OCT Evaluation of the Retina and Optic Nerve
Alison Bozung, OD, FAAO
Rob Wooldridge, OD, FAAO

Disclosure

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

Retina Refresher

10. (ELM) 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. (RPE) Retinal Pigment Epithelium
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
1. Where is the Fluid?
- Describing fluid location
  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)

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

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1. Where is the fluid
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Choroidal Nevus

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

Choroidal Nevus

- Juxtapapillary choroidal nevus

  - RPE alteration without SRF

Choroidal Melanoma

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

Geographic Atrophy
- Increased choroidal penetrance
- Outer retinal atrophy: loss of RPE and photoreceptors

Case 1: Non-exudative ARMD
- Bilateral RPE mottling and macular drusen

Case 3: Retinal Detachment
- Subretinal fluid with increased hyperreflectivity = mixed hemorrhage
- Exudates

Sub-retinal fluid with increased hyperreflectivity = mixed hemorrhage
Case 1: Non-exudative ARMD

- Color fundus photo
- Infrared reflectance

Combined “classic” and reticular pseudodrusen

Case 2: Non-exudative ARMD

- Basal laminar drusen with vitelliform macular detachment

Case 3: Exudative ARMD

- Right eye
- BM thickening
- SRF
- PED (likely fibrovascular)

- Left eye
- BM thickening
- SRF
- PED (likely fibrovascular)
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

Day 1: 20/70
Day 5: 20/100

Case 3: CME

Central retinal vein occlusion with CME

Day 1: 20/50
Day 9: 20/250
1 mo s/p IVA 20/20

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)

Before and after surgical repair

20/400 → 20/30

Complications of Vitreomacular Traction

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Topics

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

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

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)

- **Causes:**
  - Inherited retinal conditions
  - Pathologic myopia
  - Surgical

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

- **Treatment:**
  - Varied
  - (+/-) Carbonic anhydrase inhibitors

Rounded spaces

Topics

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Going below and beyond

- Thin
- Normal ~320 to 330um²
- Thick

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 6**

- 43 yo female
- Blurred vision for >1 year OU
- 20/80 OD, 20/25 OS

**Case 5: Central Serous Chorioretinopathy**

- Chronic signs
  - Pigmentary changes
  - “Guttering”

- Treatment
  - Discontinue steroids
  - Monitor

- Diagnosed with AMD last year

- ...AMD in a 43 year old?
Case 6: Polypoidal Choroidal Vasculopathy

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

- ICG remains “classic” imaging technique
  - Choroidal polyps

- Treatment:
  - Anti-VEGF
  - PDT
  - Combined PDT + Anti-VEGF

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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

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.

Macular Ganglion cell density

- 50% of ganglion cells located in central 4.5mm
- Peak ganglion cell density is 15,000 cells/mm² in macula (white region)
- GCC map covers central 6mm area

Nerve Head Map (NHM4) with Database comparisons

Patient Information
RNFL Thickness Map
RNFL Sector Analysis
Optic Disc Analysis
Parameter Tables
TSNIT graph
Asymmetry Analysis

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

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)

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.

Ganglion Cell Complex (GCC) with Database comparisons

- Patient Information
- GCC Thickness Map
- Deviation Map
- Parameter Table
- Significance Map

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)

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


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.


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


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


OCT Angle

Pre–LPI  Post–LPI
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 R 12.6 L 13.1
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
Diane

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

Diane OD 1998-2007

Diane OD 2009-2015

Diane OS 1998-2007
Is there any value in watching for progression analysis in severe glaucoma?

- 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
Nathaniel

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