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, Joel S. Schuman, William G. Stinson, Warren Chang, Michael R. Hee, Thomas Flotte, Kenton Gregory, 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 ~10^{-10} 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 mange 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"

5

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

6

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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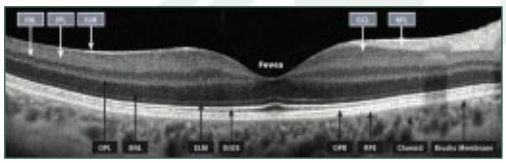
Hack/Tip # 1

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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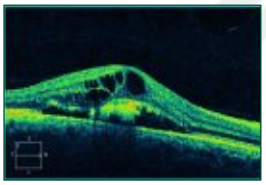
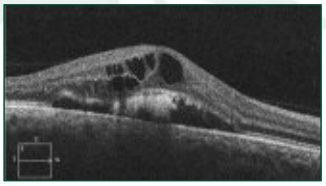
Simple Tip

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





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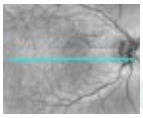
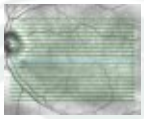
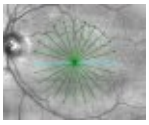
Remember: Many different Options for Visualization of Macular Detail



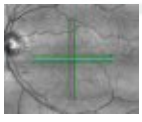
HD 1 Line 100x
- 100x averaged
- VIVID™ image Enhancement Technology
- Improved vitreous assessment
- Publication quality image



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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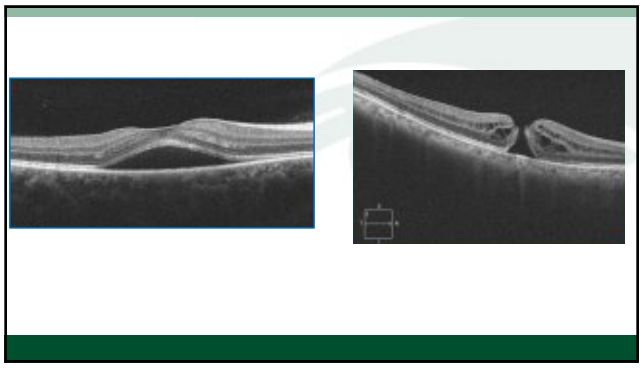

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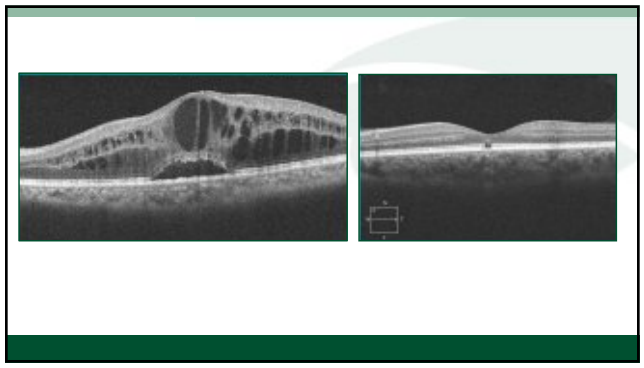

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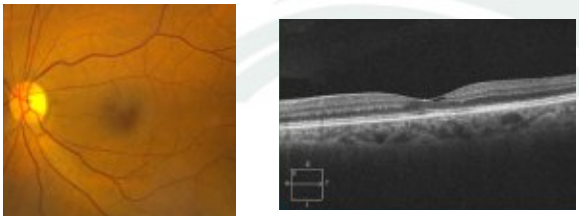
What does this “signature” OCT represent?



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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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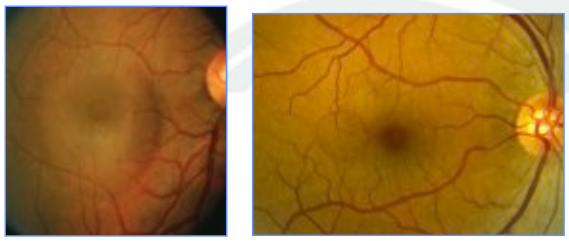
Where is the Fluid?



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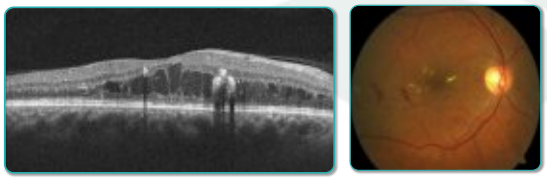
Diabetic Macular Edema (DME)



SD-OCT of a retina with DME

Color Fundus photo with DME

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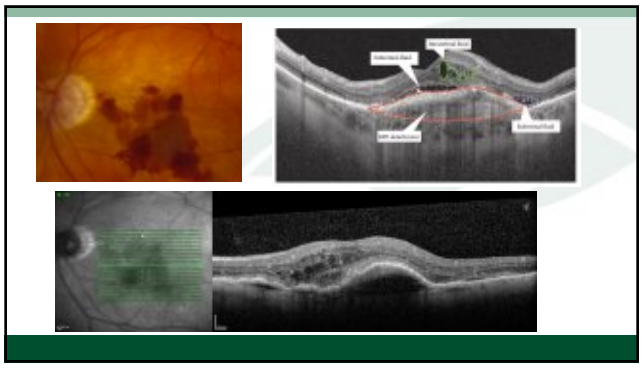

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Hack/Tip # 4:
Is there Fluid?

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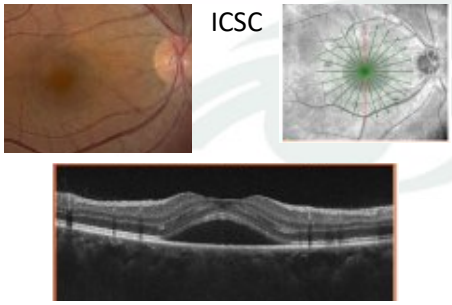

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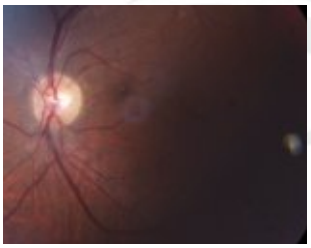
Poor Vision Following Cataract Surgery

AC IOL
Never Saw Well
VA: 20/200



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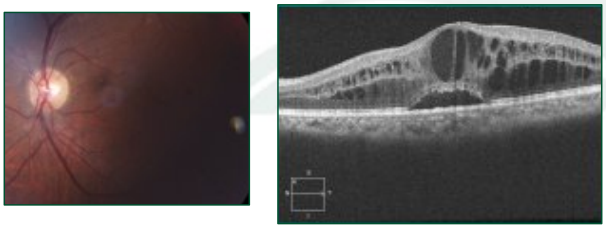

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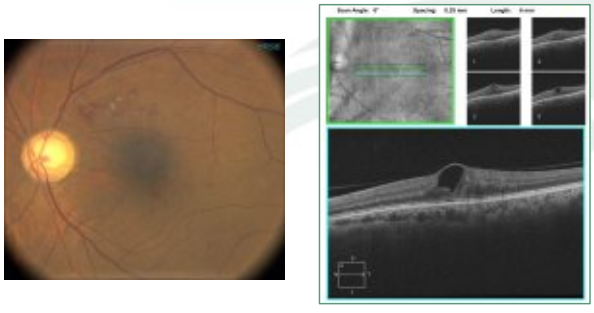

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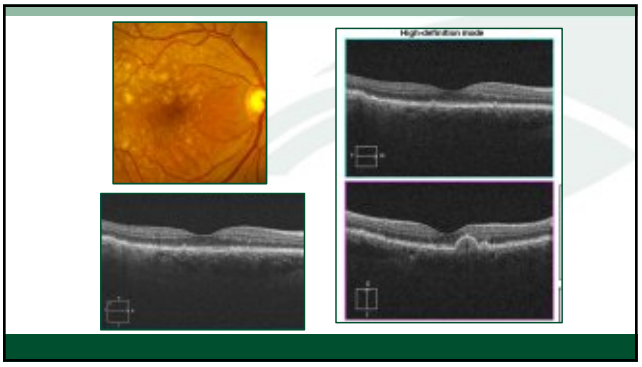
74 yo Hispanic Female

20/20 20/25

25



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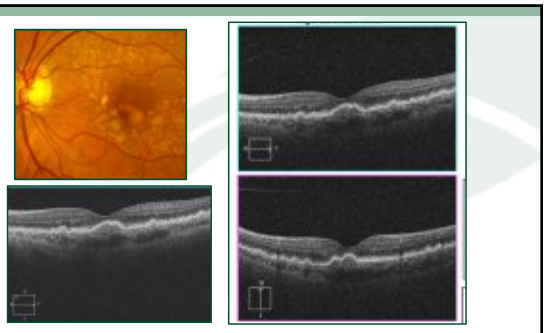

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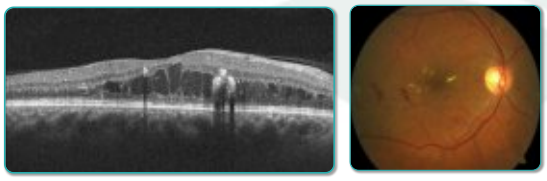
Diabetic Macular Edema (DME)



SD-OCT of a retina with DME Color Fundus photo with DME

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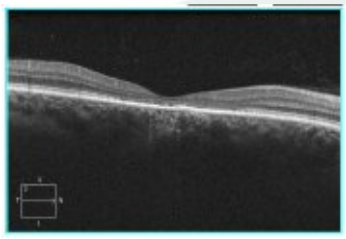
Hack/Tip # 5:
What is the Status of the IS/OS Junction?



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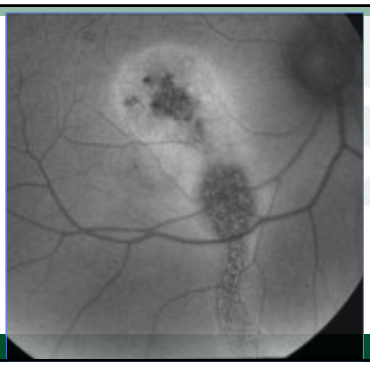

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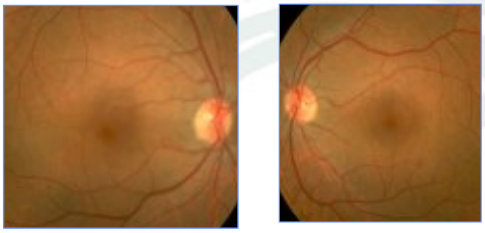
Plaquenil Toxicity



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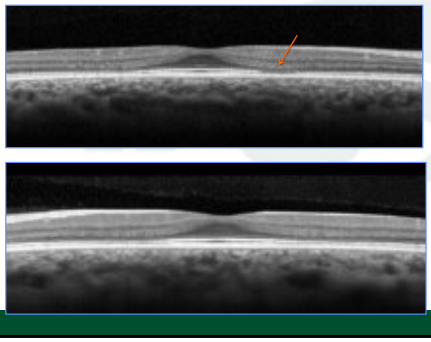

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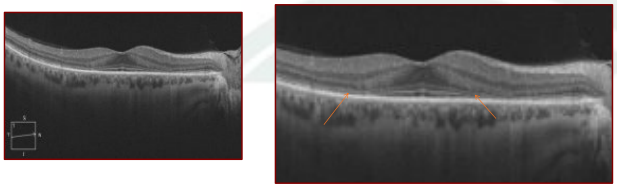
Plaquenil Toxicity



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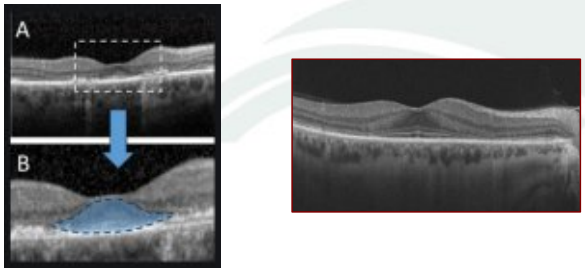

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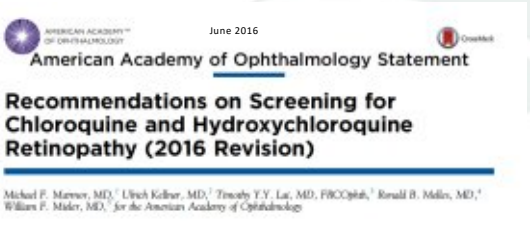
Even Newer Recommendations on Screening for Plaquenil Toxicity



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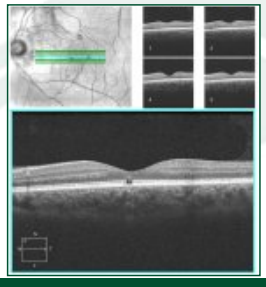
Solar Maculopathy

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



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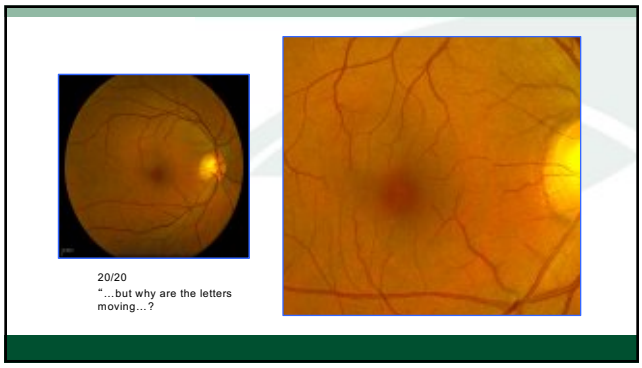

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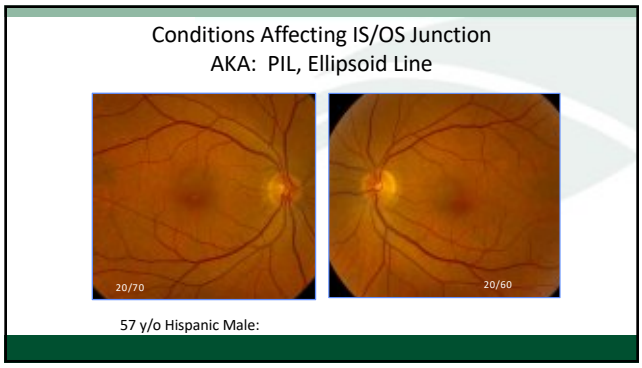

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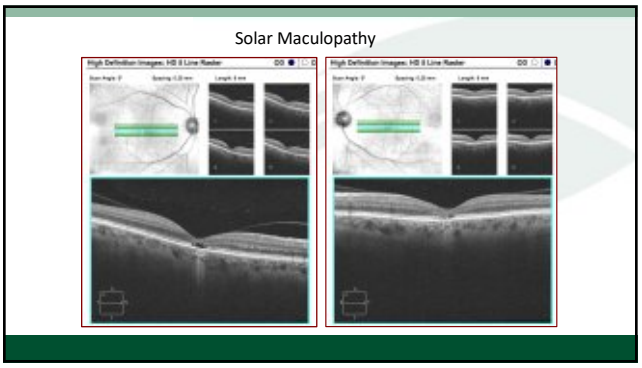

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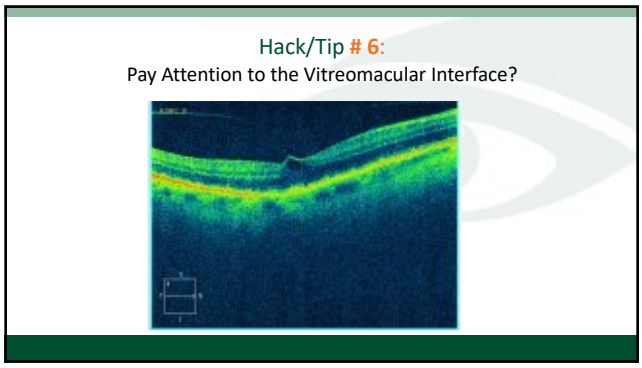

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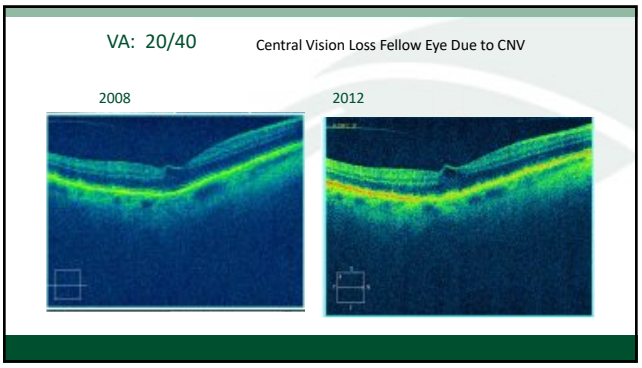

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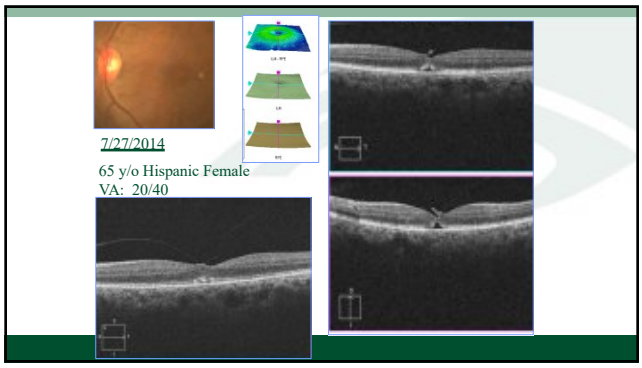

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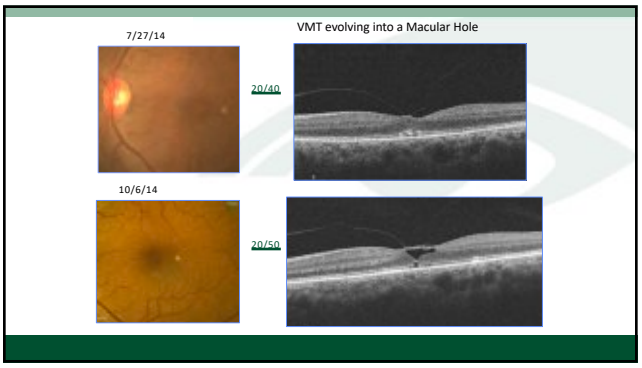

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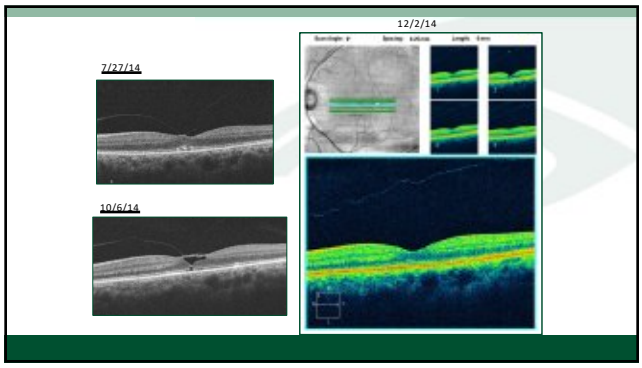

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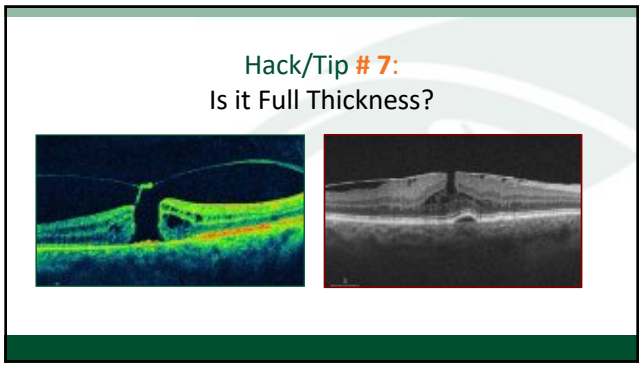

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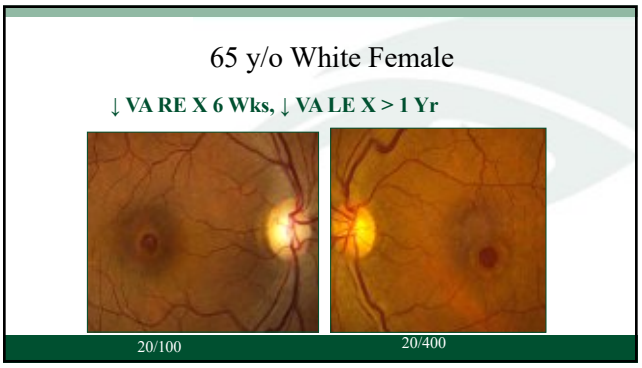

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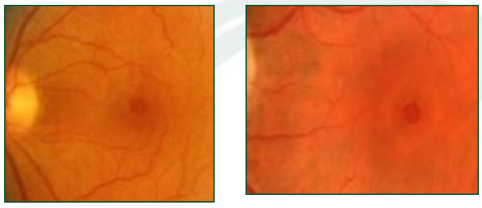
Pseudoholes vs. Full Thickness Holes



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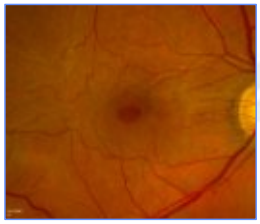

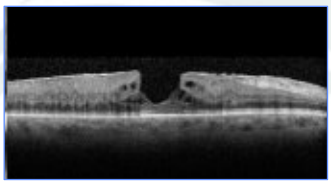

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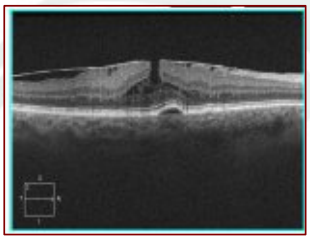

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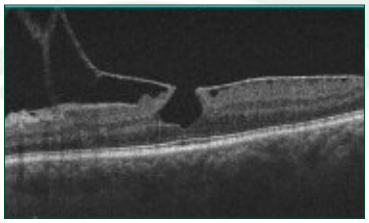

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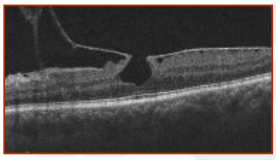
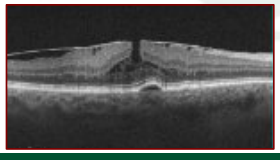


Both are Pseudoholes



Lamellar Hole

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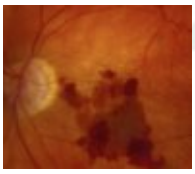
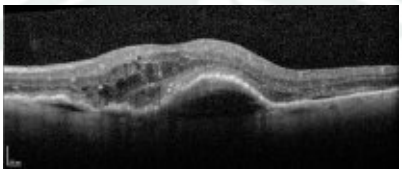
Hack # 8

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





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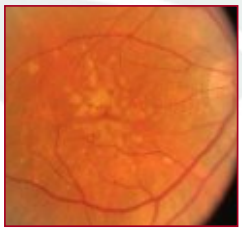
Risk Factors for Progression to Wet AMD

- 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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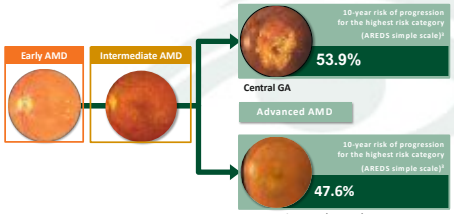
AMD Is the Leading Cause of Blindness for Caucasians in the US[1]



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):477-485. 2. Ferris FL, et al. Ophthalmology. 2013;120(4):844-851. 3. Chew EY, et al. JAMA Ophthalmol. 2014;132(3):272-277. 4. Age-Related Study Disease Study Research Group. Arch Ophthalmol. 2005;123(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

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

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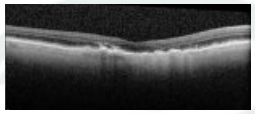
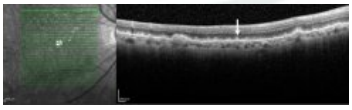
OCT Biomarkers May Help Predict Conversion to GA or Wet AMD

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





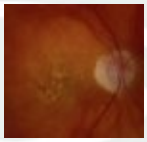
Life **2022**, *12*, 36. https://doi.org/10.3390/life12010036 https://www.mdpi.com/journal/life

58

OCT Biomarkers May Help Predict Conversion to GA or Wet AMD

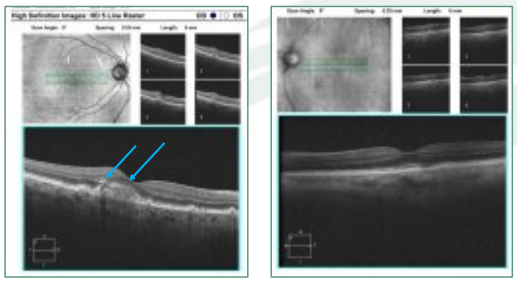
Hyper-Reflective Foci (HRF)

- 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



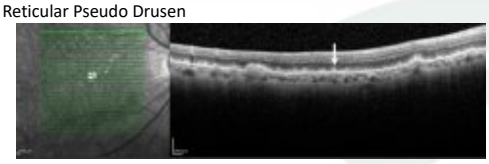
59

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



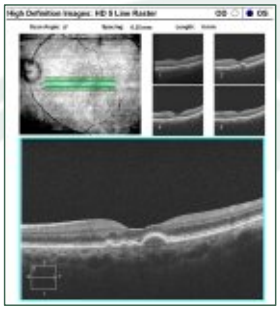
60

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

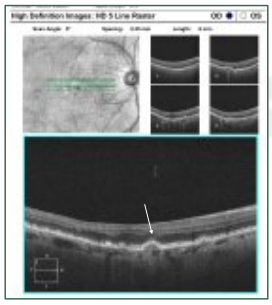
61



62

69 yo Hispanic Male

63



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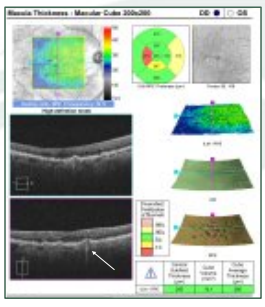
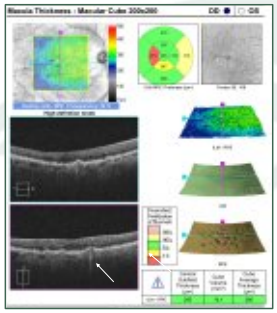


65

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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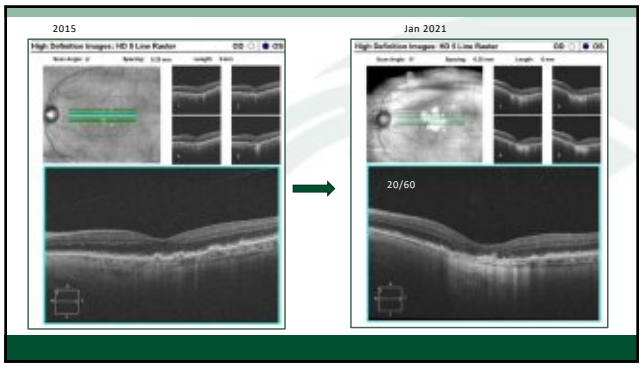

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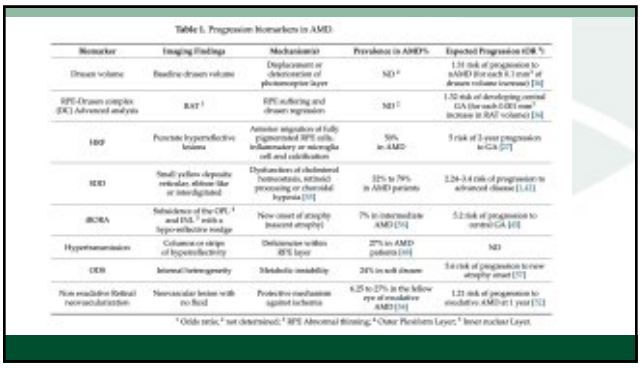
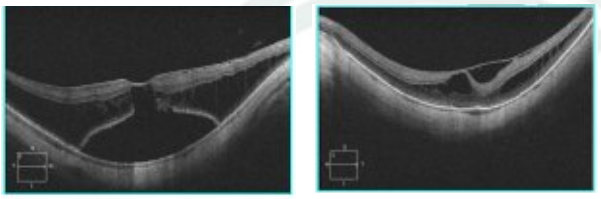


68

Hack # 9

Try to scan your high myopes



69

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

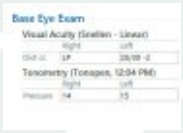
- Never recovers vision in the RE
- He is followed through the 90's with a progressive NS and declining Va ~ 20/70
  - 1 eyed patient and reluctant to have CE
- Eventually has CE/IOL 90's-early 2000's and does well
  - VA 20/25 low refractive error

70

71

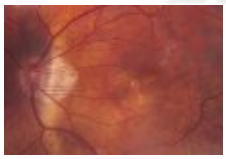
72

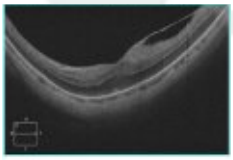
Jeff: High Myopia and VMT



3/11/19

- Feels Vision is slightly worse, increase in distortion





73

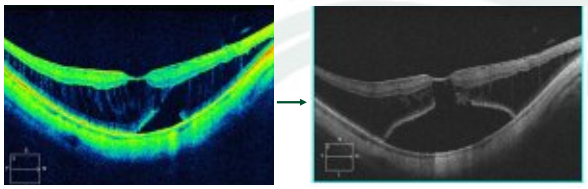
Myopic Macular Retinoschisis

- Seen in 9% of highly myopic eyes with posterior staphyloma
- 50% progress to macular hole formation or macular detachment within 2 yrs
- Caused by rigidity of ILM that induces traction

74

Initial Visit

1 year later

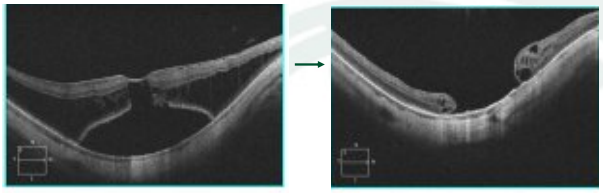


20/200

75

Pars Plana Vitrectomy

2 years after initial presentation

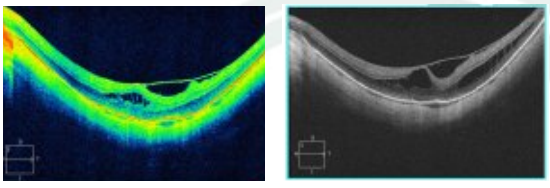


76

Pseudophakia – was myopic all her life

LE Initial Presentation

1 year later

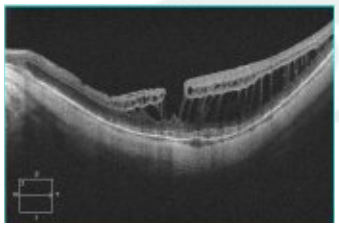


20/40 → 20/80 Has PPV

77

After Vitrectomy

Had a Vitrectomy -> 1 year later 20/40



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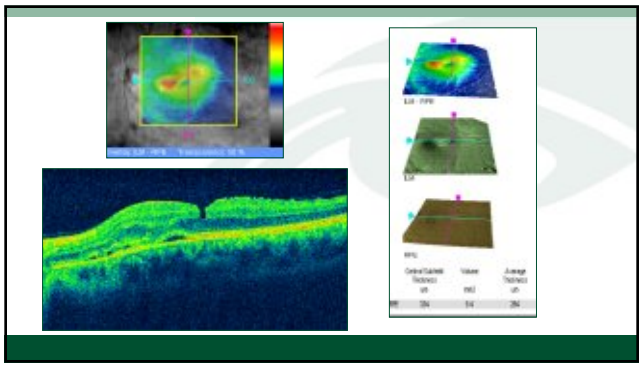
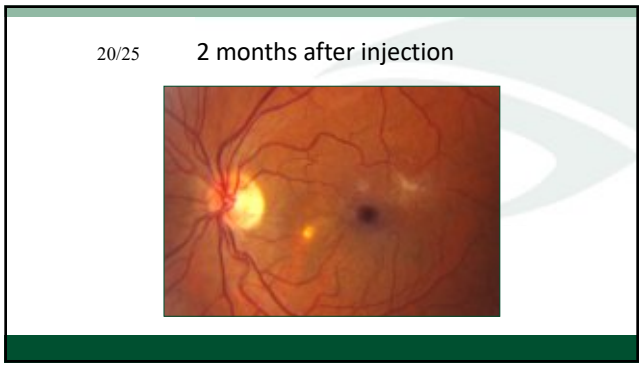


81

Diagnosis

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

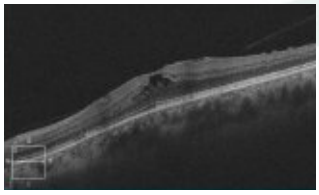
82

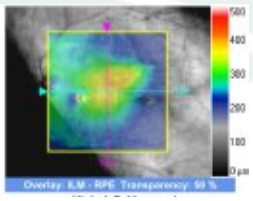


83

84

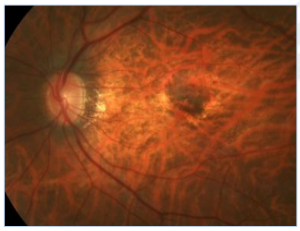
January 2019
10 years later





85

Degenerative Myopia with CNV



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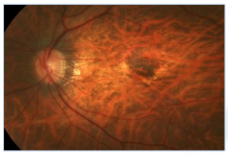
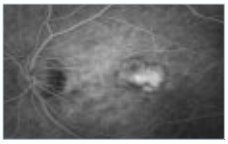
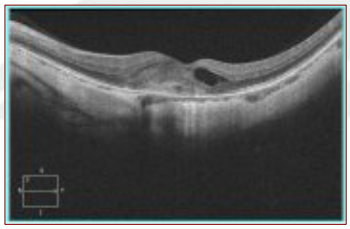






87

Hack/Tip # 10:

OCT Angiography (OCTA) is a great non-invasive tool to view the microvascular

88

Latest Advancement in OCT Technology

OCT Angiograpy (OCTA)

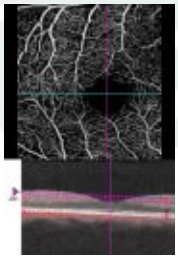
- Zeiss
  - On the Cirrus 5000, Cirrus 6000
- OptoVue
  - Avantis
- Heidelberg Spectralis
- Canon

89

OCT Angiography (OCTA)

The Basic Idea of How it Works:

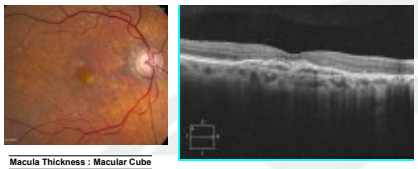
- **Capturing motion** in the retina
- Scans at 68,000 A-scans per second
  - Traditional SD OCT scan at 28,000 to 40,000 A- scans per second
- Compares repeat scans acquired at the same position in the retina to look for changes - motion



90

92 yo Hispanic Female
Blurred VA OU with current Rx -> BCVA: RE 20/40, LE 20/30

91



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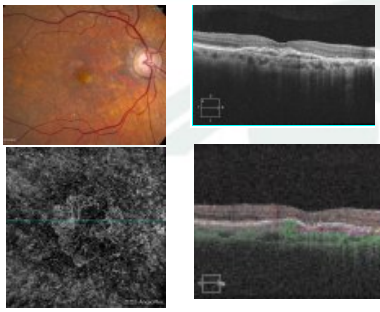
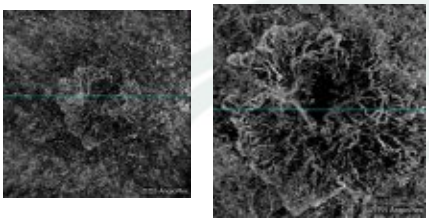


93

OCTA RE



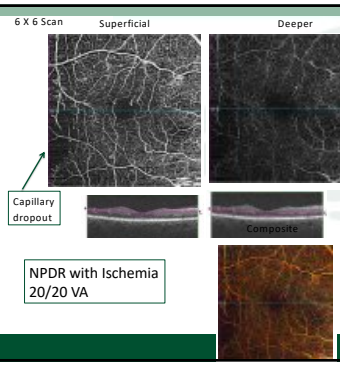
6 X 6

3 X 3

94

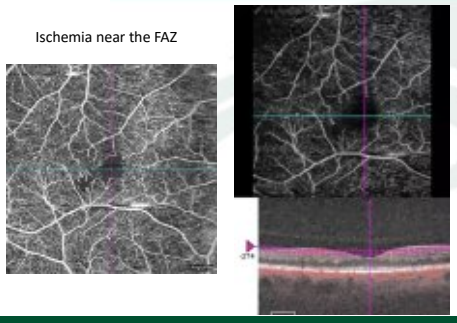
Diabetic Retinopathy

95



96

Ischemia near the FAZ



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What's Next in OCT?

Notal Home-OCT

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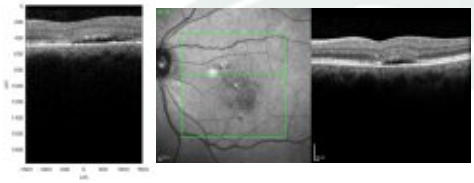
Notal Home-OCT vs. Heidelberg Spectralis

(No Averaging) With Averaging



Notal Home OCT Spectralis

99

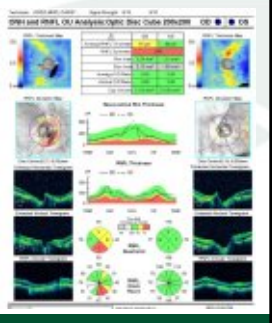
10 Hacks/Tricks for OCT Interpretation in Glaucoma

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

100

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



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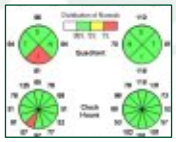
Hack/Tip #2
Do 3 RNFL scans at a time

- 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



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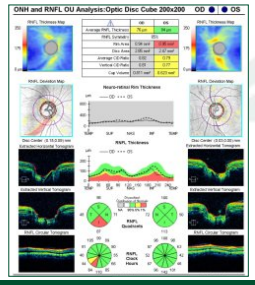
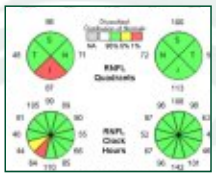
How much change needs to occur on an OCT RNFL for it to be significant?

104

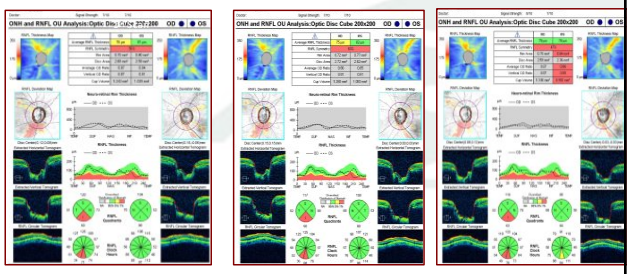
RNFL Quadrants and Clock Hours





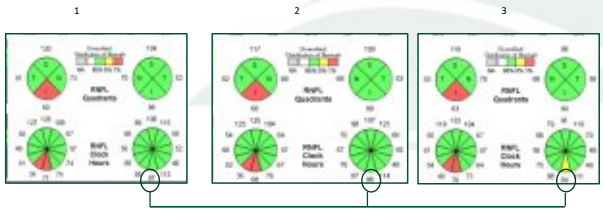
Inter-visit Tolerance:
Clock Hours: ~ 4-5 microns
Quadrant: 8-10 microns

105



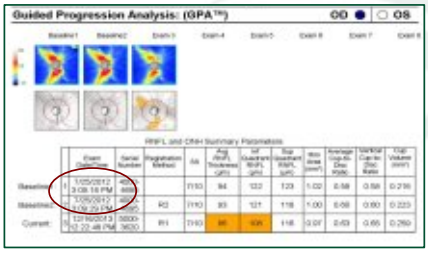
106

107



108

Using 2 of the initial scans as the baseline for GPA



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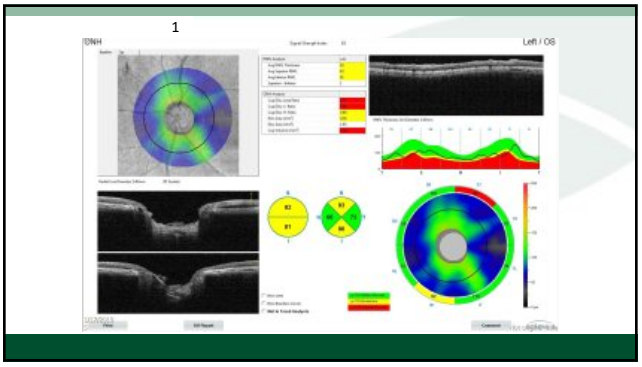

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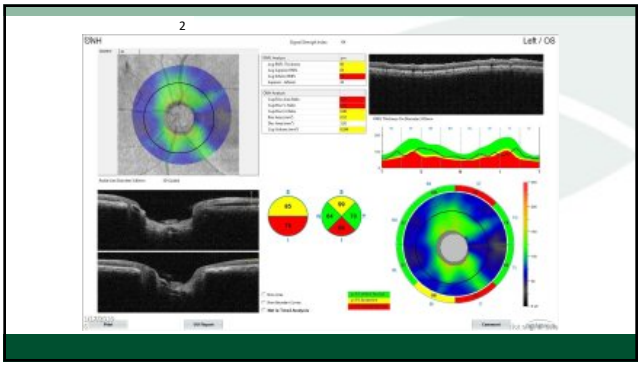

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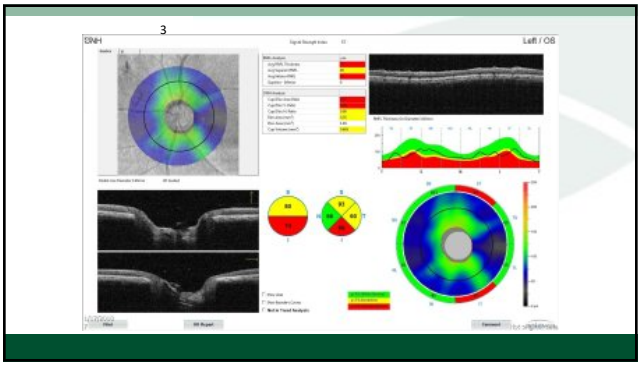

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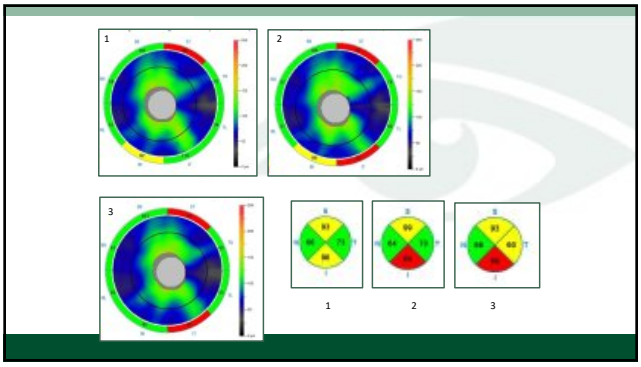
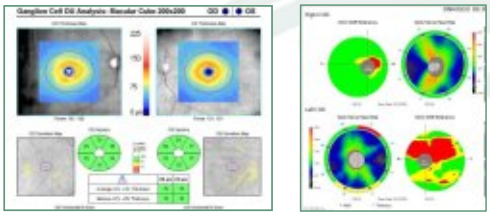


113

Hack/Tip # 3

GCC is valuable and often correlates well with the RNFL (but not always)



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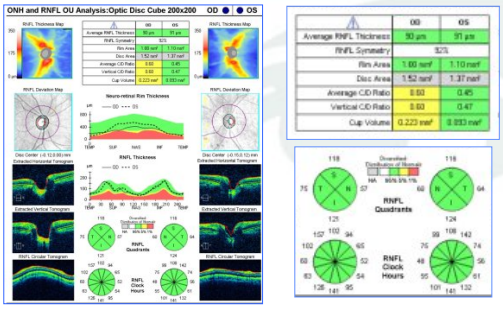

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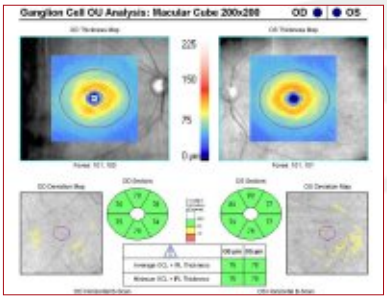

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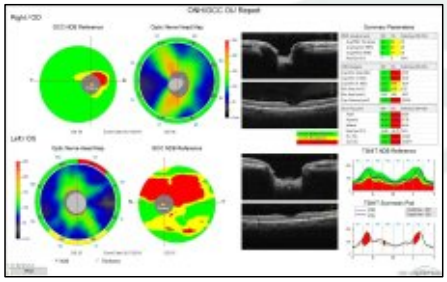
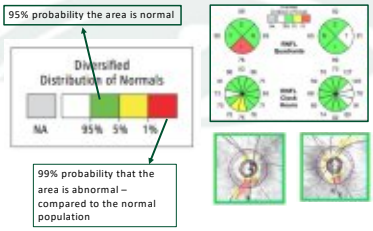


117

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 then 18 yo



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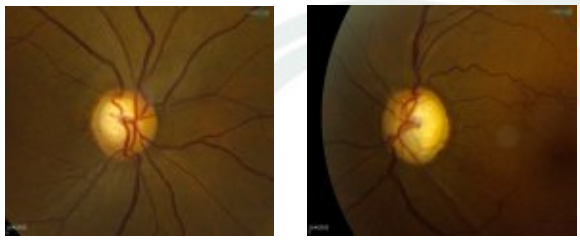
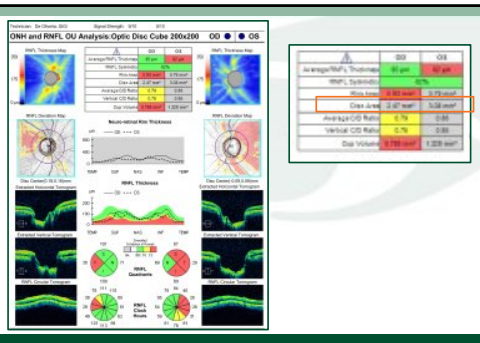
11/4/2013: Ta 14/13



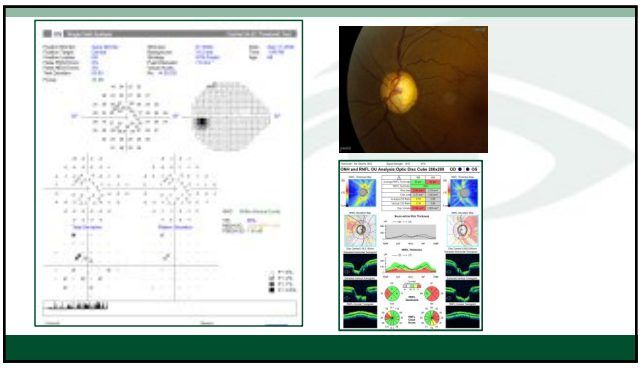
119

2019



120

121



122

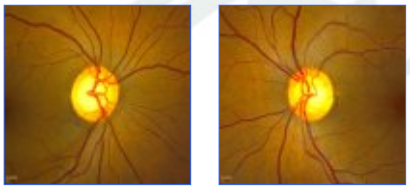
Hack/Tip #5

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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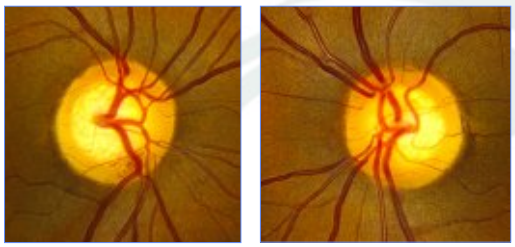

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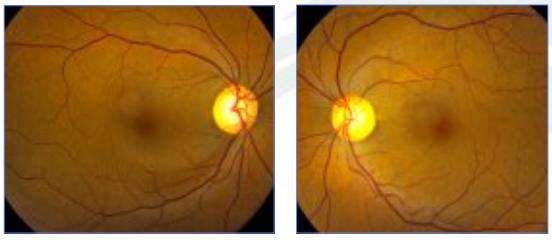
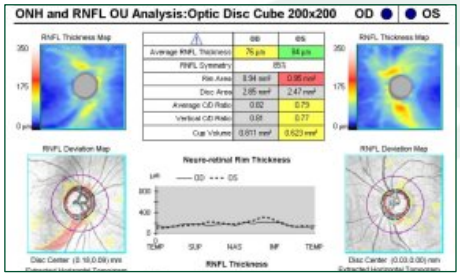


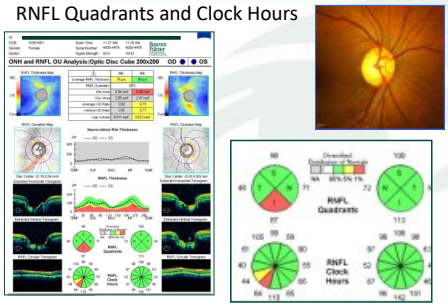
126

The Anatomy of the RNFL Printout



127

RNFL Quadrants and Clock Hours



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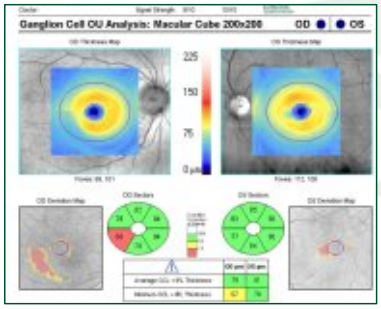

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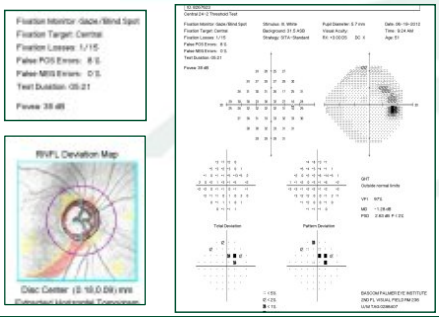
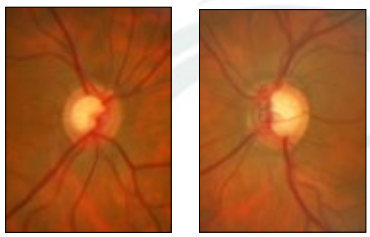


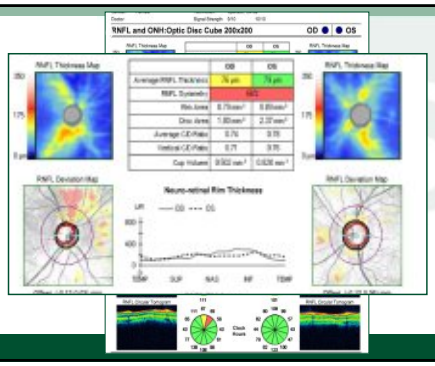
130

Watch Out for **Red** Disease!



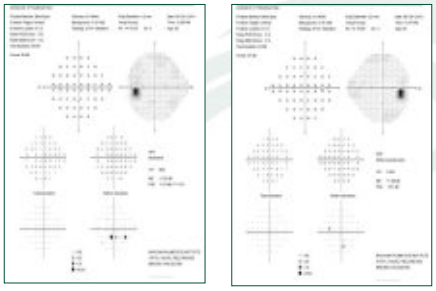
TA: 12 to 14 on T5 bid, ~ 16 off T5

131



132

6/25/2010



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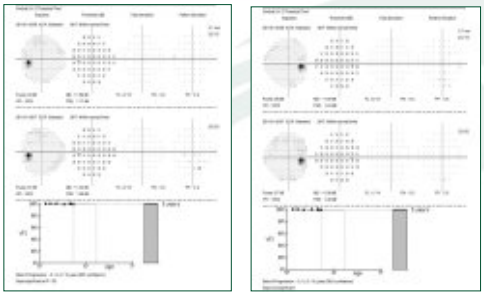


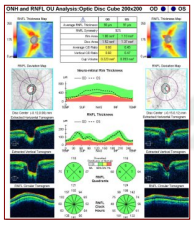
134

Hack/Tip **#7**

Be on the lookout for **Green Disease**

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

135



The Anatomy of the RNFL Printout

	OD	OS
Average RNFL Thickness	90 µm	91 µm
RNFL Symmetry		92%
Rim Area	1.00 mm²	1.10 mm²
Disc Area	1.52 mm²	1.37 mm²
Average C/D Ratio	0.60	0.45
Vertical C/D Ratio	0.60	0.47
Cup Volume	0.223 mm³	0.093 mm³

Average RNFL Thickness Ranges ~ 75 -110 microns

Tipping Point = 75 microns

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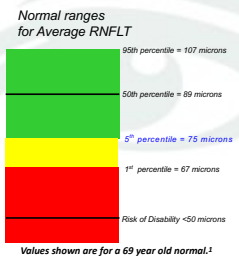
There is a Large “Range” of Normal

- *Just like perimetry, the average patient can lose a third of his/her RNFL or neuro-retinal rim and still be inside the normal range.*

Average RNFL Thickness 75 microns – tipping point

Floor Affect in Advanced Glaucoma 40-50 microns



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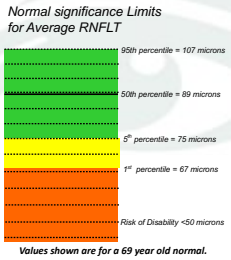
What This Means For Everyday Clinical Care

- We can measure multiple steps of statistically significant change while a glaucoma suspect still is in the green normal range
- It is possible to view SDOCT change from baseline as an early detection strategy in glaucoma suspects.



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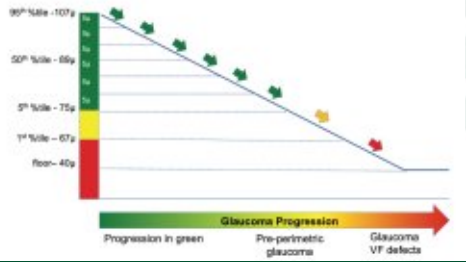
Large Range of Normal Before Tipping Point



Glaucoma Today: March/April 2021; Patella M, Goni F, Bron A, Heijl H. Aurora Meeting; 2015; Berlin, Germany.

139

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

Tanvey M. Kuang, MD,[1,2] Chanuor Zhang, MD,[1,3] Linda M. Zangwill, PhD,[1] Robert N. Weinreb, MD,[1] Felipe A. Medeiros, MD, PhD[1]

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

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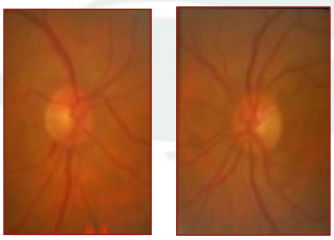
The ON

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



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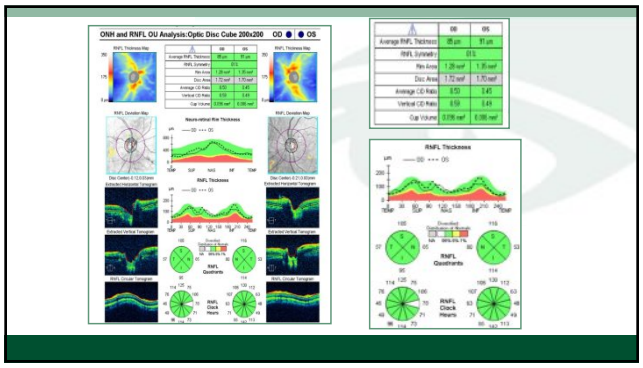

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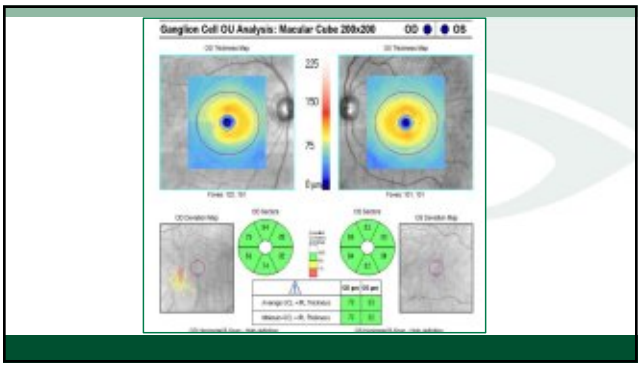

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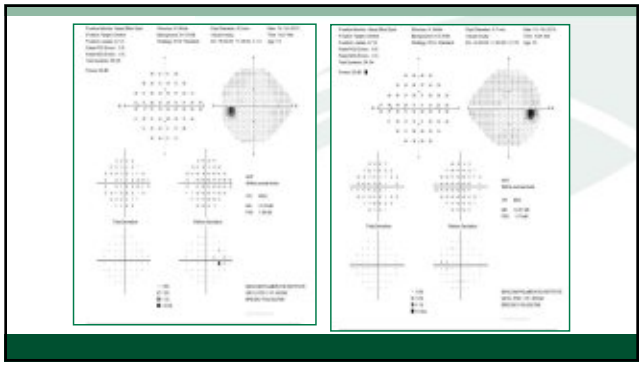
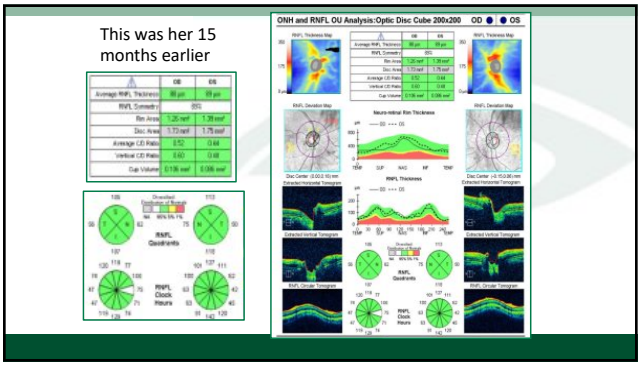


147

This was her 15 months earlier



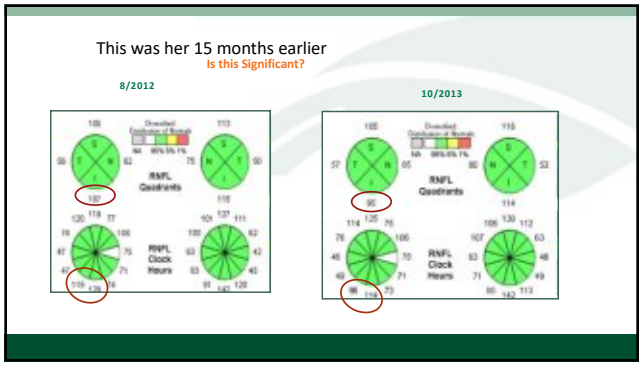
148

This was her 15 months earlier

Is this Significant?

8/2012

10/2013



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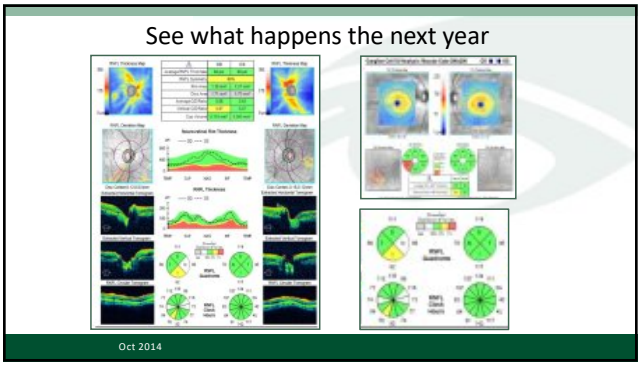
See what happens the next year



Oct 2014

150

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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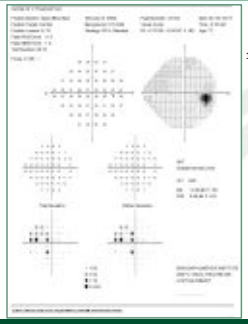
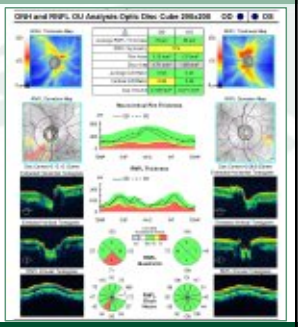


10/2016



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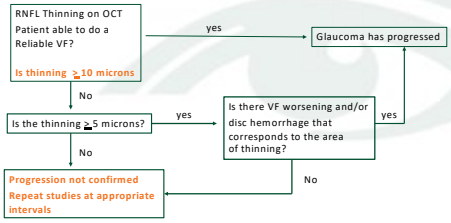
Detecting Glaucoma Progression Using OCT - RNFL



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Hack/Tip # 10

The SDOCT is not a sensitive with more severe glaucoma

- Floor Affect 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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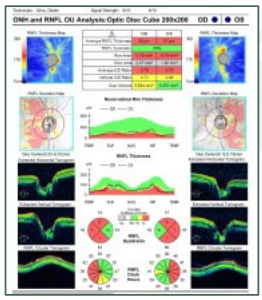
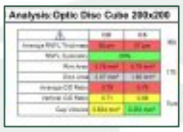
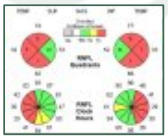




Floor Affect in Advanced Glaucoma 40-50 microns



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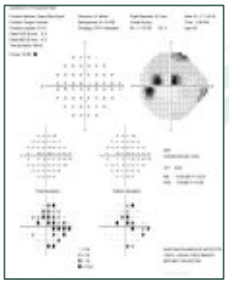

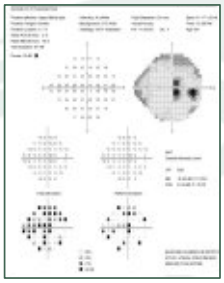

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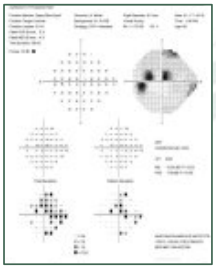
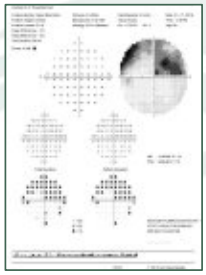

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Summary OCT in Glaucoma

- 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 ophthalmolcopy
- Advancing software has provided expanded uses OCT
- OCT Angiography has taken OCT to the next level

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