OCT and OCT Angiography in Retinal Disease

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Optometric Education Consultants
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Disclosure Statement (next slide)
Disclosures- Greg Caldwell, OD, FAAO

☞ Will mention many products, instruments and companies during our discussion
  ✶ I don’t have any financial interest in any of these products, instruments or companies

☞ Pennsylvania Optometric Association –President 2010
  □ POA Board of Directors 2006-2011

☞ American Optometric Association, Trustee 2013-2016

☞ I never used or will use my volunteer positions to further my lecturing career

☞ Lectured for: Aerie, Alcon, Allergan, BioTissue, OptoVue

☞ Advisory Board: Allergan, Maculogix, Sight Sciences, Sun, Takeda

☞ Envolve: PA Medical Director, Credential Committee

☞ Optometric Education Consultants- Scottsdale, St. Paul, Quebec City, Nashville, and Orlando/Disney OCT Users meeting; Owner
Resource: OCT Community for OCT and OCT-A

OCT CONNECT

Post your questions & cases so we can #OCTConnect!

Join this group to become part of our OCT Connect Family!
Book Resources

ATLAS of RETINAL OCT
Darin R. Goldman
Nadia K. Waheed
Jay S. Duker

Optical Coherence Tomography Angiography Atlas: A Case Study Approach
Julie A. Rodman, OD MSc FAAO

$149.95
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200 pp Hard Cover
Pub. Date: 2019
Order# 66411
Optical Coherence Tomography
Course Design
OCT and OCT Angiography

Both are Becoming Equally Important in Diagnosis, Management, and Treatment
Optical Coherence Tomography

- OCT is an optical signal acquisition and processing method
- Time domain OCT
  - 15-16 microns of resolution
  - Stratus (Zeiss)
- Spectral domain (SD-OCT) or Fourier domain OCT
  - Spatially encoded frequency domain OCT (SEFD-OCT)
  - 5-6 microns of resolution
    - Able to see photoreceptor morphology (inner/outer segments)
  - 50 times faster than time domain
- Swept source OCT
  - Time encoded frequency domain OCT
  - 1 micron of resolution
- Future of OCT- intraoperative imaging, blood flow and oxygenation measurements
- May have the possibility to assess retinal pathology like a pathologist
OCT Angiography: the Next Chapter in Posterior Imaging

- Images retinal microvasculature without dye injection
- Displays structure and function from a single imaging system

- 2002: Time Domain OCT
- 2006: Spectral Domain OCT
- 2014: OCTA
4 Basic Categories: Diseases of the...
ILM: Inner limiting membrane
IPL: Inner plexiform layer
INL: Inner nuclear layer
OPL: Outer plexiform layer
ONL: Outer nuclear layer

ELM: External limiting membrane
IS/OS: Junction of inner and outer photoreceptor segments
OPR: Outer segment PR/RPE complex

NFL: Nerve fiber layer
GCL: Ganglion cell layer
RPE: Retinal pigment epithelium
+ Bruch’s Membrane

Fovea
Normal Retinal Vasculature

Superficial Capillary Plexus
3 µm Below ILM → 15 µm Below IPL

Deep Capillary Plexus
15 µm Below ILM → 70 µm Below IPL

Outer Retina
70 µm Below IPL → 30 µm Below RPE Reference

Choriocapillaris
30 µm Below RPE Reference → 60 µm Below RPE Reference
Review of Normal
25 year old man
Review of Normal 60 year old man
60 Year Old Montage OU
Learn to predict visual acuities
OCT of Vitreoretinal Interface Disorders
OCT of Vitreoretinal Interface Disorders

- Epiretinal membrane
- Vitreomacular adhesion
  - Complete VMA at birth
  - OCT reveals specific stage of vitreous separation
- Vitreomacular traction
- Pseudohole
- Lamellar hole
- Full Thickness Macular Hole
Epiretinal Membrane

- Other names: premacular fibroplasia, preretinal giosis, macular pucker, surface wrinkling retinopathy
- Believed to be the result of proliferation of retinal glial cells on the internal limiting membrane that escaped through breaks in the internal limiting membrane
- May create macular edema
- Amsler grid may elicit metamorphosia from surface wrinkling or macular edema
- Treatment: Monitor until severe then retinal consult, possible vitrectomy with membrane peeling
Epiretinal Membrane (ERM)
Epiretinal Membrane (ERM)

En Face OCT of ILM

Raster Scan
Epiretinal Membrane (ERM)
Main Outcome Measures: Optical coherence tomography-based anatomic definitions and classification of vitreomacular adhesion, vitreomacular traction (VMT), and macular hole.

Results: Vitreomacular adhesion is defined as perifoveal vitreous separation with remaining vitreomacular attachment and unperturbed foveal morphologic features. It is an OCT finding that is almost always the result of normal vitreous aging, which may lead to pathologic conditions. Vitreomacular traction is characterized by anomalous posterior vitreous detachment accompanied by anatomic distortion of the fovea, which may include pseudocysts, macular schisis, cystoid macular edema, and subretinal fluid. Vitreomacular traction can be subclassified by the diameter of vitreous attachment to the macular surface as measured by OCT, with attachment of 1500 μm or less defined as focal and attachment of more than 1500 μm as broad. When associated with other macular disease, VMT is classified as concurrent. Full-thickness macular hole (FTMH) is defined as a foveal lesion with interruption of all retinal layers from the internal limiting membrane to the retinal pigment epithelium. Full-thickness macular hole is primary if caused by vitreous traction or secondary if directly the result of pathologic characteristics other than VMT. Full-thickness macular hole is subclassified by size of the hole as determined by OCT and the presence or absence of VMT.

Conclusions: This classification system will support systematic diagnosis and management by creating a clinically applicable system that is predictive of therapeutic outcomes and is useful for the execution and analysis of clinical studies.
# VMA versus VMT

## Focal or Broad Attachment

**Duker et al. • Classification of VMI Diseases**

<table>
<thead>
<tr>
<th>Anatomic State</th>
<th>IVTS Classification System for Vitreomacular Adhesion, Traction, and Macular Hole</th>
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<tbody>
<tr>
<td><strong>VMA</strong></td>
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<td>Definition</td>
<td>Evidence of perifoveal vitreous cortex detachment from the retinal surface</td>
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<tr>
<td></td>
<td>No detectable change in foveal contour or underlying retinal tissues</td>
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<tr>
<td>Classification</td>
<td>By size of attachment area</td>
</tr>
<tr>
<td></td>
<td>Focal (≤1500 μm)</td>
</tr>
<tr>
<td></td>
<td>Broad (&gt;1500 μm, parallel to RPE and may include areas of detruscence)</td>
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<td>By presence of concurrent retinal conditions</td>
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<td>Association of attachment with distortion of the foveal surface, intraretinal structural changes, and/or elevation of the fovea above the RPE, but no full-thickness interruption of all retinal layers</td>
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Vitreomacular Adhesion (VMA)

Optical Coherence Tomography-Based Definition and Classification of Vitreomacular Adhesion

Vitreomacular adhesion is a perifoveal vitreous detachment and is defined, as with other terms in this report, by anatomic features detected with OCT. In Uchino’s, Gaudric’s, and Johnson’s classification schemes, VMA is the equivalent of a stage 1 PVD. Most eyes have complete vitreoretinal adhesion at birth, so the concept of vitreoretinal adhesion and VMA is a normal state. In this OCT-based classification scheme, however, VMA represents a specific stage of vitreous separation wherein partial detachment of the vitreous in the perifoveal area has occurred.
Focal versus Broad in VMA and VMT

Certain key points are worth noting when considering the definition of VMA. First, this anatomic definition of VMA has been dissociated from symptomatology, because specific visual symptoms are subjective and may be caused by unrelated disease. Second, eyes with VMA may be subclassified by size of the adhesion into either: (1) focal (≤1500 µm) or (2) broad (>1500 µm; Fig 1A, B). The 1500-µm cutoff has been selected for several reasons. This 1500-µm diameter is a known area of increased vitreous adhesion to the fovea. In addition, this figure has been used routinely to distinguish focal from broad VMA in the published vitreoretinal literature and at most OCT reading centers. It remains unclear whether there is any prognostic difference between focal and broad VMA. When ascertaining the expanse of vitreous attachment, one measures areas in which the adhesion is roughly parallel to the retinal pigment epithelium (RPE). Small regions of dehiscence (<1 mm) between the vitreous and neurosensory retina may be present within zones of broad VMA and should be disregarded when classifying VMA as either focal or broad. Eyes with VMA also may have other associated macular abnormalities, including age-related macular degeneration (Fig 1C), retinal vein occlusion, or diabetic macular edema. In these eyes, VMA should be termed concurrent, and the term isolated should be reserved for cases where no ocular disease is present (Table 1).

Like VMA, VMT can be subclassified into either focal or broad, depending on the width of vitreous attachment (Table 1). Broad areas of attachment with traction can cause generalized thickening of the macula, vascular leakage on fluorescein angiography, macular schisis, and cystoid macular edema. Focal areas of vitreous attachment with traction tend to distort the foveal surface, elevate the foveal floor, form pseudocysts within the central macula, or result in a combination thereof (Fig 1D–F). The presence of pseudocysts usually is associated with diminished visual acuity and visual distortion. After release of traction, pseudocysts generally resolve over time with little remaining visual deficit.
Which eye has the better visual prognosis?
Vitreomacular Traction
Focal
Vitreo-Macular Traction (VMT)
Focal
Focal Vitreomacular Traction
Main Outcome Measures: Optical coherence tomography-based anatomic definitions and classification of vitreomacular adhesion, vitreomacular traction (VMT), and macular hole.

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Stage 1-4 Macular Holes

<table>
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<tr>
<th>Full-Thickness Macular Hole Stages in Common Use</th>
<th>International Vitreomacular Traction Study Classification System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 0</td>
<td>VMA</td>
</tr>
<tr>
<td>Stage 1: impending macular hole</td>
<td>VMT</td>
</tr>
<tr>
<td>Stage 2: small hole</td>
<td>Small or medium FTMH with VMT</td>
</tr>
<tr>
<td>Stage 3: large hole</td>
<td>Medium or large FTMH with VMT</td>
</tr>
<tr>
<td>Stage 4: FTMH with PVD</td>
<td>Small, medium, or large FTMH without VMT</td>
</tr>
</tbody>
</table>

FTMH = full-thickness macular hole; PVD = posterior vitreous detachment; VMA = vitreomacular adhesion; VMT = vitreomacular traction.
### Full Thickness Macular Hole

<table>
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<tr>
<th>FTMH</th>
<th>Concurrent Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Full-thickness foveal lesion that interrupts all macular layers from the ILM to the RPE</strong></td>
</tr>
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</table>

**Classification**
- By size (horizontally measured linear width across hole at narrowest point, not ILM)
  - Small (≤250 μm)
  - Medium (>250 μm and ≤400 μm)
  - Large (>400 μm)
- By presence or absence of VMT
- By cause
  - Primary (initiated by VMT)
  - Secondary (directly due to associated disease or trauma known to cause macular hole in the absence of prior VMT)
Full Thickness Macular Hole
Large and Without VMT
Small Full Thickness Macular Hole without VMT
What About the Other Eye?

- One eye has a full thickness macular hole
- Stage 0 macular hole
  - VMA
- Impending macular hole
  - VMT
  - Despite the name
    - Can spontaneously resolve

---

**Impending Macular Hole**

A special circumstance exists when an individual develops FTMH in one eye and OCT reveals VMA or VMT in the fellow eye. Studies show that these fellow eyes are at increased risk for development of FTMH. In the past, the finding of VMA in a fellow eye has been referred to as a stage 0 macular hole, but the term *impending macular hole* should be used instead to describe a case in which FTMH is observed in one eye and VMT is observed on OCT in the fellow eye (Tables 2 and 3). The term *impending macular hole*, despite the connotation of inevitability, does not exclude the possibility of spontaneous resolution.
Macula Hole?

Lamellar Macular Hole

Lamellar macular hole (LMH) is a partial-thickness foveal defect that typically appears on biomicroscopy as a round or oval, well-circumscribed, reddish lesion. Clinical detection of early LMH may be difficult using biomicroscopy alone. Anatomic OCT-based features of LMH include the following: (1) an irregular foveal contour; (2) a defect in the inner fovea (may not have actual loss of tissue); (3) intraretinal splitting (schisis), typically between the outer plexiform and outer nuclear layers; and (4) maintenance of an intact photoreceptor layer. Lamellar macular hole can be distinguished from FTMH on OCT best by the presence of intact photoreceptors at the base (Fig 2E).
Inner + outer retinal layer split/separation = lamellar macular hole

Intact PIL 2/20 - 2/25 vision
Pseudohole

Macular Pseudohole

Definition
Invaginated or heaped foveal edges
Concomitant ERM with central opening
Steep macular contour to the central fovea with near-normal central foveal thickness
No loss of retinal tissue

Abbreviations: ERM = epiretinal membrane; FTMH = full-thickness macular hole; ILM = internal limiting membrane; OMTRS = Ocular Macular Traction Study; LMH = lamellar macular hole; RPE = retinal pigment epithelium; VMA = vitreomacular traction.

Importantly, there is no loss of foveal tissue, as is observed typically with LMH or FTMH. Central foveal thickness usually is normal or slightly thin. Thus, OCT confirms the diagnosis on the basis of the following 4 characteristics (Fig 2F): (1) invaginated or heaped foveal edges, (2) concomitant ERM with central opening, (3) steep macular contour to the central fovea with near-normal central foveal thickness, and (4) no loss of retinal tissue.

The ERM is associated with a significant loss of macular function. Successful ERM removal often leads to significant improvement in foveal contour and some improvement in visual acuity. The new OCT-based anatomical definition may be helpful in identifying the presence of pseudohole.
Early separation of outer + inner retinal layers (lamellar hole) resulting in pseudohole turning into lamellar hole.
Let’s See How We Are Doing
Diagnosis?
Diagnosis?
8 Weeks Later - Diagnosis?
30-year-old woman - Diagnosis?
March 17, 2020
A Closer Look – Oh no!
Phew – Lucky! June 16, 2020
Next Case
8-24-2020 Phew!
Diagnosis?
OCT Angiography
A New Approach to Protecting Vision

- Non-invasive visualization of individual layers of retinal vasculature
- Pathology not obscured by fluorescein staining or pooling
- Image acquisition requires less time than a dye-based procedure
- Reduced patient burden allows more frequent imaging to better follow disease progression and treatment response
Enface OCT-A Slabs Based on Retinal Anatomy

En Face Visualization of Layers Based on Retinal Anatomy
Normal Retinal Vasculature

Superficial Capillary Plexus
3µm Below ILM → 15 µm
Below IPL

Deep Capillary Plexus
15µm Below ILM → 70 µm
Below IPL

Outer Retina
70µm Below IPL → 30 µm
Below RPE Reference

Choriocapillaris
30 µm Below RPE Reference → 60 µm
Below RPE Reference
Type 1 “Occult” CNV

- New vessels develop in the choroid
- New vessels located below RPE and above Bruch’s membrane
Type 1 “Occult” CNV

- New vessels develop in the choroid
- New vessels located **BELLOW RPE** and **ABOVE Bruch’s membrane**
CNV?

72 y/o Hispanic male
20/30
History of “Dry AMD”
Multimodal imaging and OCTA

VAGUE???
Type 1 CNV: Below RPE, Wider than Type 2, Avascular Zone Usually Not Involved
And the not so obvious ones...
Case example: 70 y/o WM, AMD
Diabetes
Identify Early Vascular Changes in Diabetic Eyes

Patients with DM have a larger FAZ than healthy eyes.³

Diabetic Eye
FAZ Area: 0.443mm²

Normal Eye
FAZ Area: 0.172mm²


Images courtesy of Julie Rodman, OD, FAAO
Assess Disease Progression with Multiscan View

Vessel Density Decreases Significantly with Disease Severity

AngioWellness Report
Comprehensive Eye Exam - Healthy
29 year old man with diabetes

- Yearly diabetic exam, reports no changes to vision
- Type 1 DM
- BS: 190 this AM, last HbA1c 8.6
- Vision 20/20
- Anterior segment: normal
- Posterior segment:
  - Non-proliferative DR
    - Hemes and exudates
  - No CSME
- Billed for:
  - Exam- 99214
  - Optomap, OCT-Wellness, and OCT-A (Angiography)
12-19-18 what do you see?
12-19-18 what do you see?
58-year-old man with diabetes

- New patient to the practice
- BS: unsure, last HbA1c unsure
- DM meds: metformin, glyburide, Invokana
- Vision 20/20
- Anterior segment: normal
Widefield Imaging
FAZ Damage – This is DR
Time to get to know your BS and HBA1c
64-year-old man with diabetes

- BS: 134 this AM, last HbA1c 8.0
- DM meds: Novolog and Amaryl
- Vision 20/20
- Anterior segment: normal
Widefield Imaging
64-year-old man with diabetes
64-year-old man with diabetes
64-year-old man with diabetes
64-year-old man with diabetes
64-year-old man with diabetes
64-year-old man with diabetes
64-year-old man with diabetes
OCT and OCT-A

- Treatment?
- Certainly useful, beneficial, essential, and important in following the patient with diabetes
- Improved HbA1c
OCT and OCT Angiography

Solve the Case
63 year old man

- Complicated ERM surgery OD
  - Increased IOP
  - Vitreous hemorrhage
- ERM peel 8-16-2018
  - My visit 11-20-18
    - IOP 18/13
- Vision 20/20
  - But “can not see top part of vision in right eye”
- Patient returned to me because the surgeon said it will take time for vision to return
- OCT and OCT-A reveals the diagnosis and prognosis
Superficial
Deep
Diagnosis?
69 year old woman

- In for 6 month diabetic check
  - History of idiopathic juxtafoveal telangiectasia
- BVA OD 20/80 OS 20/40
- Thoughts are the macula changes DM and IJT?
- OCT and OCT-A
Central Serous Retinopathy
(Neurosensorry Detachment)
Central Serous Retinopathy
(Neurosensory Detachment)
46 year old man

- Complains of a perfect yellow circle in the center of his OS
- The circle stays in the center of his vision even when he moves his eye
- VA 20/20 OU
- Refraction OD Plano OS +1.00 D
  - Prior visit Plano OU
Central Serous Chorioretinopathy

Normal patient
217 μm

CSR
449 μm

546 μm
CSR

722 μm
CSR
Central Serous Chorioretinopathy
Central Serous Chorioretinopathy
Plaquenil Toxicity

Oh Boy!
Revised Recommendations on Screening for Chloroquine and Hydroxychloroquine Retinopathy

- Last recommendations were 2002 by the American Academy of Ophthalmology
- Improved screening tools and new knowledge about prevalence of toxicity have prompted the change
  - 1% after 5-7 years of use or a cumulative dose of 1000 grams (Plaquenil)
- There is no treatment for this condition
  - Therefore must be caught early
- Screening for the earliest hints of functional or anatomic change
- Plaquenil toxicity is not well understood
PLAQUENIL ZONE

WITH ALL TESTING FOR PLAQUENIL TOXICITY...FOCUS ON THE "1.0-1.5 MM RADIUS PLAQUENIL ZONE"
SYMMETRICAL AND NOTHING OBVIOUS
1-1.5 MM PERIMACULAR GCC THINNING THE FIRST SIGN OF PLAQUENIL TOXICITY

WHY? THICKEST LAYER OF GANGLION CELLS AND SMALLEST GANGLION CELLS AT THAT LOCATION. VERY SENSITIVE TO TOXICITY
WHAT DO YOU SEE ON THE SCANS?

A. THINNING OF THE GCC IN THE PLAQUENIL ZONE
B. MACULAR EDEMA
C. COMPROMISED PIL
D. NOTHING OF IMPORT

DO YOU SEE ANY PROBLEM IN THE PLAQUENIL ZONE?
WHAT DO YOU SEE ON THE SCANS?

A. THINNING OF THE GCC IN THE PLAQUENIL ZONE
B. MACULAR EDEMA
C. COMPROMISED PIL
D. NOTHING OF IMPORT

DO YOU SEE ANY PROBLEM IN THE PLAQUENIL ZONE?
Figure 1 The flying saucer sign representing compromise of the perifoveal retinal tissue with maintenance of the foveal retinal tissue. From Chen E, Brown DM, Benz MS, et al. Spectral domain optical coherence tomography as an effective screening test for hydroxychloroquine retinopathy (the “flying saucer” sign). Clin Ophthalmol. 2010; 4: 1151-1158. Published online 2010 October 21. doi: 10.2147/OPTH.S14257
WHAT DO YOU SEE ON THE SCANS?

A. THE FLYING SAUCER SIGN
B. MACULAR EDEMA
C. INCREASED PERIMACULAR RETINAL THINNING
D. A AND C
WHAT DO YOU SEE ON THE SCANS?

A. THE FLYING SAUCER SIGN
B. MACULAR EDEMA
C. INCREASED PERIMACULAR RETINAL THINNING
D. A AND C
BILATERAL COMPROMISE OF THE PIL (WHITE ARROWS) AFTER COLLAPSE OF PERIFOVEAL RETINA (RED DASHED ARROWS) WITH FLYING SAUCER ATTACK (BLUE ARROWS)
THE END GAME...ONCE YOU DISCONTINUE PLAQUENIL IT STAYS AROUND A WHILE TO CREATE DAMAGE..LONG ½ LIFE

WAY OUTTA THE BARN
71 yo woman

- With Lupus and hypertension
- Medications:
  - Colazapam
  - Plaquenil 200 mg BID, 15 years
  - 81 mg ASA
  - Prednisone
  - Losartin

- VA 20/25 OD/OS (mild cataracts)
- Patient was told to see an ophthalmologist in 2013
Hope You Enjoyed
Thank You!

Greg