OCT Evaluation of the Retina and Optic Nerve

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Disclo$ure

- Bozung: No relevant financial relationships with commercial interests
- Wooldridge: Speakers Bureau/honoraria from Aerie, Alcon, Allergan, Bausch & Lomb, Biotissue, Centervue, Oculus, Optovue, Reichert, Synemed

OCT Evaluation of the Retina

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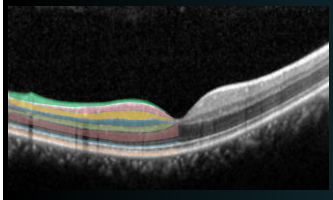
Retina Refresher



10. (ILM) Internal Limiting Membrane
9. (NFL) Nerve Fiber Layer
8. (GCL) Ganglion Cell Layer
7. (IPL) Inner Plexiform Layer
6. (INL) Inner Nuclear Layer
5. (OPL) Outer Plexiform Layer
4. (ONL) Outer Nuclear Layer
3. (ELM) External Limiting Membrane
2. (IS/OS or PIL) Inner/Outer Segment
1. (RPE) Retina Pigmented Epithelium

Topics

1. Where is the fluid
2. Common entities
3. Masqueraders
4. Going below and beyond
5. Take a second look

Topics

1. Where is the fluid
2. Common entities
3. Masqueraders
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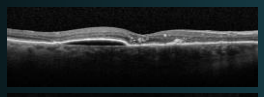
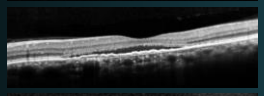
1. Where is the Fluid?

- Describing fluid location

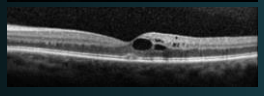
A. Sub-RPE



B. Subretinal

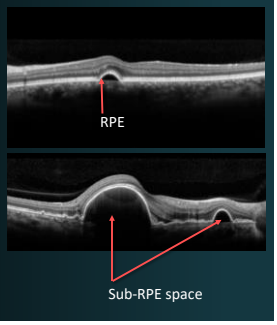


C. Intraretinal



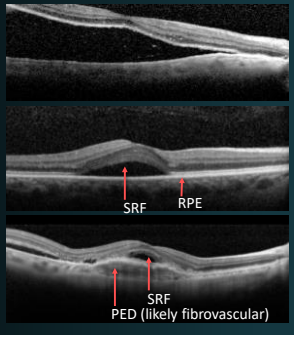
A. Sub-RPE Fluid

- Key Features:
  - Hyporeflective space
  - Directly *below* RPE
  - Often "bubble-like", but can be irregular
- Aka Pigment epithelial detachment (PED)



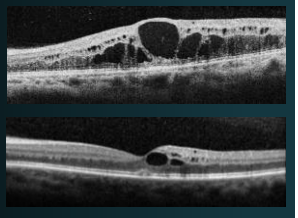
B. Subretinal Fluid (SRF)

- Key Features:
  - Hyporeflective space
  - Directly *above* RPE



C. Intraretinal Fluid

- Key Features:
  - Rounded, hyporeflective spaces
  - Within central retinal layers
- Aka Cystoid Macular Edema (CME)



Topics

1. Where is the fluid
2. Common entities
3. Masqueraders
4. Going below and beyond
5. Take a second look

2. Common entities

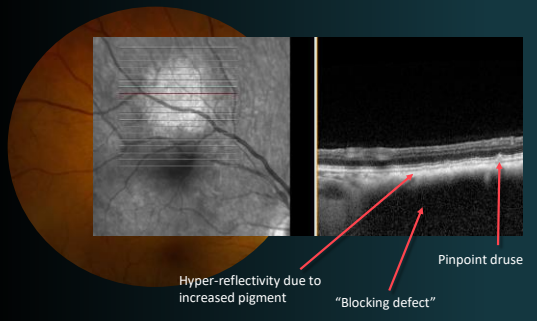
- Retina
  - Choroidal nevus
  - Retinal detachment
- Macula
  - Age related macular degeneration
  - Macular edema
  - Vitreoretinal interface
  - Epiretinal membrane
  - Macular hole

Choroidal Nevus

- Common features on OCT
  - Increased choroidal hyperreflectivity
  - Posterior blocking defect
  - Overlying drusen
  - Minimal thickness

Choroidal Nevus

Choroidal Nevus



Choroidal Nevus

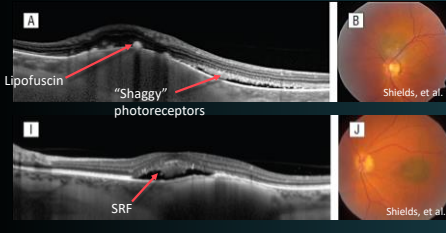
Choroidal Nevus

- Juxtapapillary choroidal nevus

Shields CL, Kaliki S, Rojanaporn D, Ferenczy SR, Shields JA. Enhanced Depth Imaging Optical Coherence Tomography of Small Choroidal Melanoma Comparison With Choroidal Nevus. *Arch Ophthalmol*. 2012;130(7):850–856. doi:10.1001/archophthalmol.2012.1135

Choroidal Melanoma

- OCT features of small choroidal melanoma include SRF, increased thickness, subretinal lipofuscin, and structural retinal alterations.

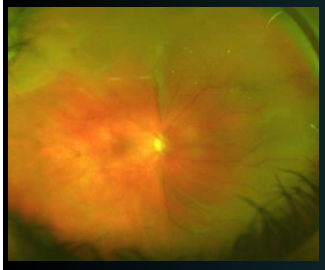


Shields CL, Kaliki S, Rojanaporn D, Ferenczy SR, Shields JA. Enhanced Depth Imaging Optical Coherence Tomography of Small Choroidal Melanoma Comparison With Choroidal Nevus. *Arch Ophthalmol*. 2012;130(7):850–856. doi:10.1001/archophthalmol.2012.1135

Retinal Detachment

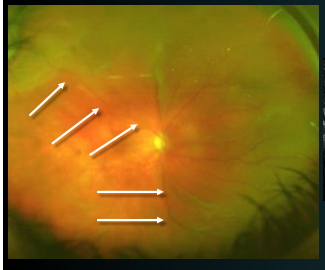
- Common features on OCT
  - Extensive subretinal fluid
  - Flat or corrugated retina
  - Intact RPE/Bruchs complex

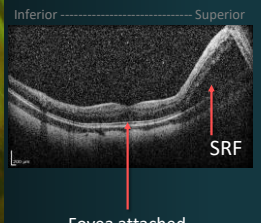
Case 1: Retinal Detachment



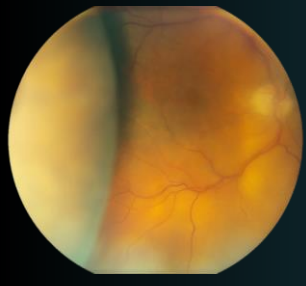
- 19 yo male
- 1 day of flashes, floaters, and vision loss OD
- Ophthalmic history:
  - Congenital cataract OU
  - PCIOL OD, Aphakia OS
  - Nystagmus
  - Glaucoma
  - HSVK OD
- BCVA OD 20/70 → 20/200
- Macula on or off?

Case 1: Retinal Detachment



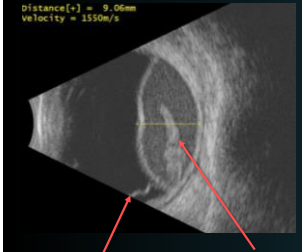


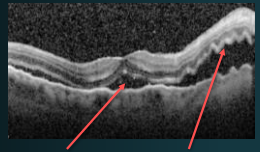
Case 2: Retinal Detachment



- 76 yo male
- 1 week vision loss OD
- Ophthalmic history:
  - PCIOL OD, NSC OS
- Medical history:
  - CAD, COPD, HTN
  - Clopidogrel, ASA 325mg
- BCVA OD 20/40
- Macula on or off?

Case 2: Retinal Detachment





Case 3: Retinal Detachment

- 82 yo female
- 2 days vision loss OD
- Ophthalmic history:
  - PCIOL OU
- Medical history:
  - Clopidogrel
  - Coronary stent
  - CHF, HTN, DM
- BCVA OD 20/50

Case 3: Retinal Detachment

Peripheral exudative hemorrhagic chorioretinopathy (PEHCR)

- Bilateral peripheral degenerative retinal condition
- Caucasians >70yoa
- Often referred to "Pseudomelanoma" due to dome-shaped exudative lesion
  - Ultrasound necessary

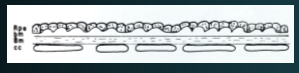
Age Related Macular Degeneration

- Common features on OCT
  - Drusen
  - Drusenoid PEDs
  - Fibrovascular PEDs
  - Geographic atrophy
  - Subretinal fluid

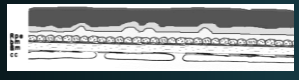
Types of Drusen

Sub-RPE, normal BM
"Classic Drusen"

Sub-RPE, thickened BM
Basal Laminar Drusen



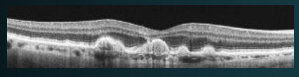
Sub-retinal
Reticular Pseudodrusen



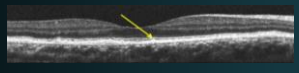
Mixed qualities

Types of Drusen

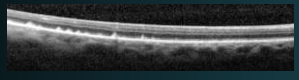
Sub-RPE, normal BM
"Classic Drusen"



Sub-RPE, thickened BM
Basal Laminar Drusen

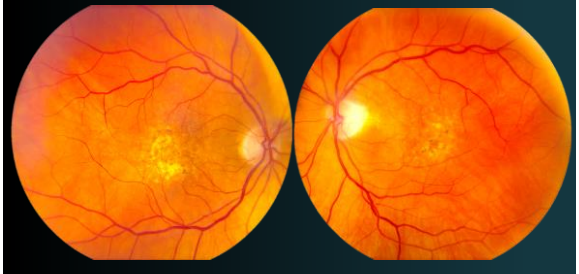


Sub-retinal
Reticular Pseudodrusen



Geographic Atrophy

Case 1: Non-exudative ARMD

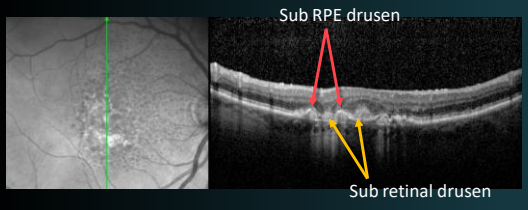


Bilateral RPE mottling and macular drusen

Case 1: Non-exudative ARMD

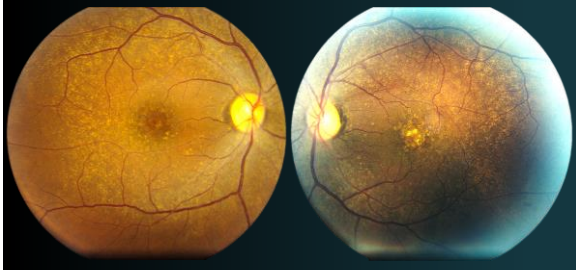
Color fundus photo | Infrared reflectance

Case 1: Non-exudative ARMD



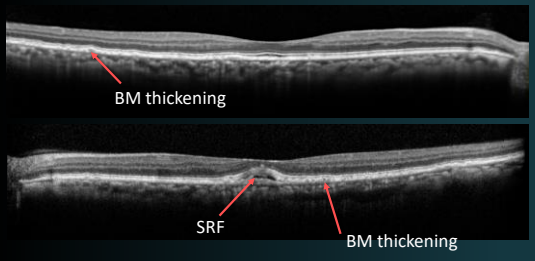
Combined “classic” and reticular pseudodrusen

Case 2: Non-exudative ARMD



Case 2: Non-exudative ARMD

Case 2: Non-exudative ARMD

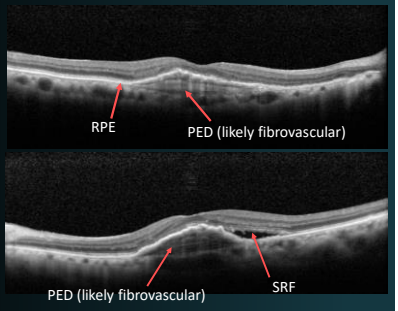


Basal laminar drusen with vitelliform macular detachment

Case 3: Exudative ARMD

Right eye

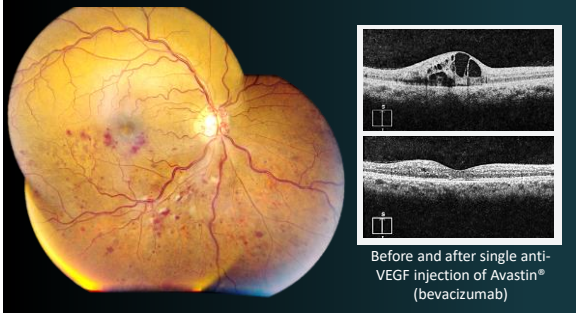
Left eye



Cystoid Macular Edema

- Common features on OCT
  - Rounded hyporeflective spaces
  - Typically located in outer plexiform layer
- Common etiologies
  - Cataract surgery
  - Diabetes
  - Retinal vein occlusion
  - Posterior uveitis

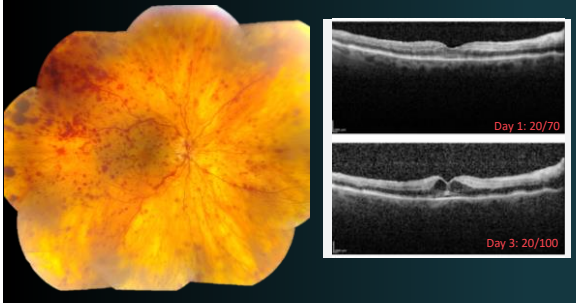
Case 1: CME



Before and after single anti-VEGF injection of Avastin® (bevacizumab)

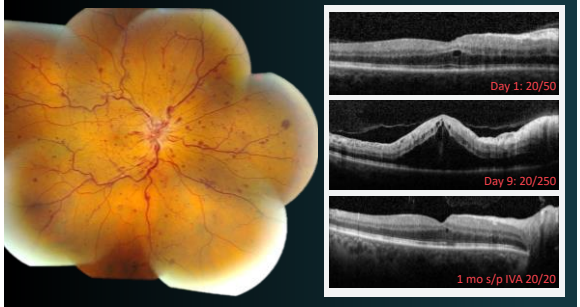
Hemicentral retinal vein occlusion with CME

Case 2: CME



Central retinal vein occlusion with CME

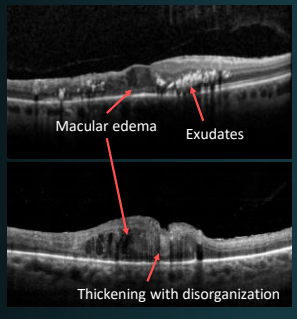
Case 3: CME



Central retinal vein occlusion with CME

CME: Diabetic Retinopathy

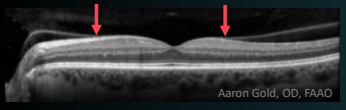
- OCT findings:
  - Exudates
  - Diffuse thickening
  - Disorganized retinal structure
  - Aka Diabetic macular edema (DME)



Vitreomacular Interface

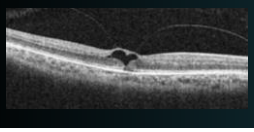
- Vitreomacular Adhesion (VMA)
  - Posterior hyaloid attachment to macula
  - NO distortion of macular contour
  - Asymptomatic
- Vitreomacular Traction (VMT)
  - Posterior hyaloid attachment to macula
  - Change in foveal contour or retinal morphology
    - i.e. surface distortion, pseudocysts, elevation of retina from RPE
  - May benefit from Jetrea® (ocriplasmin, Thrombogenics)

Vitreomacular Interface



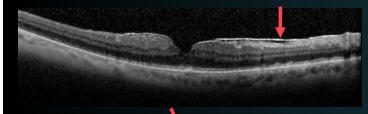
Vitreomacular Adhesion (VMA)

Vitreomacular Traction (VMT)



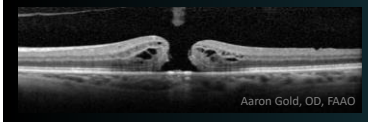
Vitreomacular Traction (VMT) with pseudocyst

Complications of Vitreomacular Traction



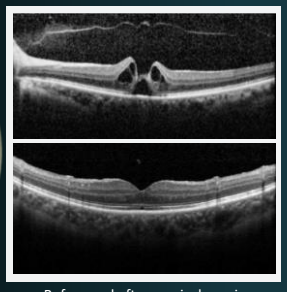
Epiretinal Membrane (ERM)

Stage 2 Macular Hole



Stage 4 Macular Hole (Full Thickness)

Complications of Vitreomacular Traction



Before and after surgical repair
20/400 → 20/30

Topics

1. Where is the fluid
2. Common entities
3. Masqueraders
4. Going below and beyond
5. Take a second look

3. Masqueraders of leakage

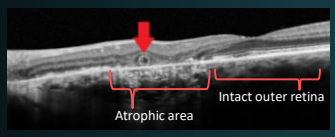
- Similar appearances, but underlying process differs
- True leakage is a *VEGF-mediated process*
- Masqueraders are typically *degenerative processes*
- Why does it matter??
  - Masqueraders typically do not respond to anti-VEGF injections

2. Masqueraders of leakage

- Common degenerative mimickers
  - Outer retinal tubulations (ORTs)
  - Macular telangiectasia (Mac Tel)
  - Retinoschisis

Outer Retinal Tubulations

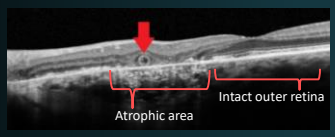
- Key Features:
  - Bright-banded encircling ring
  - Located in outer retina



Geographic atrophy (above) versus CME (below)

Outer Retinal Tubulations

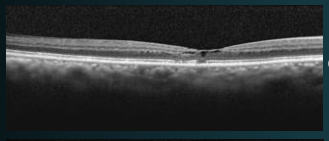
- Comprised of photoreceptor portions and ELM
- Causes:
  - Geographic atrophy
  - Outer retinal disease

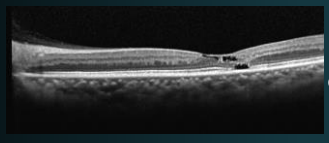


Geographic atrophy (above) versus CME (below)

Case 3

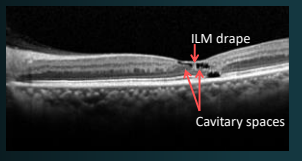
- 54 yo female
- Blur OU
- 20/30 OD, 20/25 OS





Case 3: Mac Tel

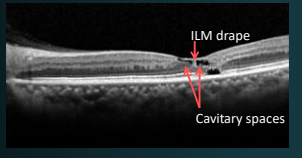
- Key features:
  - Cavitary foveal spaces
  - "ILM drape"
  - Mac Tel causes THINNING
  - CME causes THICKENING



Mac Tel (above) versus CME (below)

Case 3: Mac Tel

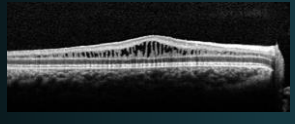
- Female > male
- Vision > 20/50
- Treatment:
  - Monitor

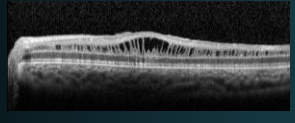


Mac Tel (above) versus CME (below)

Case 4

- 12 yo male
- Reduced vision OU
- 20/70 OD, 20/50 OS





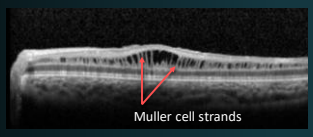
Case 4: Retinoschisis

- Key Features:
  - Elongated spaces
  - Inner/middle retina
  - Strand-like separations

Juvenile X-linked Retinoschisis (above) vs CME (below)

Case 4: Retinoschisis

- Causes:
  - Inherited retinal conditions
  - Pathologic myopia
  - Surgical
- Treatment:
  - Varied
  - (+/-) Carbonic anhydrase inhibitors



Juvenile X-linked Retinoschisis (above) vs CME (below)

Topics

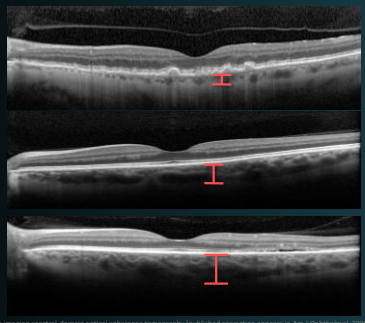
1. Where is the fluid
2. Common entities
3. Masqueraders
4. Going below and beyond
5. Take a second look

Going below and beyond

Thin

Normal
~320 to 330um[1]

Thick



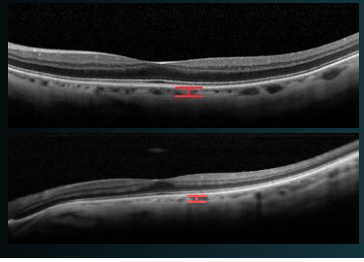
Spaide RF, Koizumi H, Pozzoni MC. Enhanced depth imaging spectral-domain optical coherence tomography [published correction appears in *Am J Ophthalmol*. 2009; 148(2):325]. *Am J Ophthalmol*. 2008;146(4):496-500

Choroidal Thinning

- Thinning with age
- Pathologic myopia
- AMD

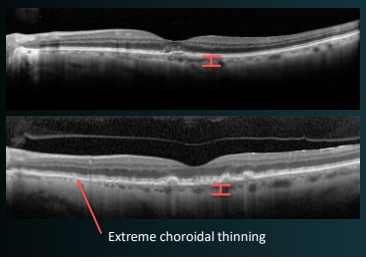
Choroidal Thinning

- Pathologic Myopia
  - Increased axial length



Choroidal Thinning

- AMD
  - Rate of thinning surpasses age-related controls



Choroidal Thickening

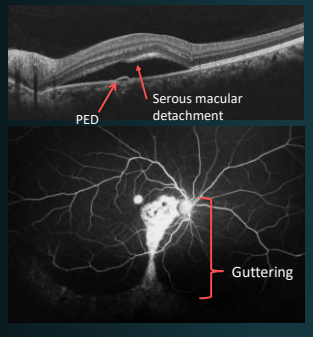
- Central Serous (CSCR)
- Polypoidal choroidal vasculopathy (PCV)

Case 5

- 35 yo female
- Blurred vision OS x 10 days
- 20/15 OD, 20/20 OS

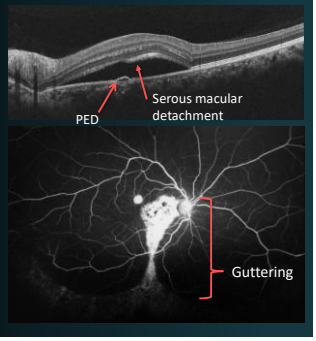
Case 5: Central Serous Chorioretinopathy

- Key Features:
  - PEDs
  - SRF
  - Thickened choroid



Case 5: Central Serous Chorioretinopathy

- Chronic signs
  - Pigmentary changes
  - "Guttering"
- Treatment
  - Discontinue steroids
  - Monitor

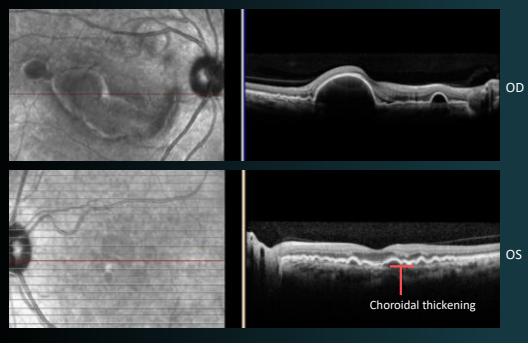


Case 6

- 43 yo female
- Blurred vision for >1 year OU
- 20/80 OD, 20/25 OS
- Diagnosed with AMD last year
- …AMD in a 43 year old?

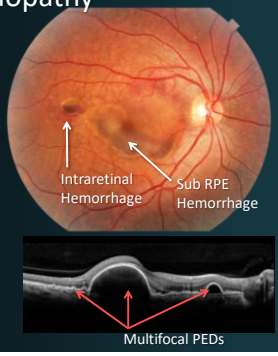
Case 6

Case 6



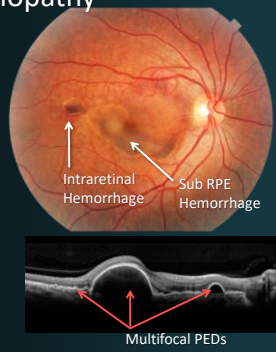
Case 6: Polypoidal Choroidal Vasculopathy

- Key Features:
  - Multifocal, hemorrhagic PEDs
  - (+/-) SRF



Case 6: Polypoidal Choroidal Vasculopathy

- ICG remains "classic" imaging technique
  - Choroidal polyps
- Treatment:
  - Anti-VEGF
  - PDT
  - Combined PDT + Anti-VEGF*



Topics

1. Where is the fluid
2. Common entities
3. Masqueraders
4. Going below and beyond
5. Take a second look

5. Take a Second Look

- How does what we *look for* guide what we *see?*

Case 7

- 27 yo African female
- Blurred vision x 2 weeks OD
- Mild eye pain and photophobia OD

Case 7

Case 7

Case 7

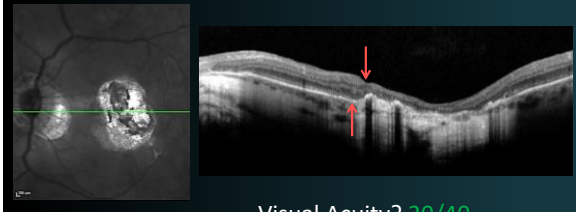
- Diagnosis:
  - Toxoplasmosis OD
- Treatment:
  - Variable, but oral antibiotics

Case 8:
Presumed Ocular Histoplasmosis Syndrome

- 32 yo white male
- Longstanding visual decrease OS

Case 8:
Presumed Ocular Histoplasmosis Syndrome

- PPA and punched out lesions OU
- Macular scar OS



Visual Acuity? 20/40

Usually, it doesn't take us long to figure out what's wrong..

Source: www.ellentv.com

..but don't let your initial glance fool you.

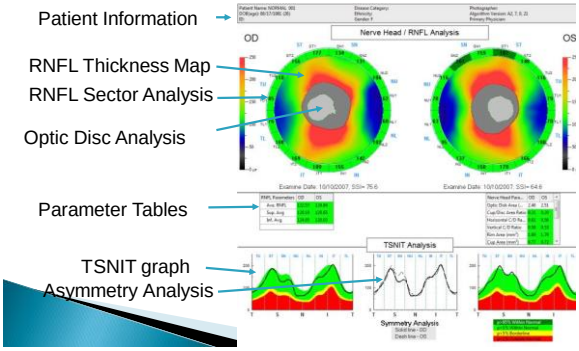
Source: www.lifebuzz.com

Questions/Comments?

alison-bozung@uiowa.edu

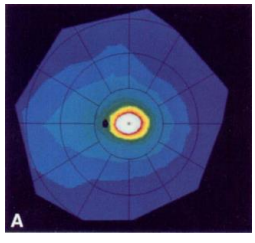
Thank you for your time and attention.

Nerve Head Map (NHM4)
with Database comparisons



Macular Ganglion cell density

- 50% of ganglion cells located in central 4.5mm
- Peak ganglion cell density is 15,000 cells/mm^2 in macula(white region)
- GCC map covers central 6mm area

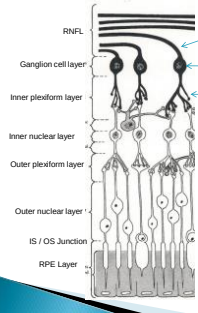


Topography of Ganglion Cells in Human Retina

CHRISTINE A. CURCIO AND KIMBERLY A. ALLEN

THE JOURNAL OF COMPARATIVE NEUROLOGY 300:5-25 (1990)

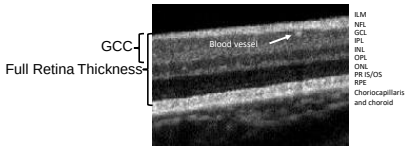
Retinal Ganglion Cells extend through three retinal layers



GCC is:

- Nerve Fiber Layer – Ganglion cell axons
- Ganglion cell layer – Cell bodies
- Inner-Plexiform Layer - Dendrites

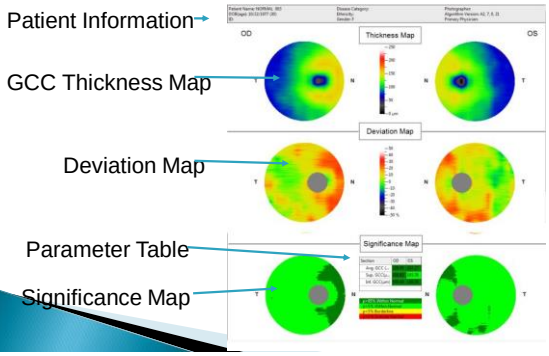
Imaging the GCC



GCC is inner retinal layers

- Nerve Fiber Layer – Ganglion cell axons
- Ganglion cell layer – Cell bodies
- Inner-Plexiform Layer - Dendrites

Ganglion Cell Complex (GCC) with Database comparisons



Diagnostic Accuracy: GCC vs FD OCT RNFL with RTVue

- Rao et al. found GCC had similar accuracy levels as FD RNFL (AROC = 0.81 for GCC vs 0.88 for RNFL)
- Seong et al. found similar results (AROC = 0.95 for GCC and 0.97 for RNFL)
- Kim et al. found AROC **values were higher for RNFL vs GCC in a group of advanced glaucoma** patients (AROC = 0.92 for GC vs 0.96 for RNFL), but **GCC values were higher than RNFL in a group of early glaucoma** patients (AROC = 0.83 for GCC vs 0.78 for RNFL)

Rao HL, Zangwill LM, Weinreb RN et al. Ophthalmology 2010; in press.
Seong M, Sung KR, Choi EH, et al. Invest Ophthalmol Vis Sci 2010; 51:1446-1452.
Kim NR, Lee ES, Sung GJ, et al. Invest Ophthalmol Vis Sci 2010; in press

RTVue FD OCT: GCC vs Disc vs RNFL

- Huang et al. compared the diagnostic accuracy for GCC, optic disc, and RNFL from the RTVue
- AROC for RNFL was highest (AROC = 0.92), with GCC second (AROC = 0.86), and vertical C/D ratio a close third (AROC = 0.854)
- They found the accuracy improved when they combined all three structures in an LDF (AROC = 0.97)

Huang JY, Pekmezci M, Mesiwala N, Kao A, Lin S. J of Glaucoma 2010

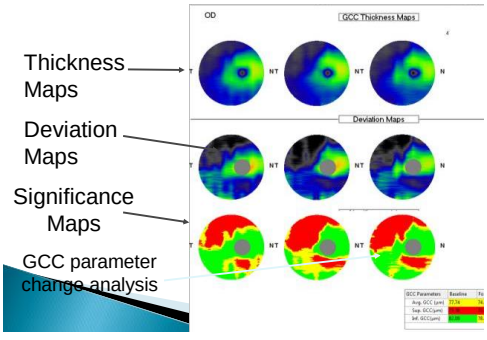
Ability of Fourier-domain OCT to Detect GCC Atrophy in Glaucoma Patients

- 113 patients with different stages of glaucoma; 30 normals
- Imaged NFL and GCC with Optovue RTVue-100
- Conclusions: GCC and NFL thickness measurements performed by FD-OCT showed high diagnostic ability in detecting glaucoma. Mean thickness values can be determined for each glaucoma stage.

Sevim MS; Buttanri B Journal of Glaucoma. 22(7):542-549, September 2013.

Glaucoma Progression Analysis

(GCC of stable glaucomatous eye)



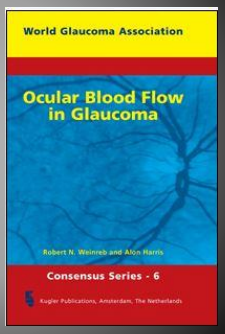
Age Effects on NFL and GCC

- Studied longitudinal (4 years) and cross sectional age and IOP effects on 192 normals (40-75yo)
- NFL thickness decreased 0.14 +/- 0.07 um per year (P = 0.04)
- NFL was 0.21 +/- 0.06 um thinner (P < 0.001).
- GCC thickness decreased 0.25 +/- 0.05 um per year (P < 0.001)
- GCC thickness was 0.17 +/- 0.05 um thinner per year of baseline age (P < 0.001)
- ***Equivalent to 0.2% per year***
- IOP had no effect on rate of thinning

Zhang X, Francis BA, et al. Trans Vis Sci Tech. 2016;5(2):1, doi:10.1167/5.2.1

World Glaucoma Association

- 1.Glaucoma Diagnosis 2004
- 2.Glaucoma Surgery
- 3. Angle Closure
- 4. IOP
- 5. Glaucoma Screening
- 6. Ocular Blood Flow 2006
- 7. Medical Treatment
- 8 Progression
- 9. Childhood Glaucoma
- 10. Diagnosis of POAG 2013



Optic Nerve Head Structure

- Clinical evaluation and documentation of the optic nerve head is essential for the diagnosis and the monitoring of glaucoma.
- Clinical diagnosis of glaucoma is predicated on the detection of a thinned RNFL and narrowed neuroretinal rim.
  - These features often appear first in the supero- or inferotemporal quadrants.

Diagnosis of POAG pp 1-19 Weinreb RN, Garway-Heath D et al. 2016 Klugler Publications

Disc Rim, Nerve Fiber Layer (RNFL)

- Detecting progressive glaucomatous RNFL thinning and neuroretinal rim narrowing are the best currently available gold standards for glaucoma diagnosis.
  - Disease-related damaged should be differentiated from age-related change

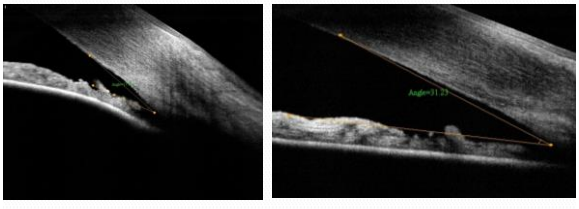
Diagnosis of POAG pp 1-19 Weinreb RN, Garway-Heath D et al. 2016 Klugler Publications

OCT

- RNFL is the most clinically useful parameter of the ones currently available with OCT.
- Macular RGC loss in glaucoma also can be detected by OCT.
- RNFL thickness and RGC loss are complementary

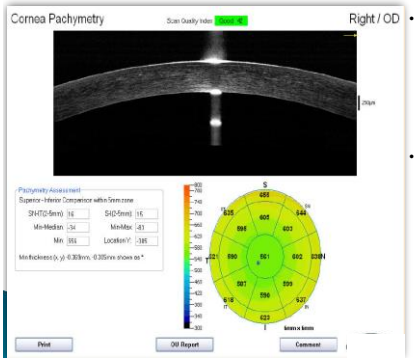
Diagnosis of POAG pp 1-19 Weinreb RN, Garway-Heath D et al. 2016 Klugler Publications

OCT Angle



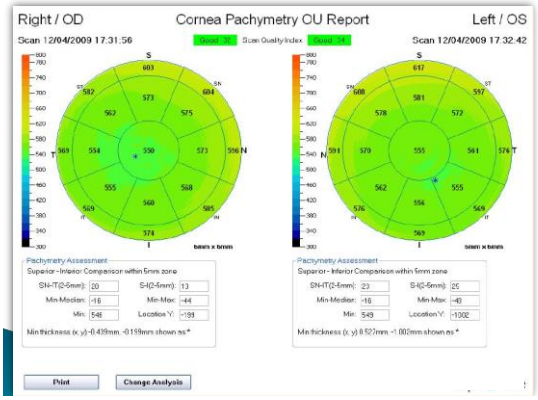
Pre-LPI	Post-LPI

CORNEA



- Full 6x6mm Pachymetry Mapping
  - Minimum Thickness Marker
- Change & Symmetry Analysis

CORNEA

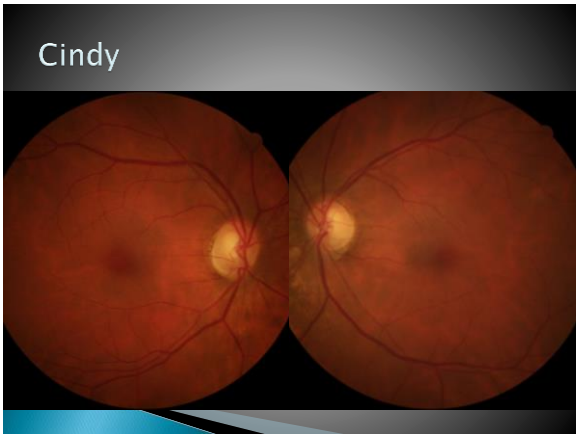


Glaucoma

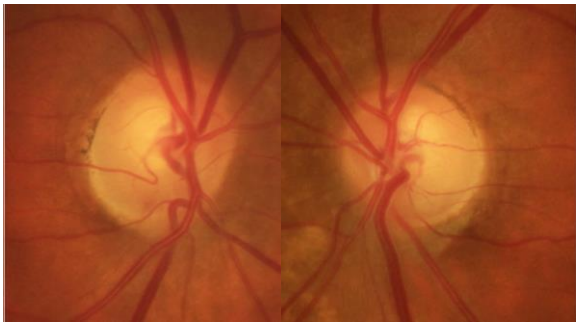
- Mild
- Moderate
- Severe

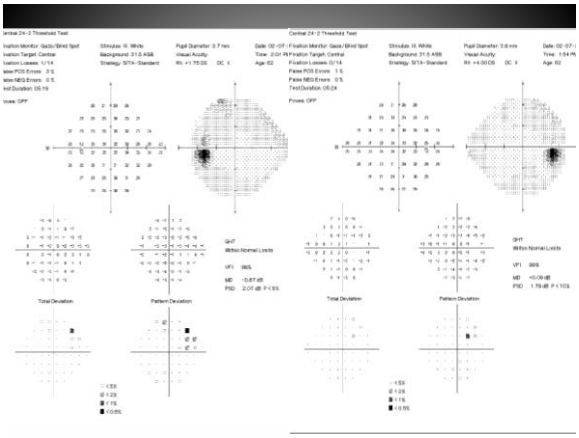
Cindy

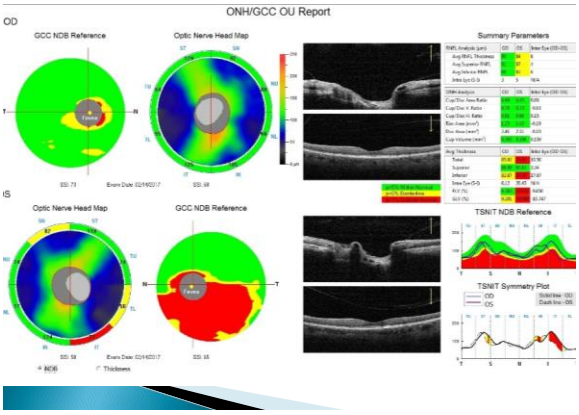
- 62yoF referred as glaucoma suspect
- S/P LASIK OD only
- VAcc 20/15 OU
- GAT R 18 L 19
- CCT R 628 L 635
- ORA R 14, L 17
- CH R12.6 L 13.1



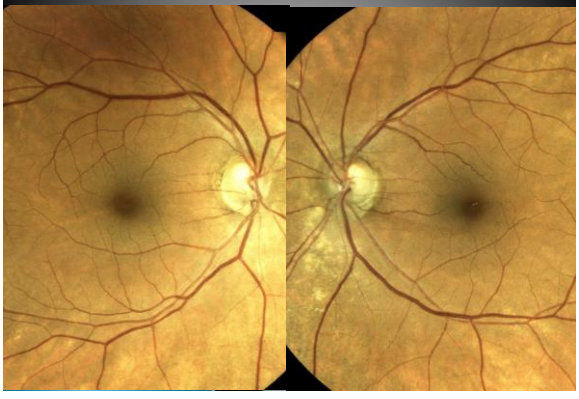
Cindy



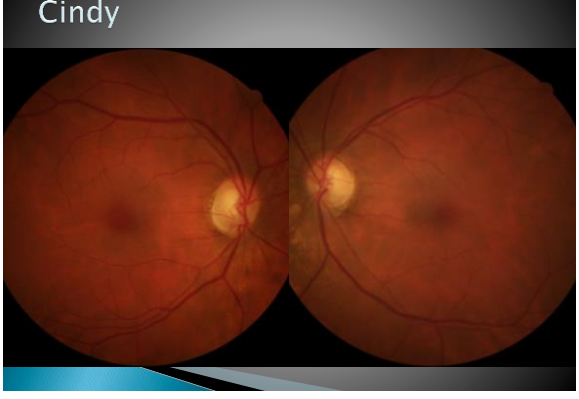




Cindy



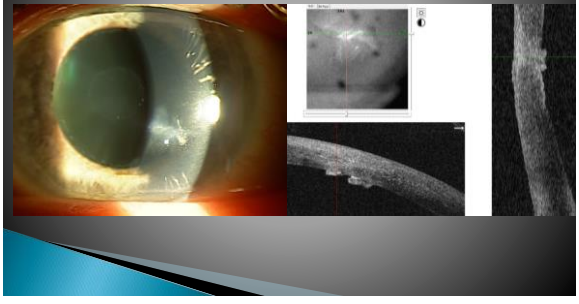
Cindy



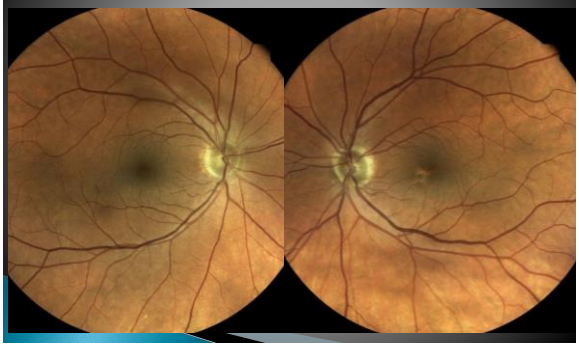
Steve 2017

- VA sc OD 20/25 OS 20/30
- SLE Penetrating scar with retained metallic debris
  - From galvanized nail
  - PXE noted OU
- IOP R 20 L 38
- DFE C/D R 0.2 L 0.3 x 0.2 healthy OU
- IOP repeated one week later
  - R 22 L 32
- Rx Travatan-Z QHS OU

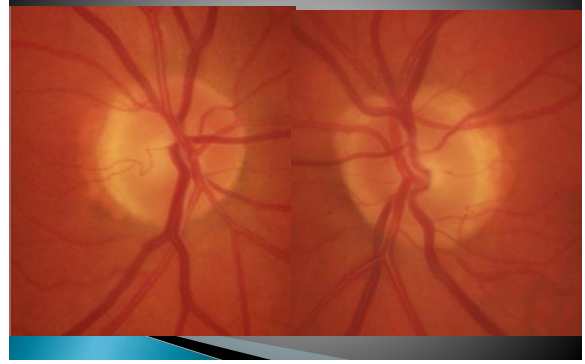
Steve

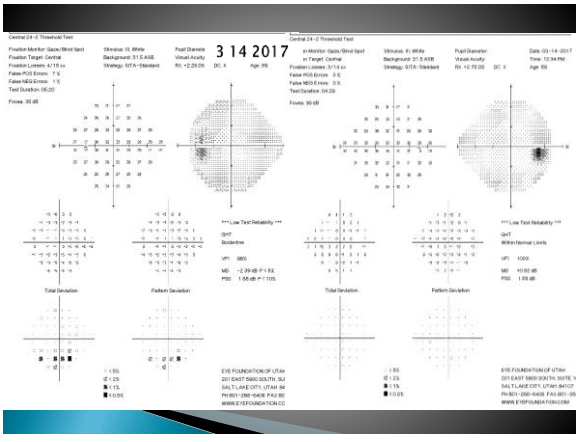


Steve 3 7 17

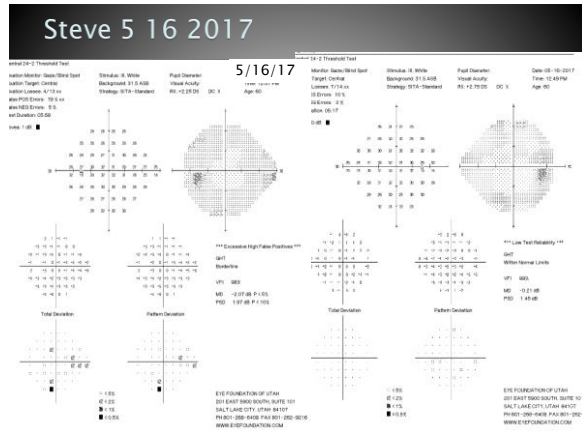


Steve 3 7 2017

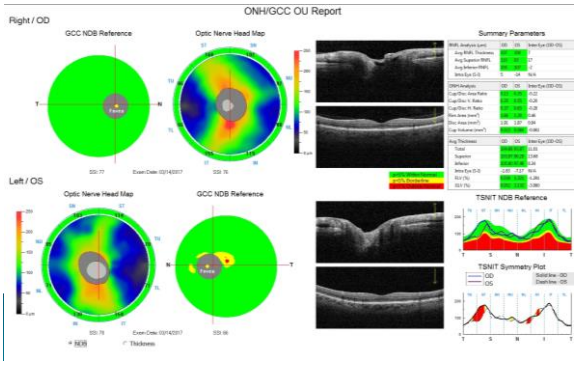




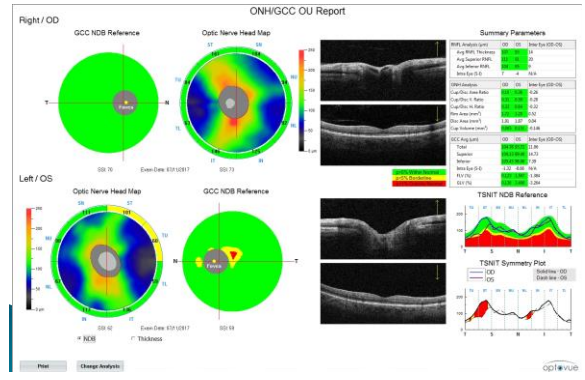
Steve 5 16 2017



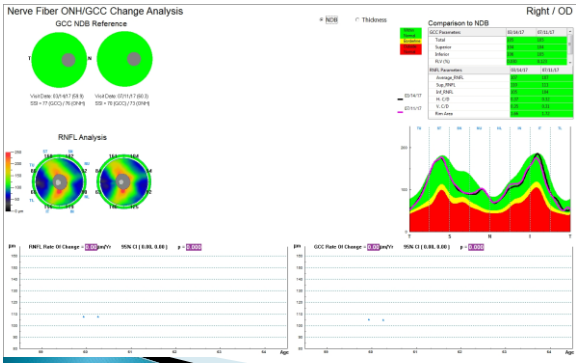
3 14 2017



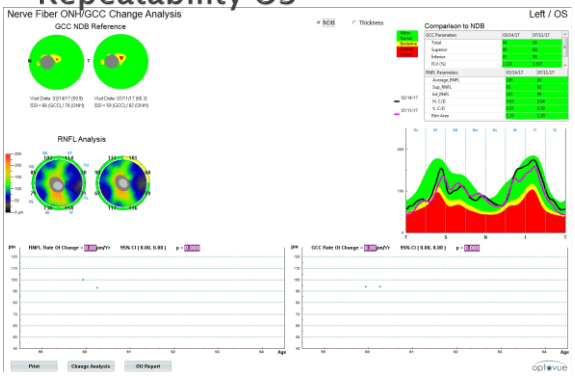
7 11 2017



Repeatability OD



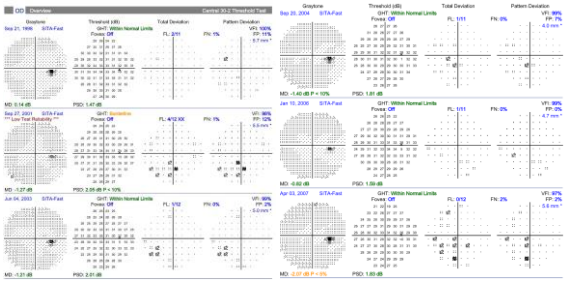
Repeatability OS



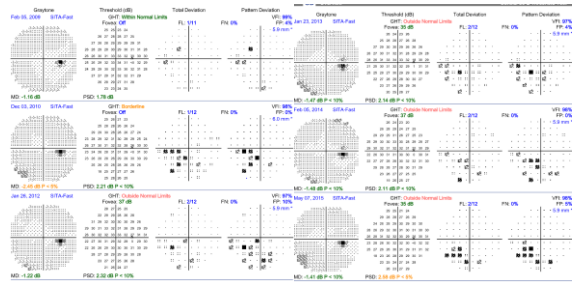
Diane

- 53yo WF
  - with PDS
- IOP
- R 20 L 22

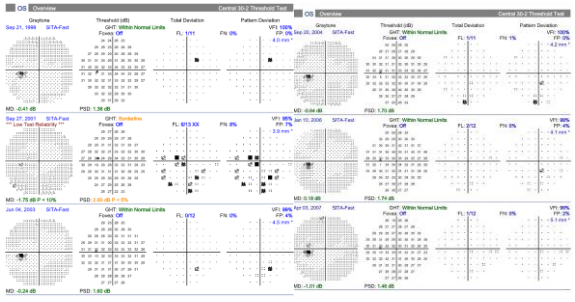
Diane OD 1998-2007



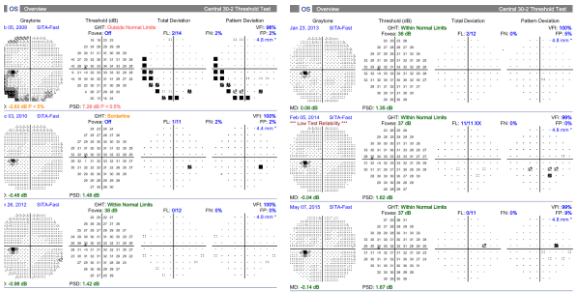
Diane OD 2009-2015



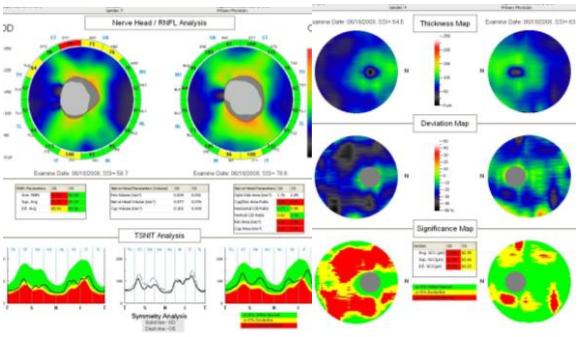
Diane OS 1998-2007

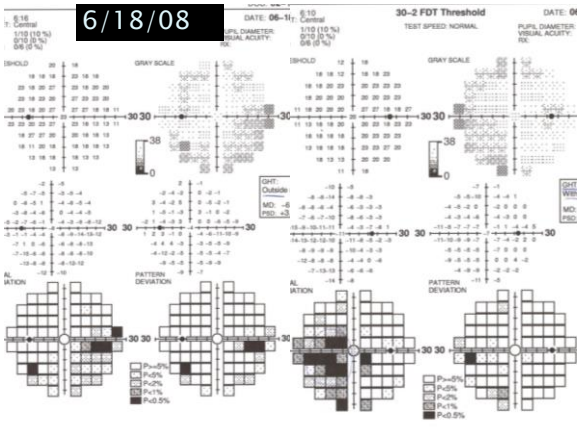


Diane OS 2009-2015



Dianne OD NFL v. GCC





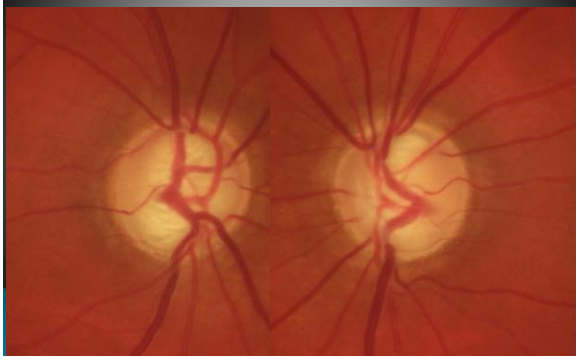
What does the OCT look like in severe glaucoma?

Is there any value in watching for progression analysis in severe glaucoma?

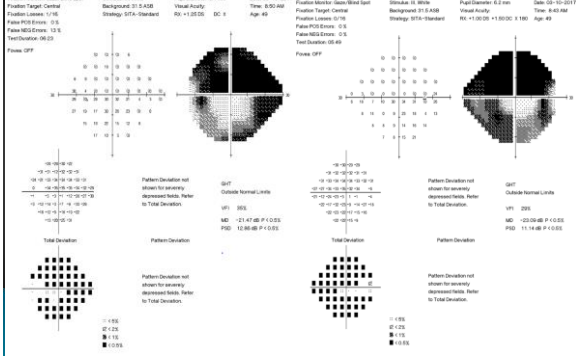
Troy

- 50yo M Pigmentary Glaucoma
- Pre-Tx IOP R 30 L 30
- ORAcc R 32 L 28
- CCT R 600 L 602
- S/P SLT OU
- Travatan-Z, Simbrinza, timolol
- Current IOP R 14 L 14
- ORAcc R 17 L 17

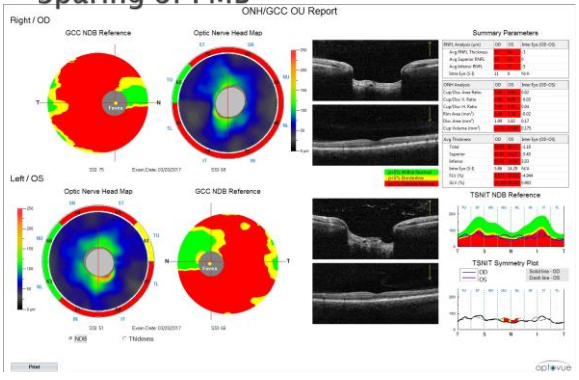
Troy 3 7 17



Troy 3 10 17



Sparing of PMB



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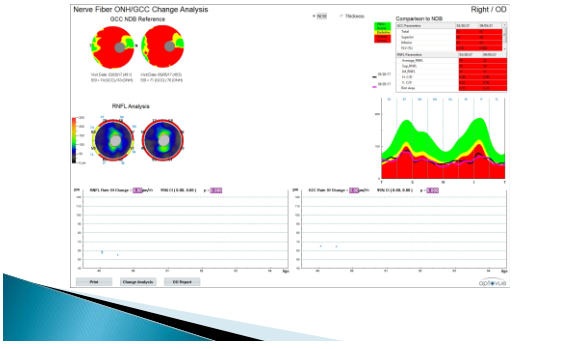

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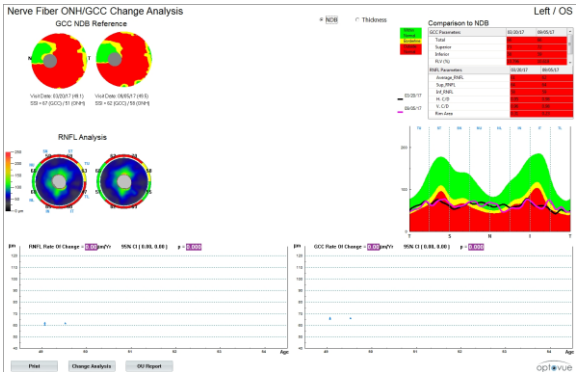
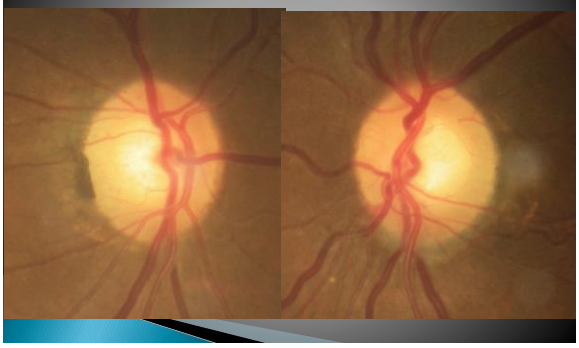


Progression Analysis

Nathaniel

- 60yo AAM treated many years for OAG
- Stable or progressing?

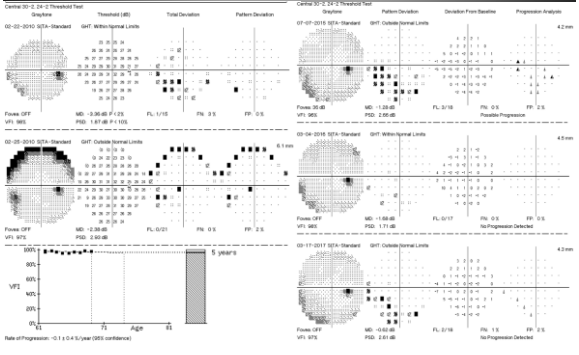
Nathaniel 11 29 2016



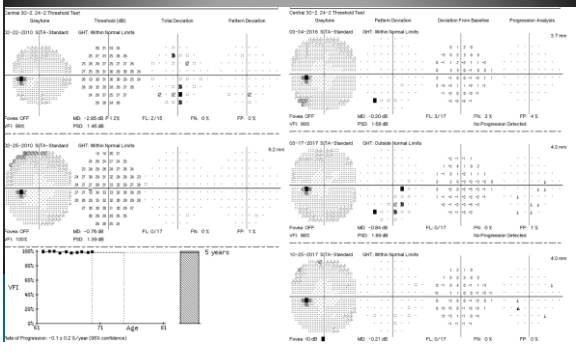
OD 11 29 16

OS 11 29 16

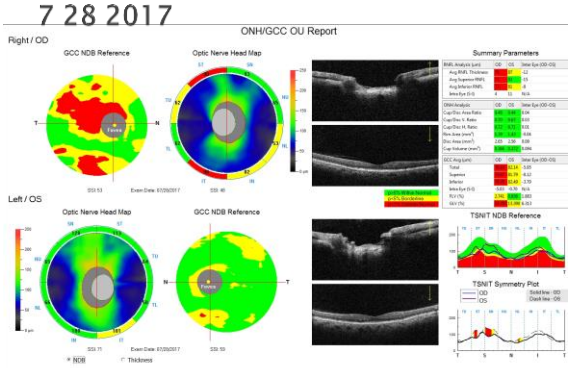
OD Stable through 2017



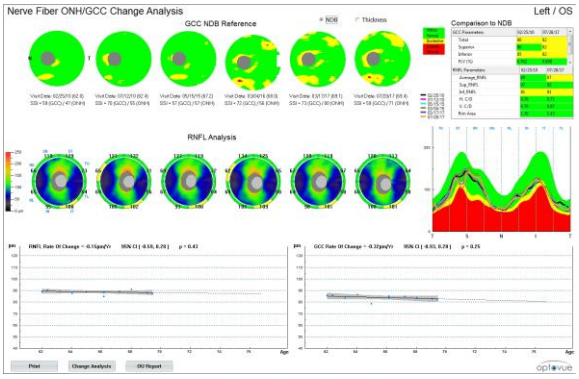
OS Stable through 2017



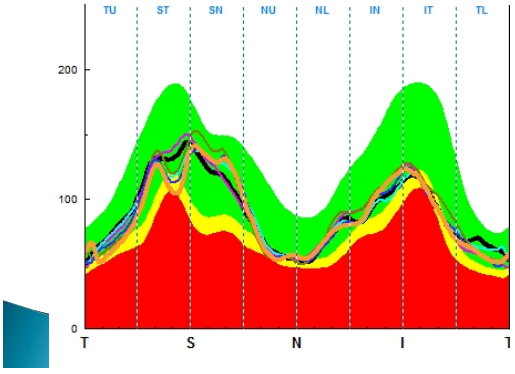
7 28 2017



OS 2010-2017



OS 2010-2017



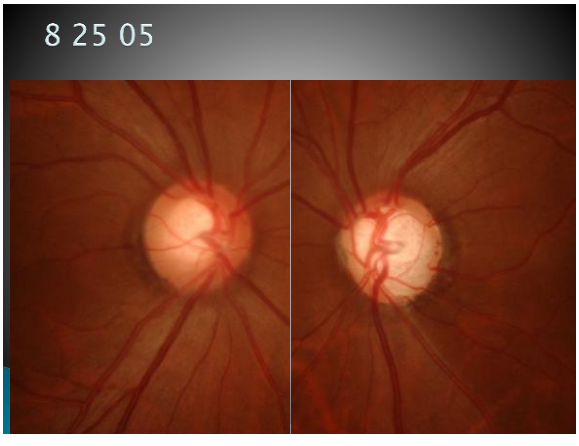
Moral of the Story

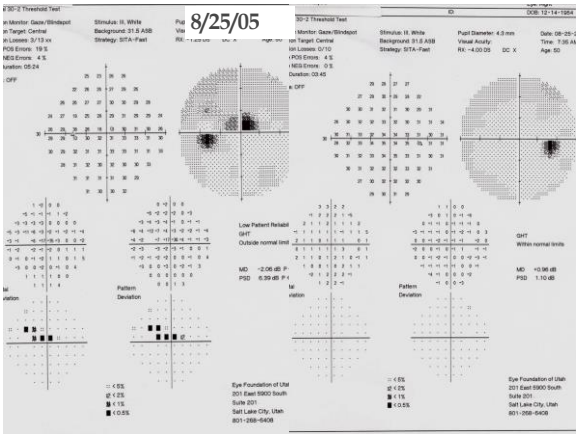
- Don't just watch for the slope of the NFL and GCC Rate of Change line!
- Need to look at the NFL curve and GCC images!

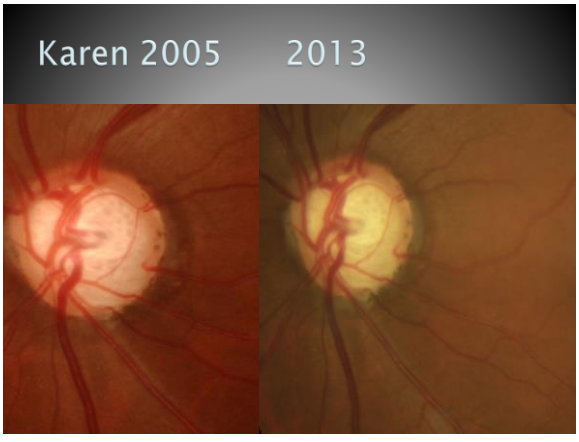
Karen 9 1 05

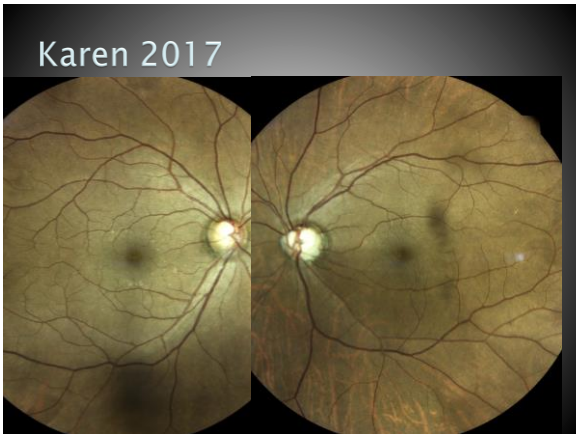
- Taking Travatan OS
- IOP: R 14 L 13
- IMP: +response to Travatan
- Plan: Continue Travatan OS for now

8 25 05

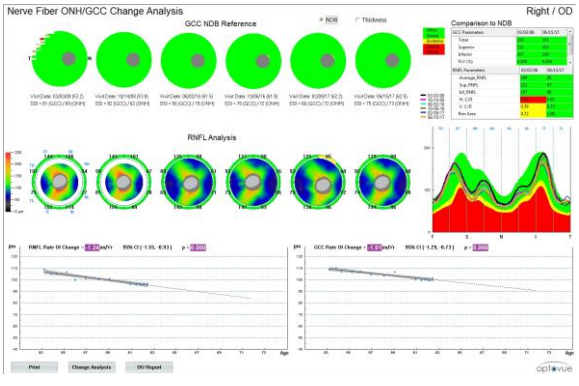




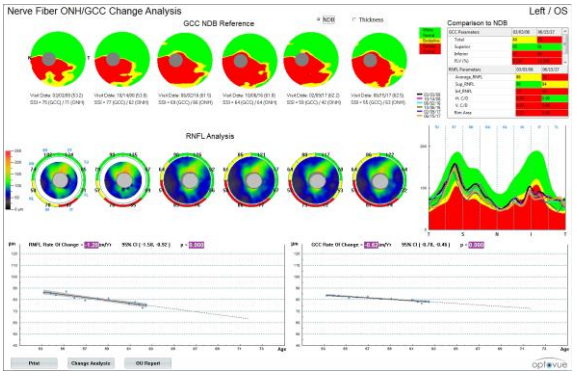


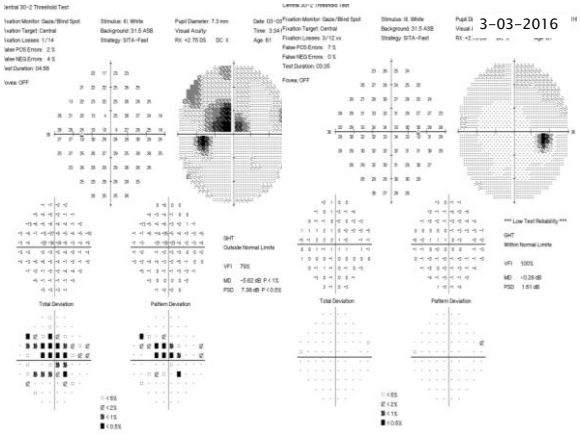


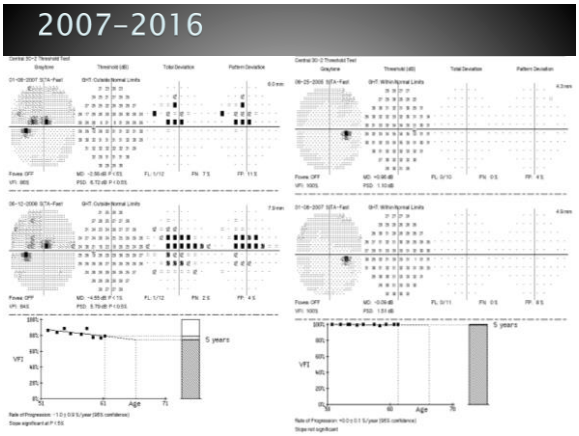
OD: Stable or Progressing?



OS: Stable or Progressing?







What have we learned?

- Definitely can detect damage on OCT prior to VF
- Check OCT, VF, ONP/NFL photos for correlation
  - May not correlate in early stage glaucoma
- Watch both NFL and GCC
  - Can see damage better with NFL in some cases
  - Can see damage better with GCC in others
- Watch for asymmetry!
  - OD v OS
  - Superior rim v Inferior rim