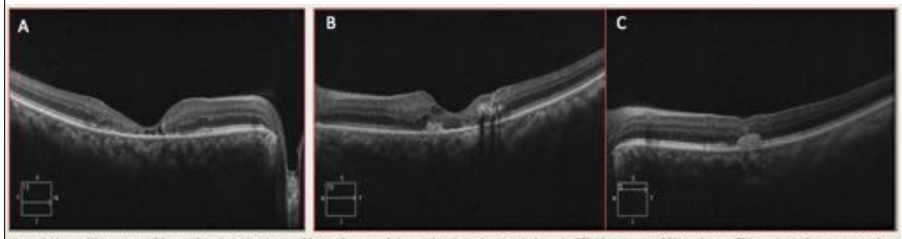
- OCT-Angiography of OS highlights temporal perifoveal telangiectasias in the superficial and deep layers of the retina. In addition, two areas of sub-retinal neovascularization (SRN) can be visualized in the avascular retina: the most prominent SRN is nasal to the fovea, and more subtly, a small SRN is present superior to the fovea.

OS



HD RASTER SCANS

OD OS OS



Above: A: shows a HD raster scan of the macula and partial optic nerve OD, revealing areas of pigment clumping and outer-retinal atrophy. B/C: HD raster scan of OS showing two SRN complexes adjacent to areas of pigment clumping in the macula.

ASSESSMENT AND PLAN

Assessment: Bilateral MacTel (Type 2)

Plan. The patient was referred for consideration of SRN treatment, low vision evaluation, and diabetes and hypertension workup. An Amsler grid was dispensed.

Treatment. Most treatment options for MacTel are of limited efficacy and lack sufficient evidence. Anti-VEGF and PDT may be beneficial in Mactel cases with SRN.

TREATMENTS AND DISCUSSION

Treatment/Discussion.

- Anti-VEGF therapy is the most promising treatment for Mactel with SRN.
- New research suggests that Anti-VEGF agents improve structure in Mactel both with and without SRN, but functional gain is limited to eyes with proliferation.
- It is important to monitor eyes with Mactel every 4-6 months for SRN development.

Conclusion.

- OCT-A aids in the diagnosis of MT and may enable earlier detection of SRN.

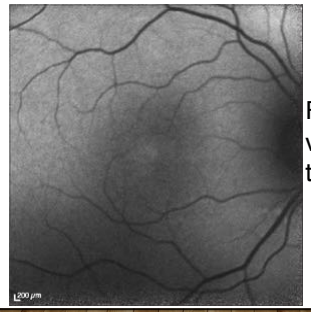
ABOUT MACTEL

- Macular telangiectasia (Mactel) is characterized by congenital or acquired perifoveal dilated retinal capillaries. Some caps take a right-angle turn toward FAZ.
- Mactel Type 2 is bilateral, affects both sexes equally, and is the most common form.
- The pathophysiology is unknown; however, dominant inheritance is suspected.
- Fundus findings include perifoveal telangiectasias, crystalline deposits, retinal pigmentation, retinal/RPE atrophy, blunted venules, and sub-retinal neovascularization (SRN).
- Long-term visual prognosis is variable. According to the Mactel Project, patients with type 2 will have a mean VA of 20/40; rarely do patients have VA <20/200.
- In several studies, HTN and DM have been highly correlated to cases of Mactel.

TYPES OF MACTEL

- Type 1
  - Perhaps a mild form of Coats disease.
  - Like Coats, these patients are typically male and have a unilateral presentation. Exudates, heme.
  - Changes are more often localized to the macula and paramacular area than is seen in Coats disease.
- Type 2
  - Male or female and usually have a bilateral presentation. This form is associated with minimal to no lipid exudation and demonstrates superficial retinal crystals in approximately 50% of patients.
  - Pigment hyperplasia, migration and plaque formation can be seen in the later stages.
- Type 3
  - This type is exceedingly rare. Capillary occlusions are a hallmark sign.

QUESTIONS AND DISCUSSION



FAF useful in visualizing right-angle telangectatic BVs.

WINE MOMENT

Summary

- Contemporary OCT provides valuable information about tissue morphology, retinal/ choroidal vasculature, and stability versus progression of disease.
- This information, combined with history, DFE, MMI and functional testing, enables clinicians to establish accurate diagnoses and make better-informed decisions.

CONCLUSION

OCT, OCTA, and MMI have revolutionized posterior segment care.

Indeed OCT has forever changed retina!

THANK YOU!

Joe

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