

10 Hacks for Understanding and Interpreting OCT in Retina and Glaucoma

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Mark Dunbar: Disclosure

- Optometry Consultant
 - Carl Zeiss
 - Allergan
- Advisory Board for:
 - Allergan
 - Carl Zeiss
 - Regeneron
 - Genentech

Mark Dunbar does not own stock in any of the above companies

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Reports **SCIENCE**

Optical Coherence Tomography 1991

DAVID HUANG, ERIC A. SWANSON, CHARLES P. LIN, JOSE S. SCHUMBERG, WILLIAM G. STIVINSKI, WARREN CHANG, MICHAEL R. HEI, THOMAS FLOTTIE, KINSTON GREGGORE, CARMEN A. PULIAFITO, JAMES G. FUJIMOTO*

A technique called optical coherence tomography (OCT) has been developed for noninvasive cross-sectional imaging in biological systems. OCT uses low-coherence interferometry to produce a two-dimensional image of optical scattering from internal tissue microstructures in a way that is analogous to ultrasonic pulse-echo imaging. OCT has longitudinal and lateral spatial resolutions of a few micrometers and can detect reflected signals as small as $\sim 10^{-16}$ of the incident optical power. Tomographic imaging is demonstrated in vitro in the peripapillary area of the retina and in the coronary artery, two clinically relevant examples that are representative of transparent and turbid media, respectively.

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Why Do You Need an SDOCT

- Increased demands for eye care due to rapidly growing aging population
- An “aging” population means more patients with disease
- The responsibility on the doctor to accurately diagnose and manage is too great
- **If you are going to practice medical eye care OCT is essential**

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ARVO The Association for Research in Vision and Ophthalmology

November 2016

New Videos, Resources Launch Outreach Campaign On Vision-Preserving Technology

Impact of optical coherence tomography on patients, general public revealed

OCT has become the predominant means of detecting and monitoring diseases like macular degeneration, diabetic retinopathy and glaucoma. Everyone over the age of 60 is recommended to get an OCT scan once a year.

“Everyone over the age of 60 is recommended to get an OCT scan once a year”

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The Evolution of OCT Imaging

- OCT has changed how clinicians look at the retina
- OCT has changed how we manage glaucoma
- The assessment of retinal abnormalities and glaucoma based on OCT imaging has advanced eye care
- OCT in Optometry practices ~ what %
- As the technology has evolved -> prices continue to come down

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Advances in SD-OCT

- Improving software
- **Faster – virtual angiography**
- Noise reduction/over sampling technology
- Wider and deeper scans
- Greater density in the scans
- Improvements in 3D imaging
- Enhanced depth imaging – imaging choroid
- Progression analysis software

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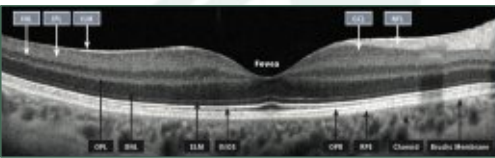
10 Hacks for OCT Interpretation: Retina

1. Don't make it more complicated than it needs to be: keep it simple and don't get caught up in the minutia
 2. Many macular disease conditions have a "signature" OCT feature
 - Learn what those are and the diagnosis and interpretation becomes easier
 3. Correlate what you see on clinical exam with anatomy on OCT
 4. Is there fluid?
 5. What is the status of the IS/OS line
 6. Pay attention to the vitreoretinal interface
 7. Is it full thickness?
 8. OCT findings in dry AMD can be a predictor for progression to GA or CNV
 9. Make sure you are scanning all your high myopes
 10. Look for change over time
- OCT Angiography (OCTA) is a great non-invasive tool to view the microvascular

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Hack/Tip # 1

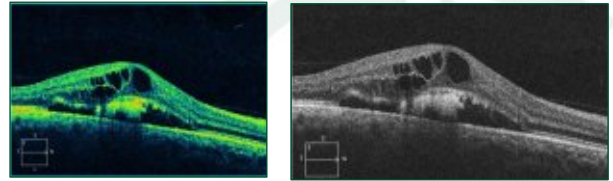
1. Don't make it more complicated than it needs to be
 - Keep it simple
 - Don't get caught up in the minutia!



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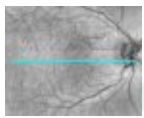
Simple Tip

Print/View B Scan Images in Black and White -> not color: you loose resolution with color

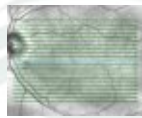


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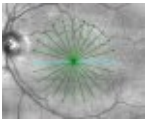
Remember: Many different Options for Visualization of Macular Detail



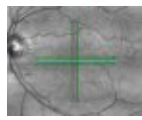
- HD 1 Line 100x**
- 100x averaged
 - VFI™ image Enhancement Technology
 - Improved vitreous assessment
 - Publication quality image



- HD 21 Line**
- 21 lines
 - 4/8x averaged
 - Ideal for anti-VEGF therapy monitoring



- HD Radial**
- 12 lines
 - 8x averaged
 - Fovea as common reference point
 - Ideal for macular hole assessment & surgical planning



- HD Cross**
- 5 horizontal
 - 5 vertical
 - 8x averaged

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Hack #2

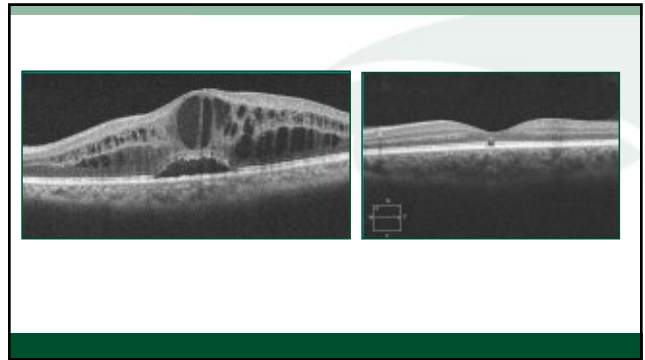
Many macular disease conditions have a "signature" OCT feature

Learn what those are and the diagnosis and interpretation becomes easier

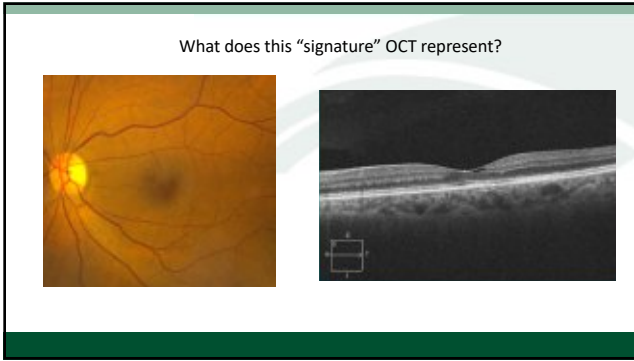
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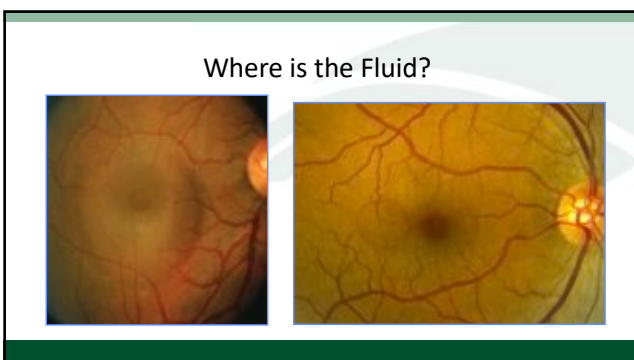
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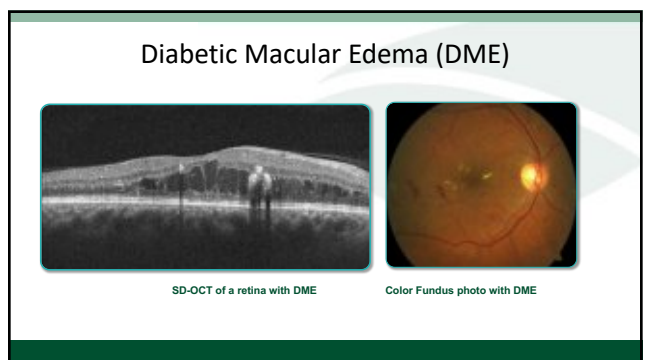
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Hack/Tip #3
 Correlate what you see clinically
 with what is happening anatomically
 (The OCT does not exist in a vacuum)

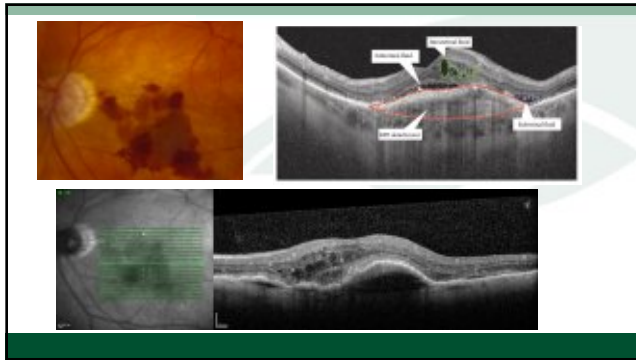
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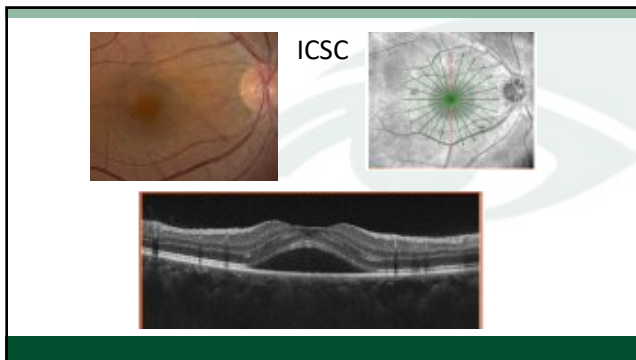
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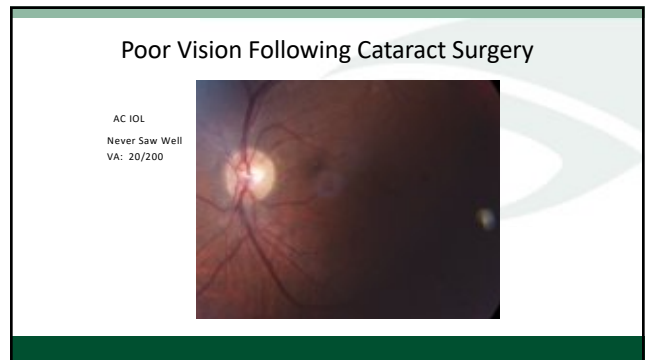
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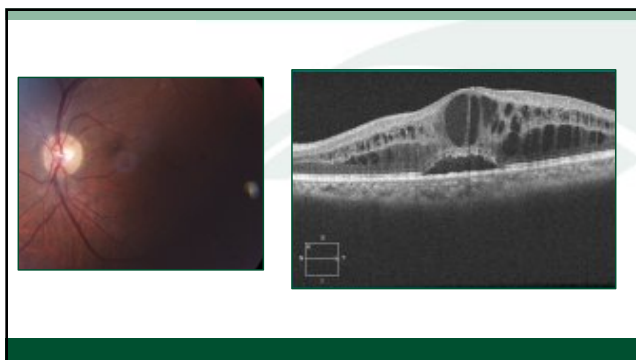
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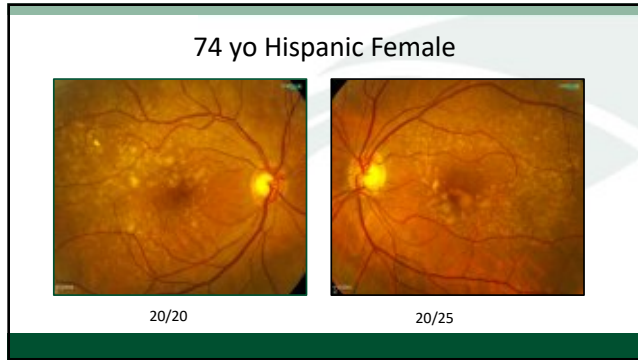
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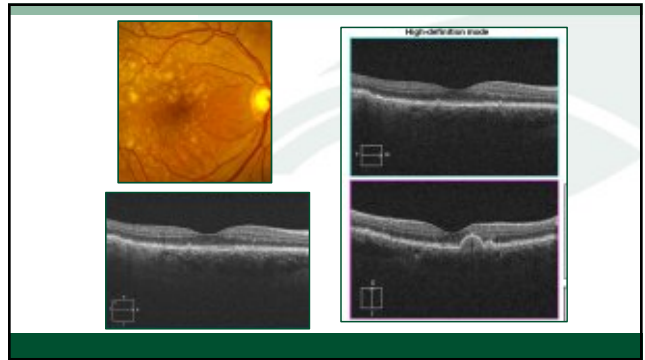
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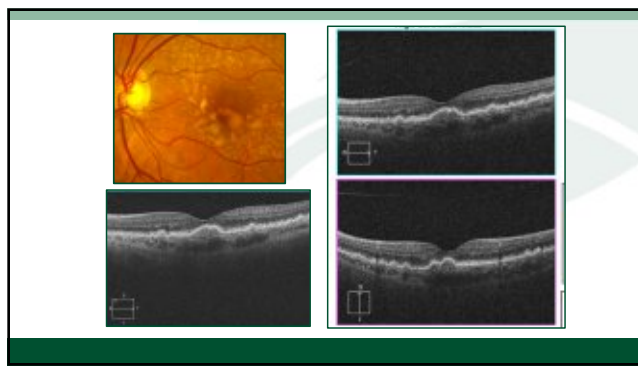
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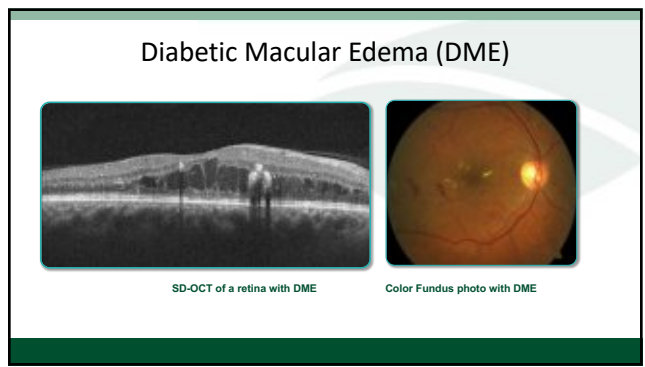
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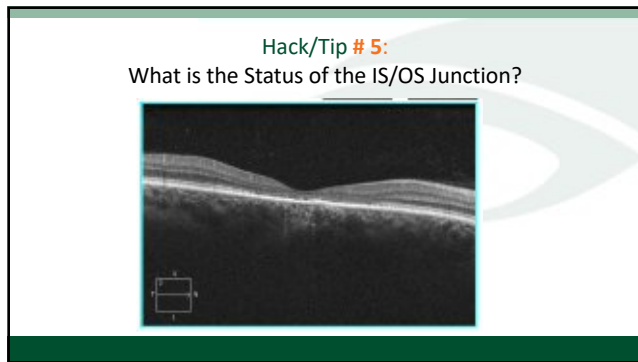
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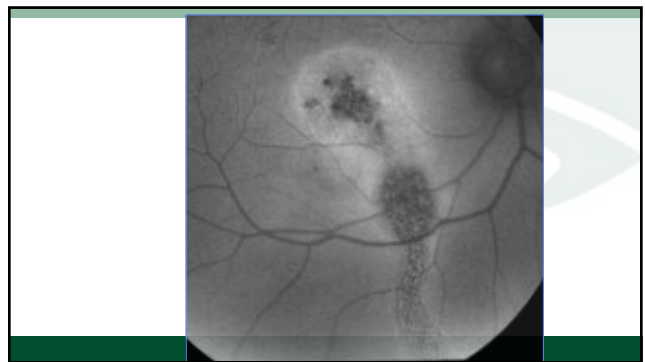
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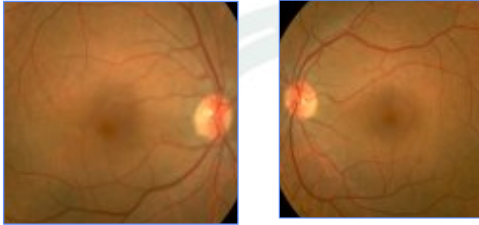


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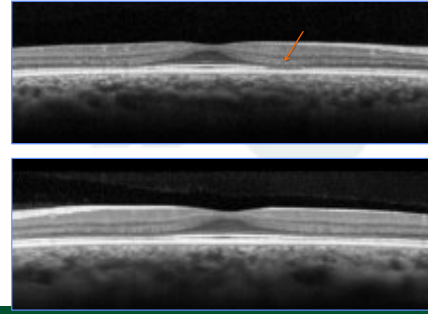


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Plaquenil Toxicity

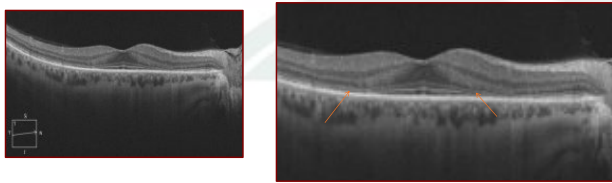


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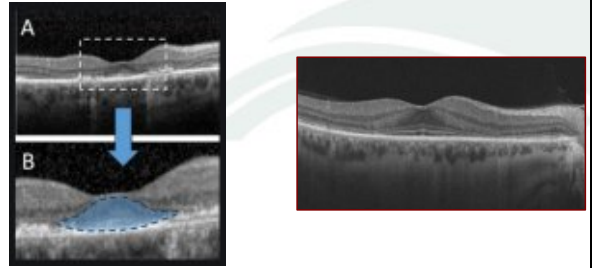


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Plaquenil Toxicity



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Even Newer Recommendations on Screening for Plaquenil Toxicity



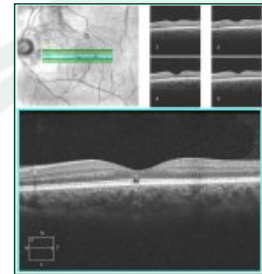
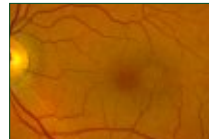
American Academy of Ophthalmology Statement Recommendations on Screening for Chloroquine and Hydroxychloroquine Retinopathy (2016 Revision)

Michael F. Marmor, MD,¹ Ulrich Kellner, MD,² Timothy Y.Y. Lau, MD, FRCOphth,³ Ronald B. Miller, MD,⁴
William F. Mider, MD,⁵ for the American Academy of Ophthalmology

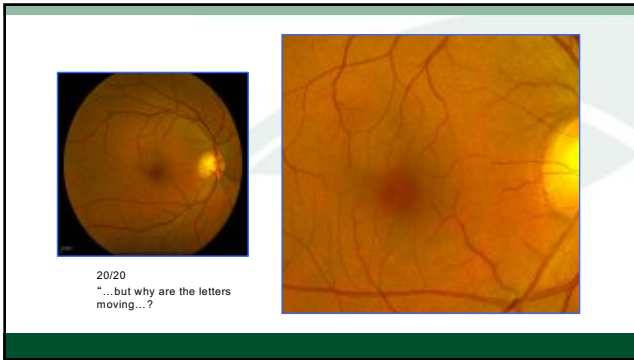
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45 y/o Hispanic Female
Routine Exam
VA 20/25

Solar Maculopathy



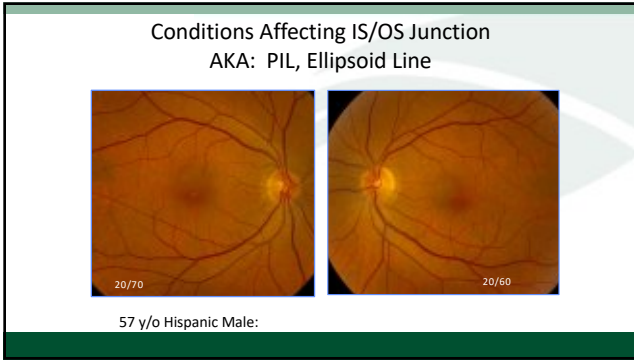
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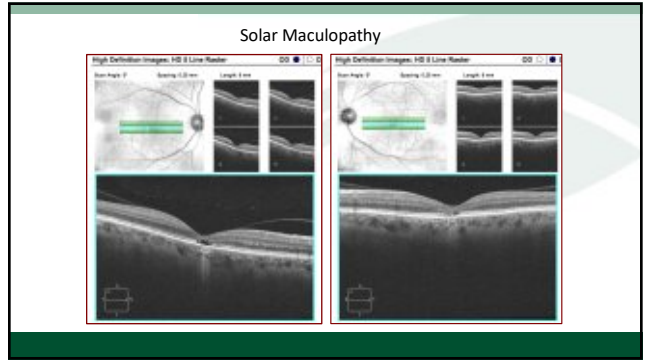
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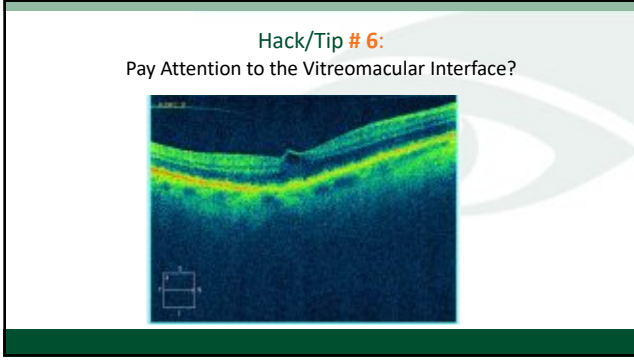
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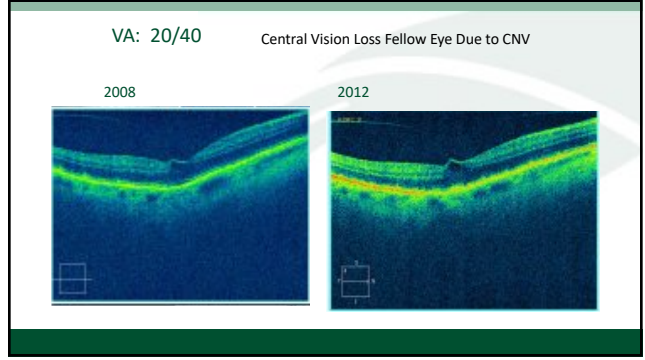
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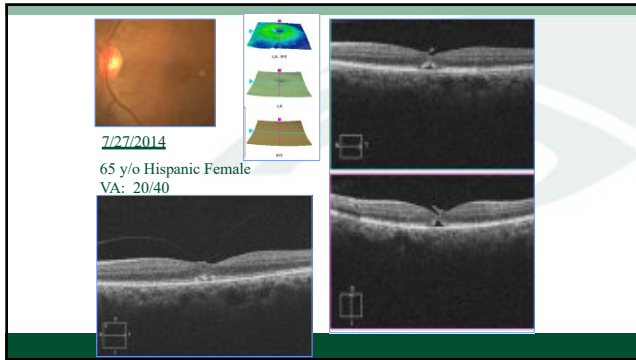
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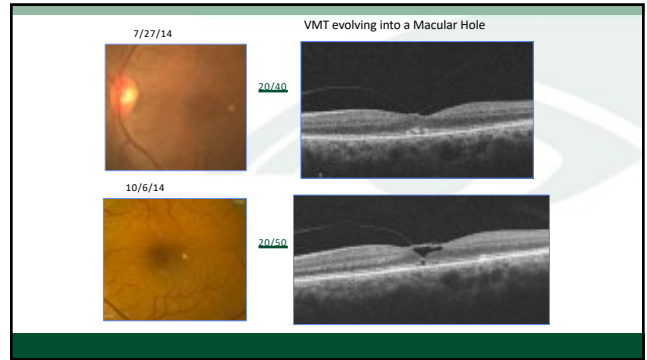
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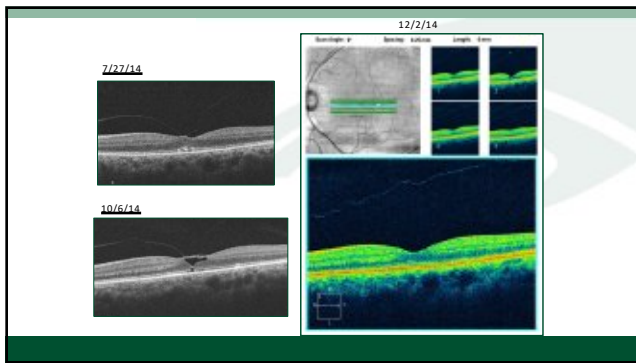
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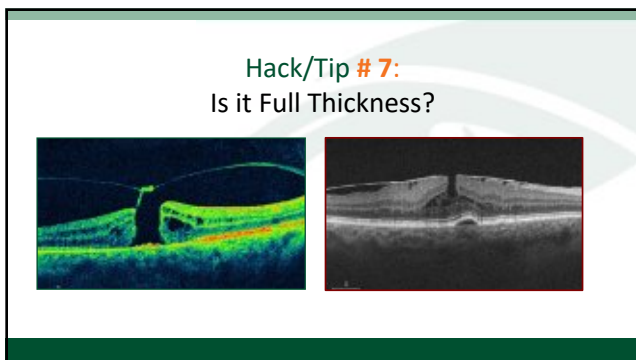
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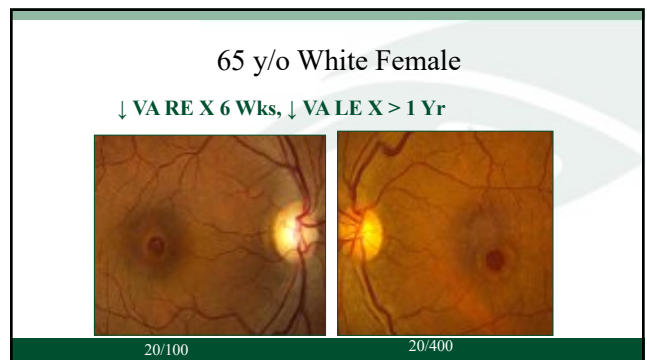
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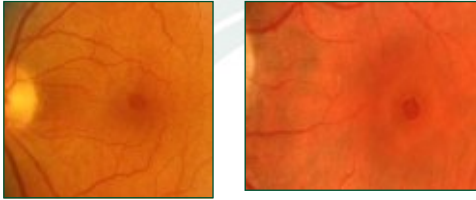


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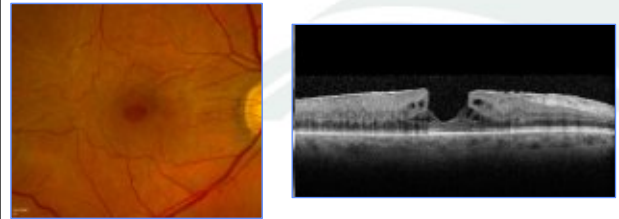


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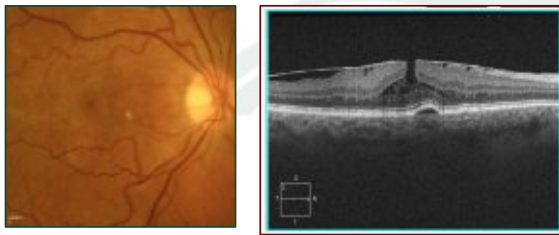
Pseudoholes vs. Full Thickness Holes



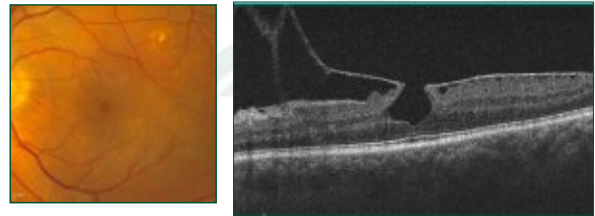
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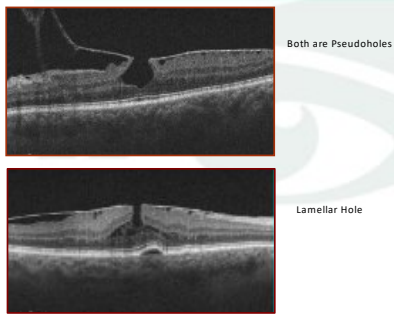
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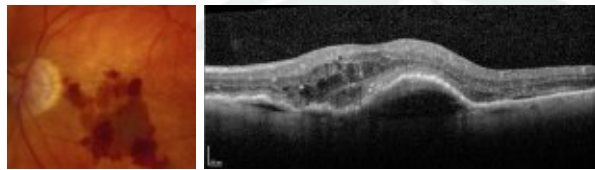


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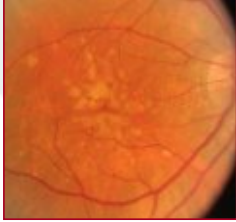
Hack # 8
OCT findings in dry AMD can be a predictor for progression to GA or CNV



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Risk Factors for Progression to Wet AMD

- Traditionally based on clinical appearance
- Intermediate AMD
 - Large drusen > 125 microns
 - RPE mottling/pigmentary abnormalities
- Risk of conversion to wet AMD over 5 years > 50%



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AMD Is the Leading Cause of Blindness for Caucasians in the US¹

10-year risk of progression for the highest risk category (AREDS simple scale)²

53.9% Central GA

Advanced AMD

10-year risk of progression for the highest risk category (AREDS simple scale)²

47.6% Neovascular AMD (nvAMD)

AMD, age-related macular degeneration; AREDS, Age-Related Eye Disease Study; GA, geographic atrophy; nvAMD, neovascular AMD. 1. Eye Diseases Prevalence Research Group. Arch Ophthalmol. 2004;122(4):477-483. 2. Ferris FL, et al. Ophthalmology. 2013;120(4):844-851. 3. Chew ET, et al. JAMA Ophthalmol. 2014;132(3):272-277. 4. Age-Related Eye Disease Study Research Group. Arch Ophthalmol. 2006;124(11):1570-1574.

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OCT Biomarkers May Help Predict Conversion to GA or Wet AMD

Review Article
OCT Biomarkers in Neovascular Age-Related Macular Degeneration: A Narrative Review

Cristian Aizcarguena^{1,2}, Simona D'Amico^{1,2}, Marco Maccia^{1,2}, Marina Formicola^{1,2}, Walter Scudato^{1,2}, Giulia Di Stefano^{1,2}, Marina Baldo^{1,2}, Paolo Barbero^{1,2}, Eliseo Prasad^{1,2}, and Elisabetta Assietti^{1,2}

1. Department of Ophthalmology, University of Palermo, Palermo, Italy; 2. Department of Ophthalmology, University of Palermo, Palermo, Italy; 3. Department of Ophthalmology, University of Palermo, Palermo, Italy; 4. Department of Ophthalmology, University of Palermo, Palermo, Italy.

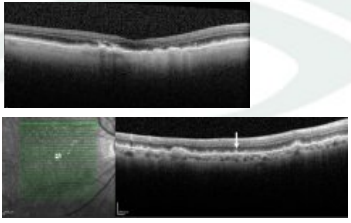
Retinal Progression Biomarkers of Early and Intermediate Age-Related Macular Degeneration

Walter Scudato^{1,2}, Eliseo Prasad^{1,2}, Paolo Barbero^{1,2}, and Miguel C. Veloso^{1,2}

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OCT Biomarkers May Help Predict Conversion to GA or Wet AMD

- Hyper-Reflective Foci (HRF)
- Reticular pseudo drusen
- Incomplete Retinal Pigment Epithelial and Outer Retinal Atrophy (iRORA)
 - Without RPE loss
 - Replaces "Nascent GA"
- Hyper-transmission defects
- OCT-Reflective Drusen Substructures




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OCT Biomarkers May Help Predict Conversion to GA or Wet AMD

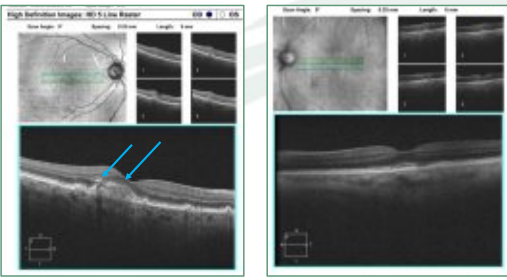
Hyper-Reflective Foci (HRF)

- Extracellular pigment granules and outer segment debris (outer HRF)
- May also represent displacement and clumping of degenerated RPE cells or
- AREDS2 study: Patients with HRF had 5 X increased risk of progression to GA at 2 years vs. controls



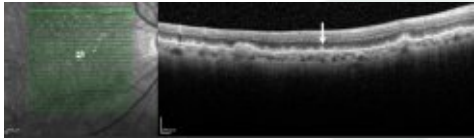
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11/30/2021: Multiple anti-VEGF injections OU



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Reticular Pseudo Drusen




- Subretinal collections of granular, interlacing, hyper-reflective material located above RPE
- Commonly found in the superior macula or close to superotemporal arcade
- Undergo a characteristic lifecycle of growth, invasion into the ellipsoid zone, and finally regression
- Reticular pseudodrusen is associated **with an additional 2-6-fold increased risk of progression to nAMD or central GA**,
 - Risk of progression higher for reticular pseudodrusen located outside the macula

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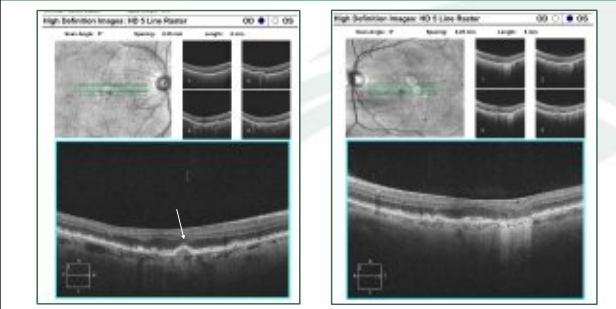


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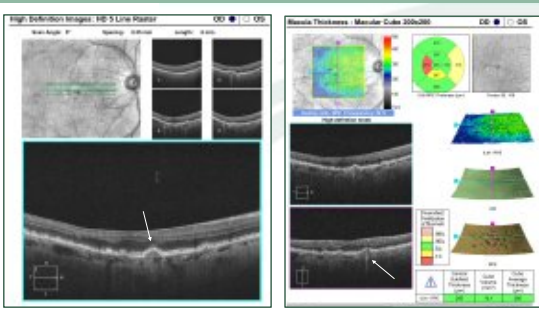
69 yo Hispanic Male



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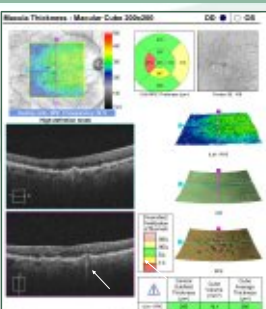
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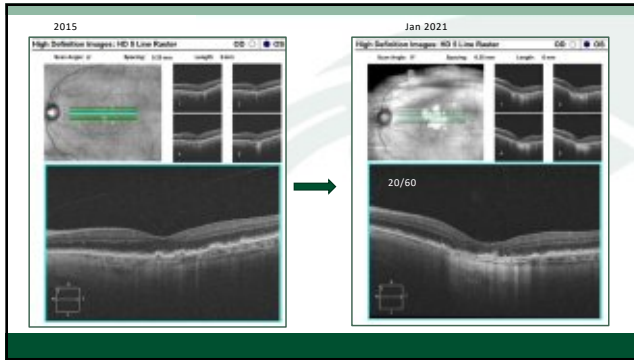
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Hyper-reflective Columns

- Narrow strips of light transmission
- Overlying RPE appears intact
 - May represent micro-cracks
- Increased risk of progression to GA
 - Present in 27% of eyes that progressed to GA nAMD



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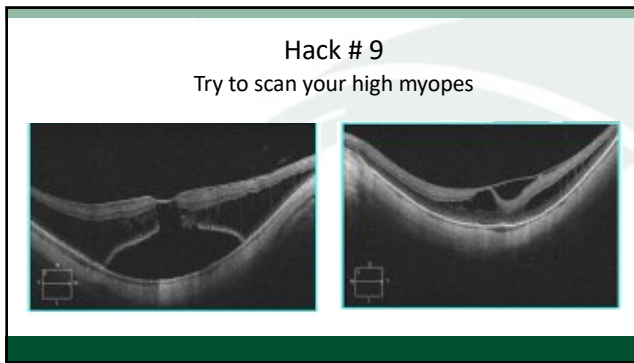
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Table 5. Progression Biomarkers in AMD

Biomarker	Imaging Findings	Mechanism	Prevalence in AMDs	Expected Progression HR, %
Drusen volume	Baseline-drusen volume	Displacement or detachment of photoreceptor layer	MD ^a	1.04 risk of progression to AMD (for each 1.1 mm ³ of drusen volume increase) [14]
SPE-Drusen complex (DC) Advanced analysis	RAF ^b	SPE softening and drusen regression	MD ^c	1.20 risk of developing central GA (for each 0.025 mm ² increase in RAF volume) [14]
ICBP	Punctate hyperreflective lesions	Anterior migration of fully pigmented SPE cells, inflammatory or microglial cell and calcification	50% in AMD	5 risk of 3-year progression to GA [17]
REI	Small yellow deposits, reticular drusen-like or interdigitated	Disturbance of choroidal histogenesis, retinal2 processing or choroidal hypoxia [11]	2% to 3% in AMD patients	2.24-3.4 risk of progression to advanced disease [1,11]
BCVA	Subsidence of the IPL ^d and ISL ^e with a hyper-reflective ridge	New onset of atrophy (senescent atrophy)	7% in intermediate AMD [16]	5.2 risk of progression to severe GA [16]
Hypertransmission	Collar on edges of hyperreflecting	Delamination within RPE layer	27% in AMD patients [16]	ND
DCR	Internal heterogeneity	Structural instability	24% in each disease	3.4 risk of progression to severe atrophy onset [17]
Plus sensitive (beta) nonvascularization	Nerve fiber layer with no flow	Protective mechanism against ischemia	6.25 to 27% in the fellow eye of moderate AMD [16]	1.21 risk of progression to moderate AMD (11 year) [16]

^a Odds ratio; ^b not determined; ^c SPE: Abnormal Bleeding; ^d Choroid Reticular Layer; ^e Inner Nuclear Layer

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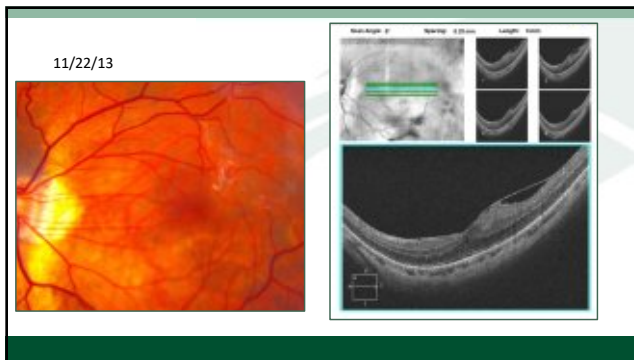


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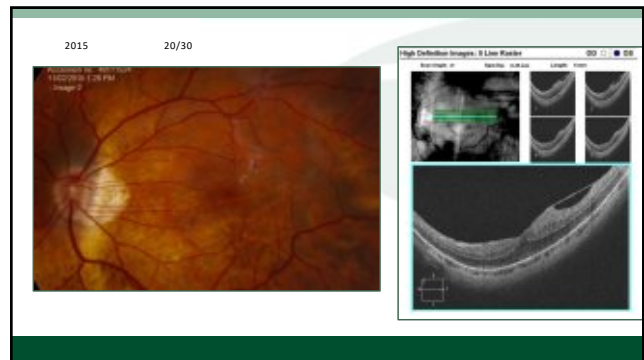
Jeff: mid-50's Attorney, High Myopia
Hx of RD Repair in both eyes: RE: 1985 LE 1989

- Never recovers vision in the RE
- He is followed through the 90's with a progressive NS and declining Va ~ 20/70
 - 1 eyed patient and reluctant to have CE
- Eventually has CE/IOL 90's-early 2000's and does well
 - VA 20/25 low refractive error

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71



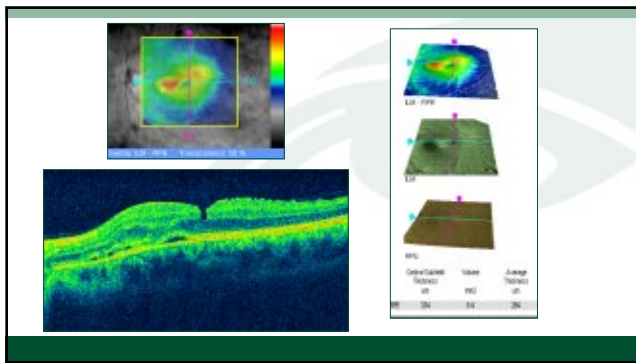
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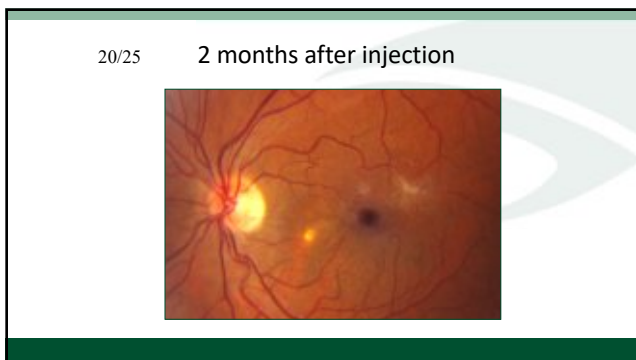


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Diagnosis

- ◆ CNV – related to pathologic myopia
- ◆ Tx: Avastin injection

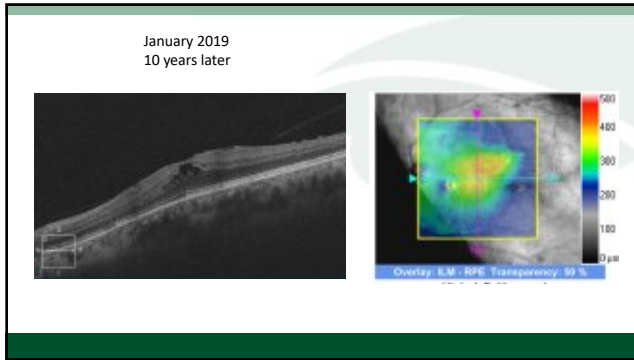
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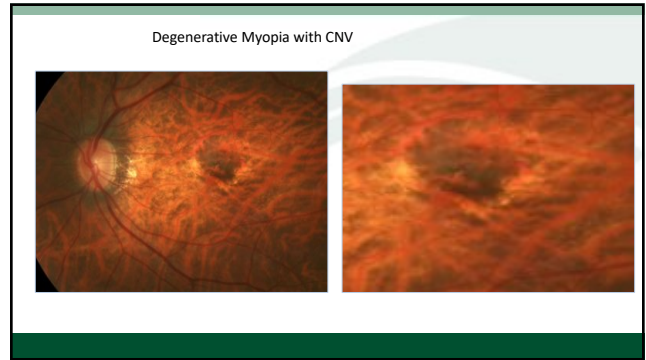
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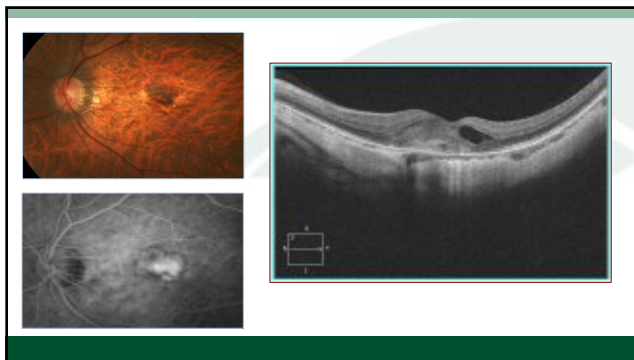
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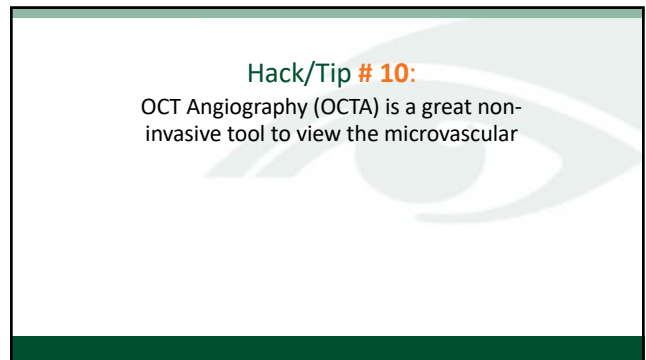
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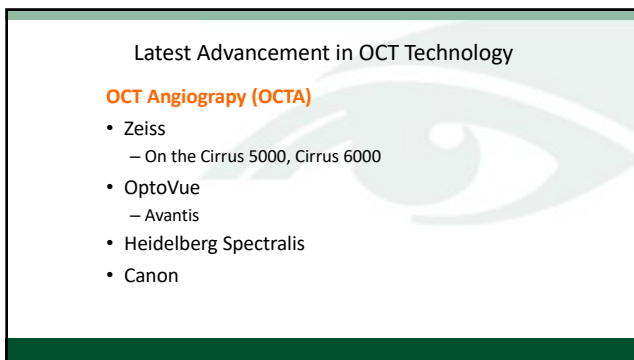
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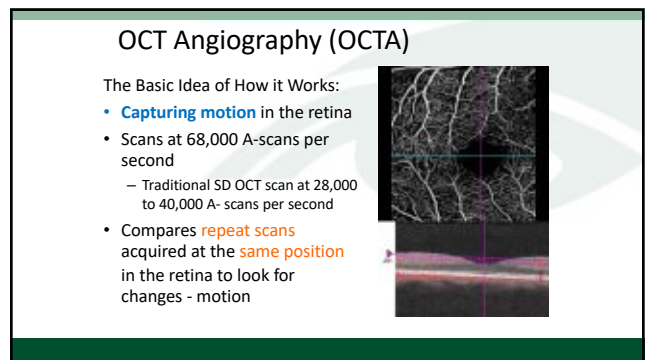
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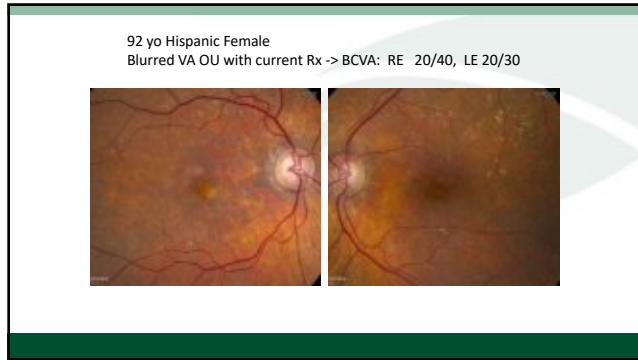
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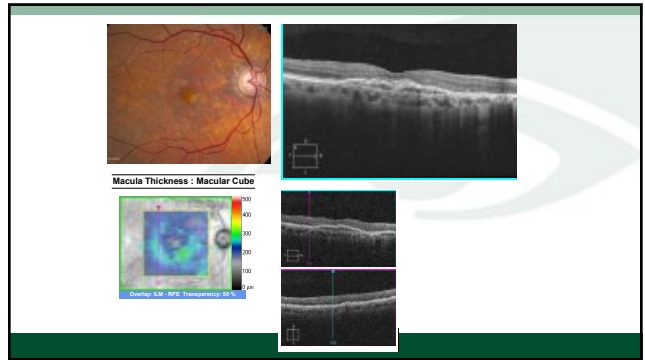
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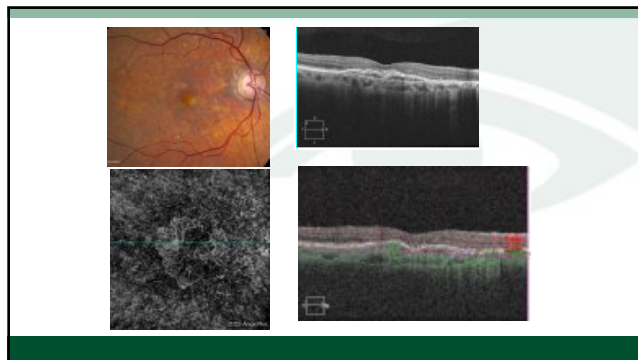
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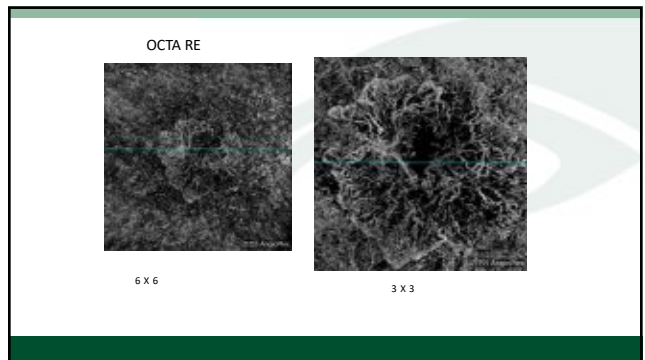
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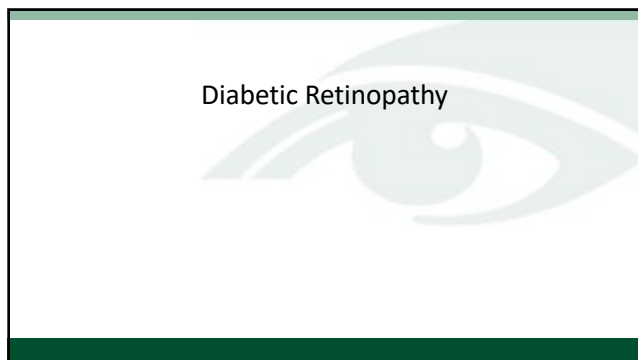
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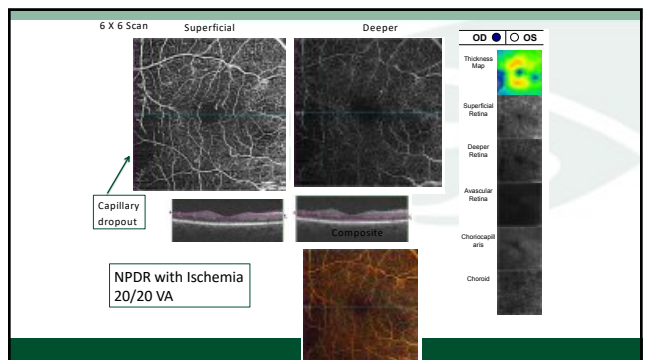
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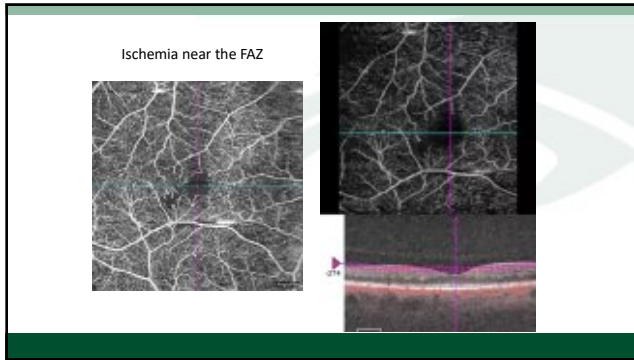
94



95



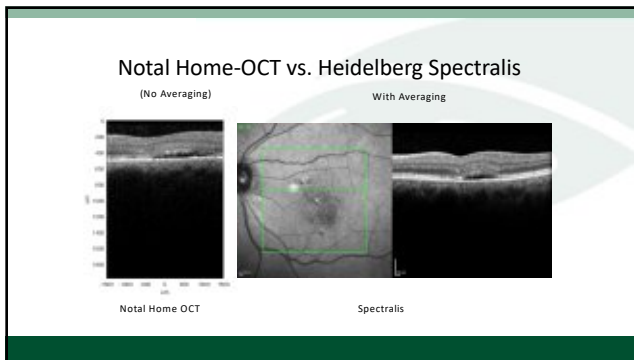
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98



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- ### 10 Hacks/Tricks for OCT Interpretation in Glaucoma
1. Make sure it is a reliable scan
 2. Do 3 RNFL scans at a time
 3. GCC is valuable and often correlates with RNFL
 4. Can the RNFL/optic nerve of your patient be applied to the normative data base?
 5. Does the OCT findings fit with the clinical presentation?
 6. Watch out for **"Red Disease!"**
 7. There is a large range of **normal** before the RNFL reaches a tipping point
 8. The OCT can show glaucomatous change **BEFORE** it is seen on visual fields
 9. A change of ≥ 10 microns from previous measurements is significant
 10. The SDOCT is not as sensitive with more severe glaucoma

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Hack/Tip #1

Make Sure it is a Reliable Scan

- Make sure you have a good single strength:
 - Cirrus: a signal strength ≥ 7
 - 6 is borderline
 - OptoVue: 40 and above
- Make sure there is no algorithm failure

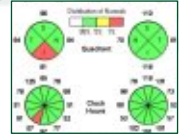
101

- ### Hack/Tip #2
- Do 3 RNFL scans at a time
- Ensures consistency/reliability
 - On **follow up 2 of the scans** can be used as the baseline for guided progression analysis GPA

102

What is the Reproducibility of RNFL OCT Clock Hour Measurements

- A. 0-3 microns
- B. About 4-5 microns
- C. About 10 microns
- D. > 10 microns

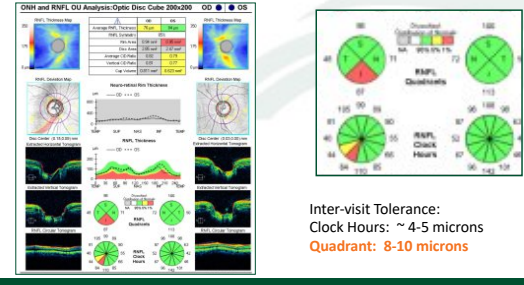


103

How much change needs to occur on an OCT RNFL for it to be significant?

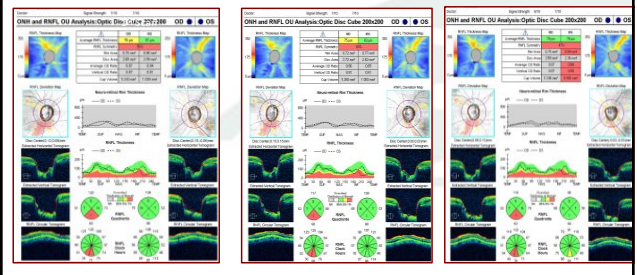
104

RNFL Quadrants and Clock Hours

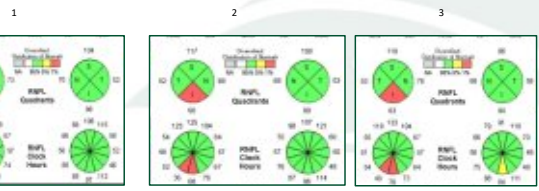


Inter-visit Tolerance:
 Clock Hours: ~ 4-5 microns
 Quadrant: 8-10 microns

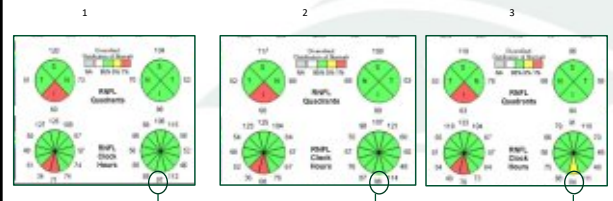
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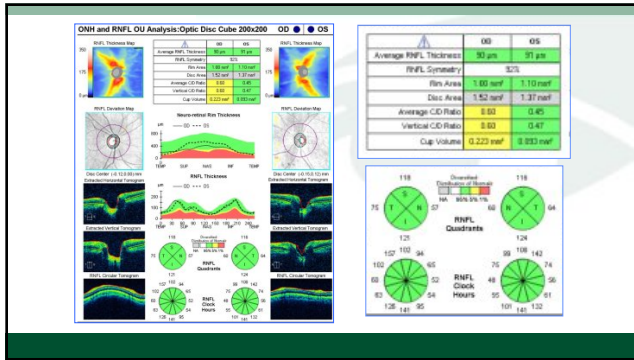
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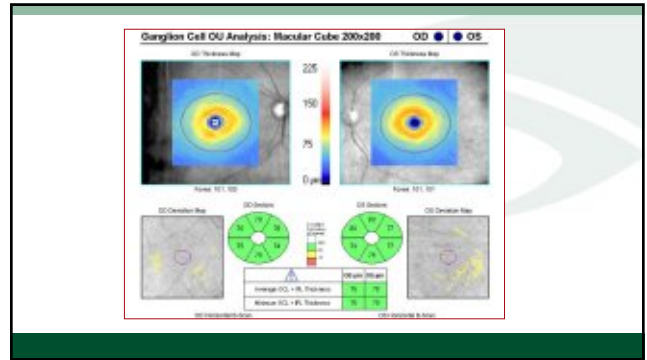
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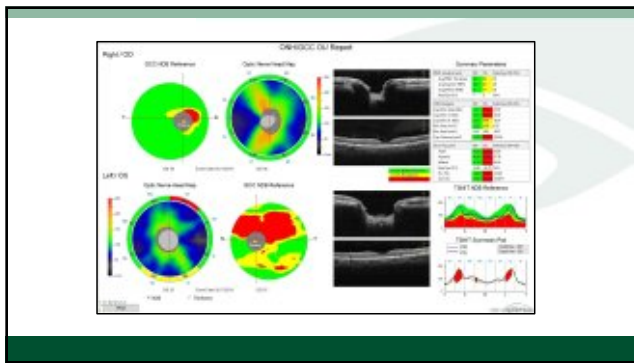
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Hack/Tip # 4

Can the RNFL/optic nerve of your patient be applied to the normative data base?

- Pathologic myopia
- Tilted disc
- Extremely large cups (and small)
- Patients less than 18 yo

95% probability the area is normal

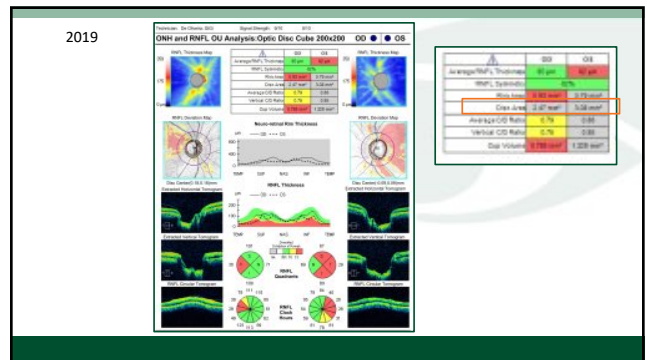
Diversified Distribution of Normals

99% probability that the area is abnormal – compared to the normal population

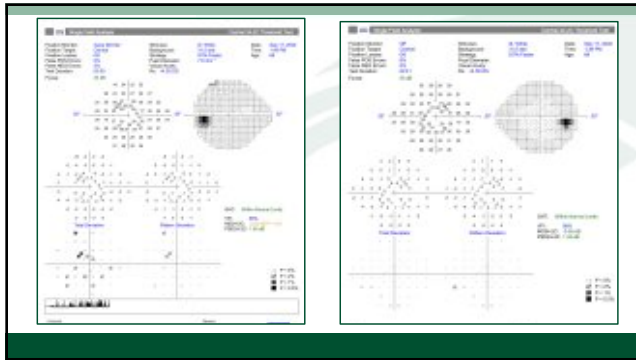
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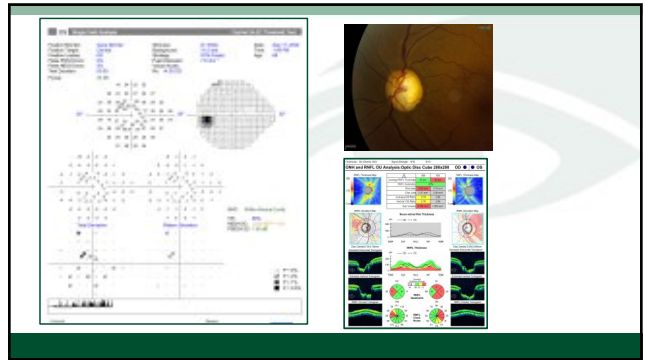
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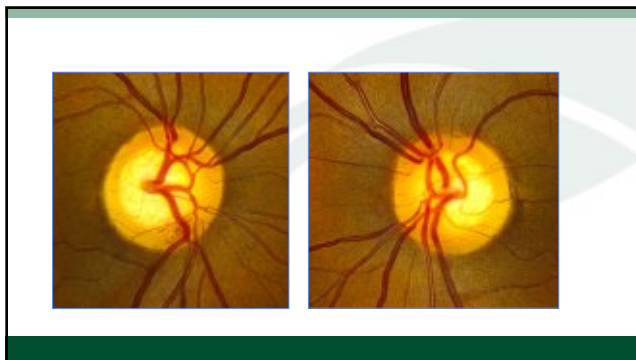
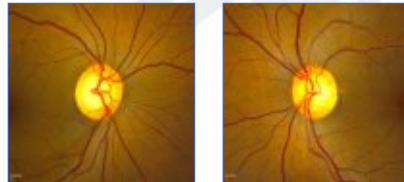
Hack/Tip #5
Does the OCT findings fit with the clinical presentation?

123

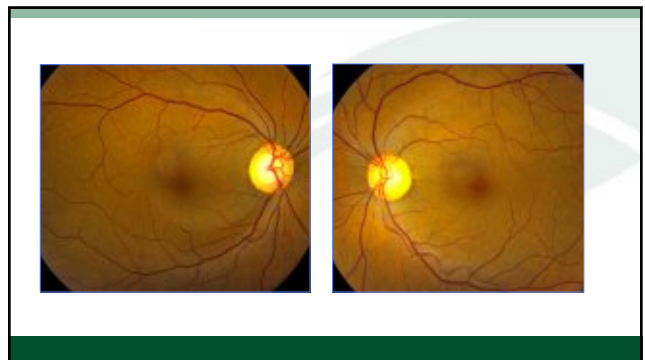
51 y/o Hispanic Female

- Reports shadow peripherally in her LE
- TA: 16-17 on 3 visits

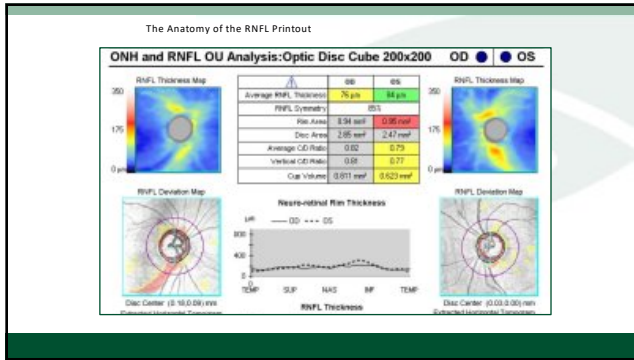
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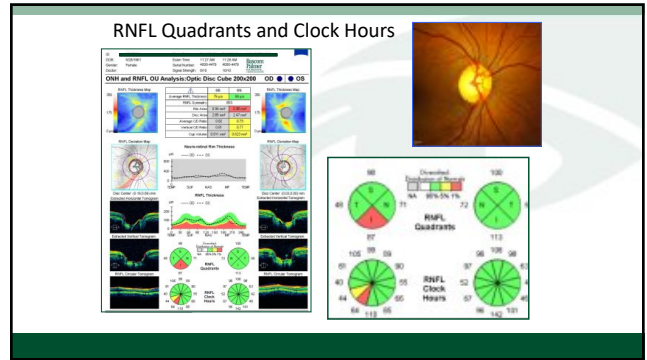
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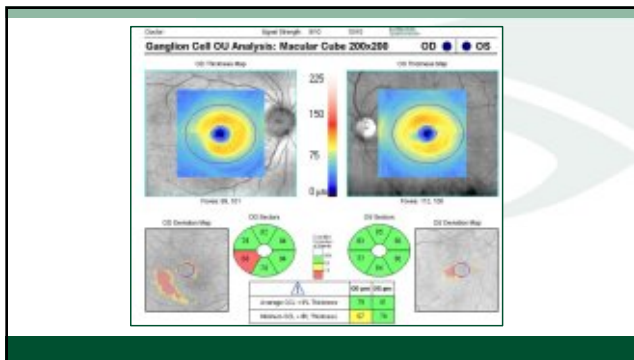
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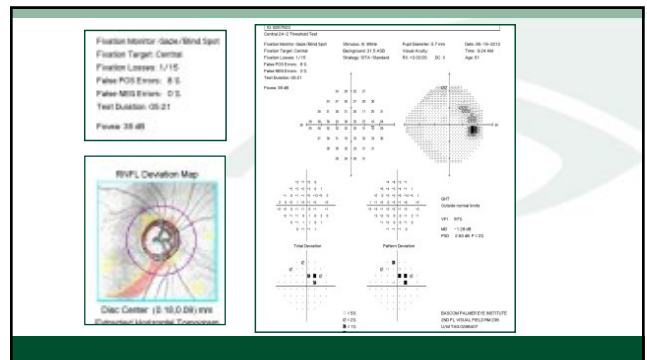
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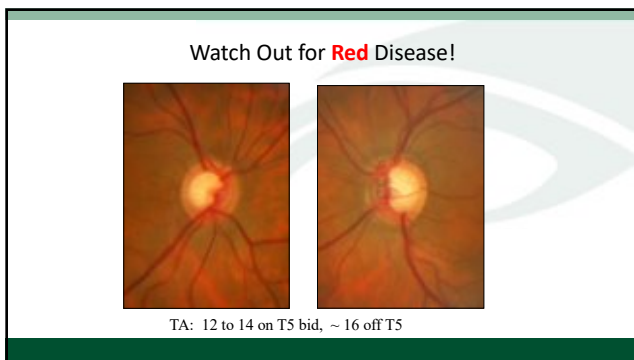
128



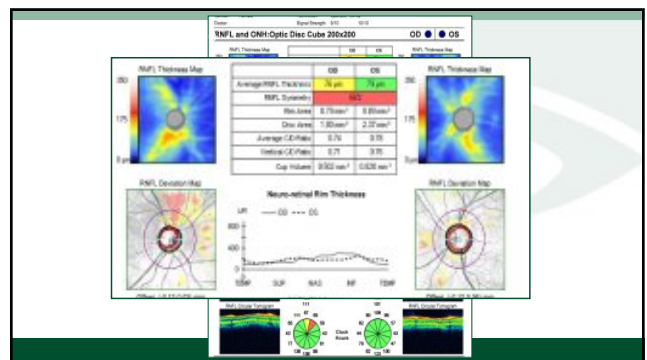
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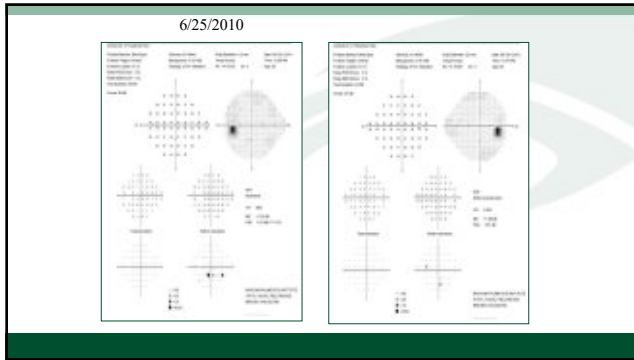
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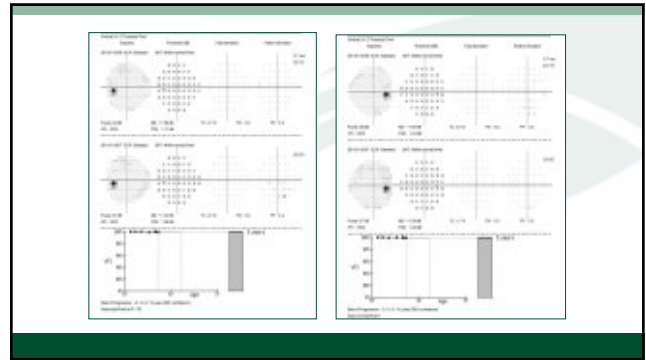
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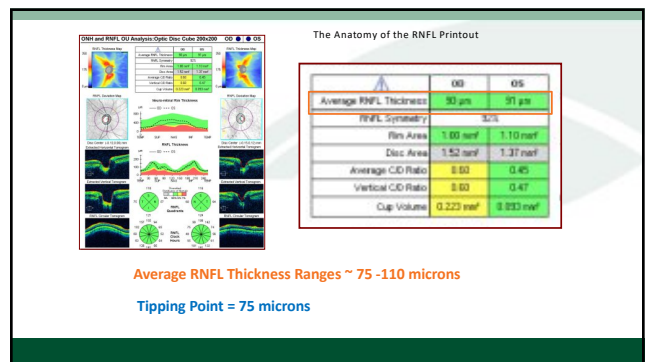


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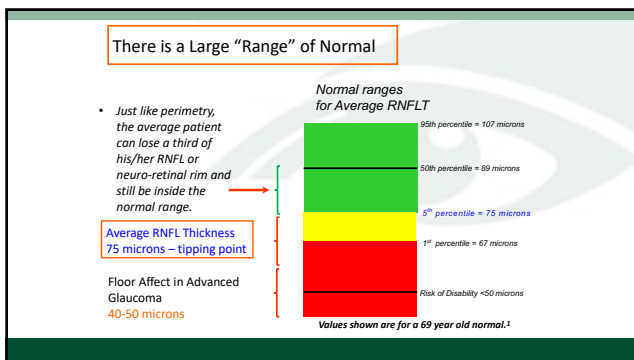
Hack/Tip #7
 Be on the lookout for **Green Disease**

There is a large range of "normal" before the RNFL reaches the "tipping point"

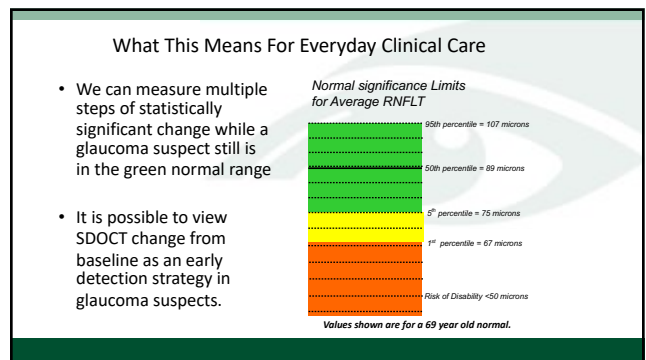
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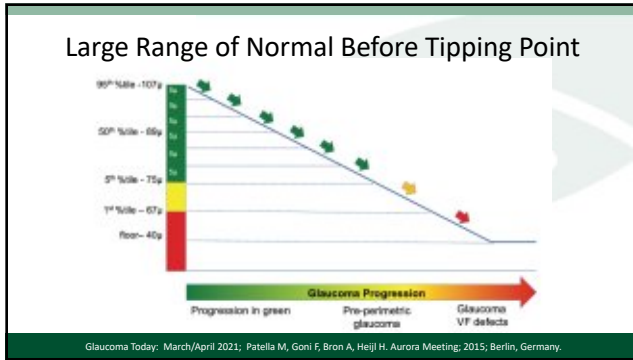
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Hacks/Tips #8

The OCT can show glaucomatous change **BEFORE** it is seen on visual fields

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Estimating the Lead Time Gained by Optical Coherence Tomography in Detecting Glaucoma before Development of Visual Field Defects

Tanay M. Khong, MD,^{1,2} Chaoxi Zhang, MD,^{1,2} Linda M. Zangwill, PhD,¹ Robert N. Weinreb, MD,¹ Felipe A. Medeiros, MD, PhD^{1,2}
Ophthalmology. 2015 Oct;122(10):2002-9.

- At 95% specificity, up to **35% of eyes had abnormal average RNFL thickness** 4 years before development of visual field loss and **19% of eyes had abnormal results** 8 years before field loss.
- Conclusions:** Assessment of RNFL thickness with OCT was able to detect glaucomatous damage before the appearance of VF defects on SAP. In many subjects, significantly large lead times were seen when applying OCT as an ancillary diagnostic tool.

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Hacks/Tips #8

The OCT can show glaucomatous change **BEFORE** it is seen on visual fields

Hacks/Tips #9

A change of ≥ 10 microns from previous measurements is significant

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Case MC

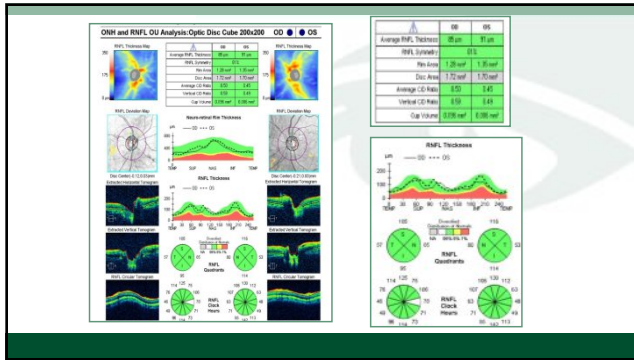
- 73 yo female presents for follow up: GL Suspect
- Past history single elevated IOP
- BCVA 20/25 and 20/20
- IOP 21 RE 19 LE;
 - CCT 560u R 565u L
- Anterior segment normal
- Mild NS and cortical cataracts

143

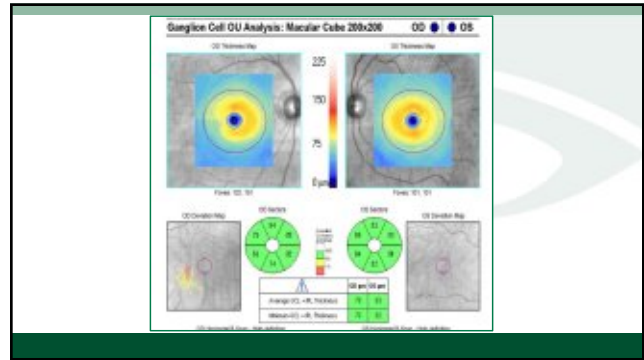
The ON

- Small optic discs OU
- RE c/d ~ 0.6 but
 - Appeared saucerized infero temporally
- LE c/d .35

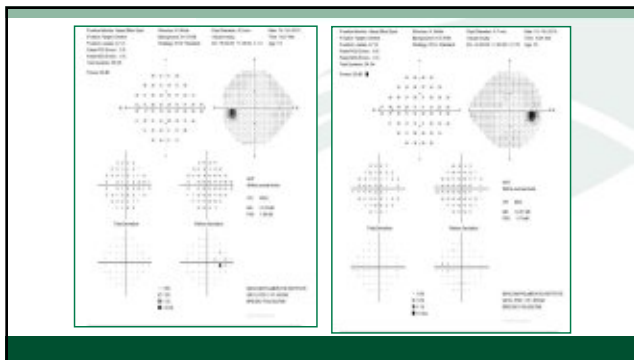
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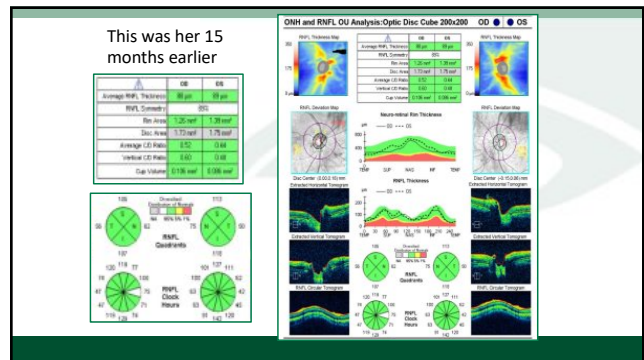
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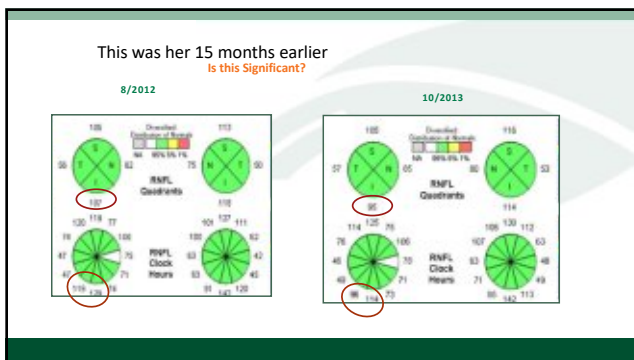
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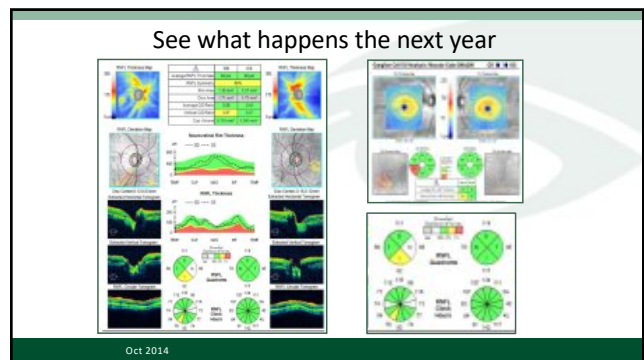
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148



149

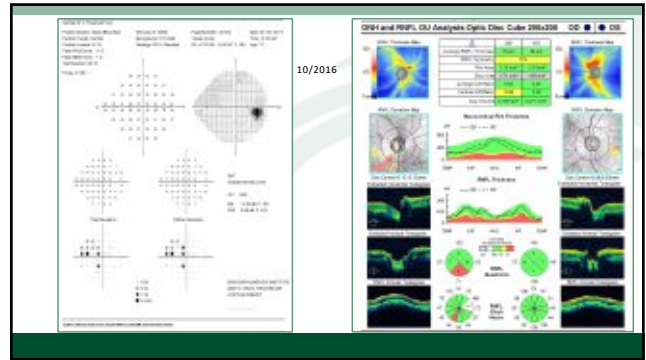


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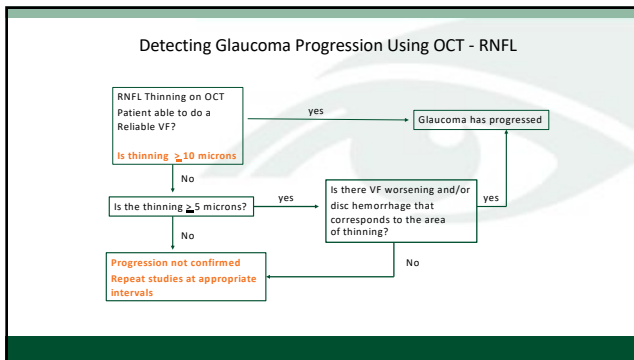
Case MC progression

- Clinical suspicion proved true
- Initial progression in normal range and continued
 - Rate is important consideration
- Treatment initiated
- Subtle corresponding VF defect evolved
- Currently stable in short term on well tolerated meds

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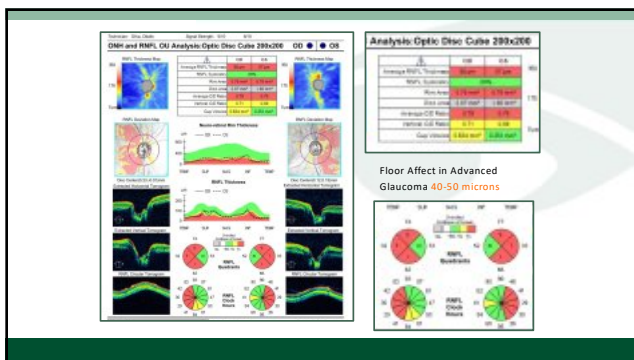
Hack/Tip # 10

The SDOCT is not a sensitive with more severe glaucoma

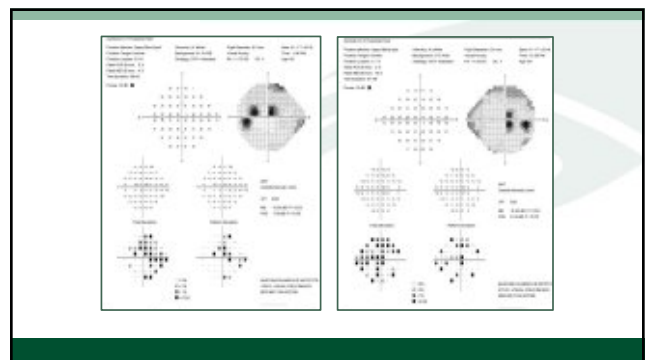
- Floor Effect in Advanced Glaucoma ~40-50 microns
- Difficult to use the OCT to measure progression

Visual Fields become more important....particularly 10-2 VF

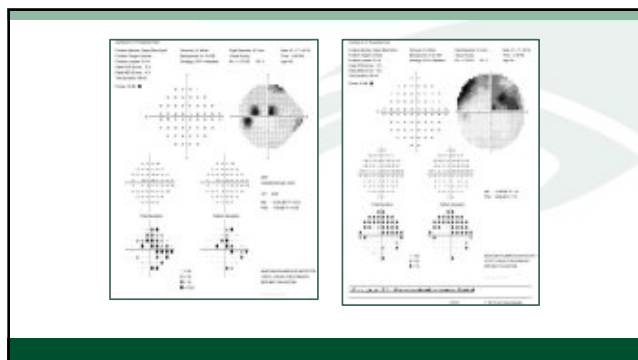
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Summary OCT in Glaucoma

- OCT provides another piece information for the “glaucoma puzzle”
 - Along with IOP, visual fields and clinical appearance of the nerve
- It provides an objective means of comparing “glaucomatous” nerves from normal or physiologic optic nerve
- It provides an objectives means of determining progression

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Summary: OCT in Retina

- SD OCT has emerged as a critical tool in the diagnosis and treatment of retinal disease
- It has changed how we evaluate the macula
- Helps establish a diagnosis that is difficult to determine with only standard ophthalmology
- Advancing software has provided expanded uses OCT
- OCT Angiography has taken OCT to the next level

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