The Future of Retinal Imaging Has Arrived!

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Goals of this Course
- To provide a broad overview of Post Seg Imaging
- Past, Present, and …
- Clinical Applications and Interpretation

Imaging Technologies
- Fundus photography
- Wide-field/panoramic
- Angiography
  - Fluorescein (FA)
  - Indocyanine Green (ICGA)
- Scanning lasers
  - OCT
  - En face
  - Enhanced depth
  - OCTAng

Financial Disclosure
- Pizzimenti:
  - Honoraria
    - Kemin
    - Nicox
    - Review of Optometry
    - Optometric Management
    - VSP
  - Scientific Advisory Boards
    - ZeaVision
    - Zeiss
    - Thrombogenics
- Pelino: nothing to disclose

Questions and Comments?
“Most major advances in the understanding of retinal diseases have been preceded by advances in imaging.”

Richard Spaide, MD
NY Retina Consultants

Optos Wide-Field Angiography

Digital retinal imaging does not replace a dilated retinal examination.

Fundus Biomicroscopy and BIO

Milestones in Retinal Imaging

- Fundus Photography 1920s
- Fluorescein Angiography 1950s
- B-Scan Ultrasound 1970s
- ICG Angiography (Digital) 1980s
- CSLO (HRT), SLP (GDX) 1990s
- OCT first demonstrated 1991
  - High-res OCT 2001
  - Fourier (Spectral) Domain OCT 2007
Milestones in Retinal Imaging

1909-Thorner’s Stereo Photos

2016 En face OCT angiograms

FAF of ON Drusen

OCT Angiography

Factors to consider when purchasing new technology:

- 
- 
- 
- 
- 

The Critical Question

Will this technology improve patient care?

How can imaging technologies help me grow my practice?
**Benefits of Post Seg Imaging**

- Provide a higher level of care for our patients
- Less referrals to sub-specialists (Dry AMD, CSC, Nevus)
- Keep care in-house, keep revenues in house
- Use our new technology as a marketing tool to attract new patients: A/B-scan, OCT, FAF, wide retinal field imaging
  - These important tests also generate revenue
- I get referrals from many local ODs. You can too.
  - Become a recognized expert by reading and using the right tools.

**Macular Pigment Optical Density (MPOD)**

Heterochromatic Flicker Photometry

**The Importance of Macular Pigment**

- Filters blue light
- Acts as an antioxidant by quenching free radicals
- Provides support to sensory retina
- MPOD is a biomarker of retinal and systemic health (DM, cog)

**Measurement of Macular Pigment Optical Density (MPOD)**

HFP works on the principle that:

- Macular pigment absorbs blue light (not green light)
- Dense or thicker macular pigment = longer time to see the target begin to flicker
- Results are quantified in density units (du) via software
What is Multicolor Imaging (MCI)?

- Simultaneous imaging with multiple laser colors.
- MCI selectively captures diagnostic information originating from different posterior segment structures and layers within a single scan.
- Delivers high contrast, detailed images and en face slices.
- A simultaneous SD-OCT image can be obtained for multi-modal analysis.

How does MCI work?

MCI is achieved using the principle of confocal scanning laser ophthalmoscopy (cSLO).

Multicolor images are illuminated with three select color wavelengths: infrared, green, and blue.

Wide Field Imaging - MCI

MCI and FAF on Choroidal Mass

Multiple drusen appear well delineated in the Multi Color Image on right. Simultaneous SD-OCT confirms the confluent drusen pattern.

What is Multispectral Imaging (MSI)?

- The use of several non-overlapping discrete spectral bands, or slices, to highlight certain features within the field of view.
- Produces discrete en face slices of posterior segment tissue.
- FAF possible.
How does MSI work?

- MSI uses discrete light emitting diodes (LEDs) across a wavelength range from 520 nm (green) to 940 nm (infrared).
- Progressively images the layers of the sensory retina, RPE, and choroid.
- Longer wavelengths penetrate deeper into the tissues.

Multi-spectral Imaging

- Multi-spectral Imaging

Confocal Scanning

- Confocal Scanning
  - In TrueColor confocal fundus photography white light is flashed onto the retina and gets reflected back to the sensor.
  - Image quality is NOT affected by cataract and other media opacities because light reflected by other layers crossed (cornea, aqueous, lens, vitreous) is filtered and does NOT contribute to image formation.
  - Image quality is less affected by pupil size (min 2.6 mm)
  - FAF possible

Confocal Scanner Images

- Confocal Scanner Images

Red-free

- Red-free
Dry AMD-GA

True-Color Confocal Image

Images courtesy of Jonathan A. Sadile, MD

Scanning Laser Match Game

Instruments
- OCT
- HRT 3
- GDX

Technologies
- Confocal scanning laser ophthalmoscopy (CLSO)
- Scanning laser polarimetry (SLP)
- Low Coherence Interferometry

OCT: The Big Dog in PS Imaging
Optical Coherence Tomography

Unlike FA, OCT is non-invasive.

Posterior Segment Applications
- Vitreous/Vitreoretinal Interface
- Neurosensory retina, RPE/Bruch’s
- Choriocapillaris/Deeper Choroid (EDI)
- Optic Nerve/NFLA

Coverage for OCT
- Anterior Seg 92132
- Glaucoma/ON 92133
- Retina 92134

Coding Caveats
- These codes are only billed once, whether you scan both eyes or just one.
- 92133 and 92134 are mutually exclusive, so they cannot be billed on same day, regardless of diagnosis.
- In many areas, 92132 is also considered to be inappropriate to bill on the same day with either of the posterior segment procedures.
- Check your local LCD.

Questions and Comments?

OCT vs. Other Imaging

- Resolution (log)
- Penetration depth (log)
- Confocal microscopy
- High frequency
- Ultrasound
- Standard clinical

- OCT

- 1 mm
- 1 cm
- 10 cm
Optical Coherence Tomography

Analogous to ultrasound

TOmography: cut/cross-section CAT, MRI, OCT, B-Scan

TOPOgraphy: relief/mapping Corneal Top

Scan of the reflectivity of a sample as a function of depth is referred to as an A-scan.

A cross-sectional tomograph is achieved by laterally combining a series of A-scans.

Two-dimensional data sets are digitized by a computer and presented as a gray-scale or false-color image.

Identification of Retinal Layers-TD

NFL: Nerve Fiber Layer
INM: Inner Nuclear Membrane
GCL: Ganglion Cell Layer
IS/OS: Junction of inner and outer photoreceptor segments
RPE: Retinal Pigment Epithelium
CC: Choriocapillaris
IPL: Inner Plexiform Layer
OPL: Outer Plexiform
SD-OCT Healthy Macula

SD-OCT Healthy Macula w/Layers

Cross-sectional image of live tissue; a "virtual biopsy"
Wide Field OCT--VMA

High Definition and Resolution

Posterior Segment Applications

OCT Interpretation: In Order of Increasing Reflectivity (brightness)

Bright colors = High reflectivity

The Vitreoretinal Interface

Posterior Segment Applications

- Vitreous/Vitreoretinal Interface
- Neurosensory retina, RPE
- Choriocapillaris
- Optic Nerve/NFLA
Case: 58 y/o WM
Gradual blur, VA 20/60

Anomalous PVD: VFTS or Stage 1 Macular Hole

Is this patient a candidate for

Vitreoretinal Interface

The Vitreous
The Vitreous

Chemical Vitrectomy for Vitreomacular Adhesions (VMA)

MIVI-TRUST Program
- Microplasmin for IntraVitreous Injection-Traction Release without Surgical Treatment
- Two randomized, placebo controlled, double-masked, multi-center trials (Phase III)
  - single-dose 125 µg intravitreal Ocriplasmin (ThromboGenics) v. placebo for symptomatic VMA.
- Primary endpoint of both trials was resolution of VMA one month after injection.
- Over 650 patients were enrolled
- 90 centers in 7 countries.

Goal: Complete PVD

Results
- At 28 days, VMA resolved in 29.8% of 464 eyes treated with Ocriplasmin and 7.7% of 188 eyes given placebo.
- Total posterior detachment occurred in 17% of treated eyes.
- Moreover, 25.5% of treated eyes gained two or more lines of acuity at 6 months.
- At 6 months, 40.6% of treated eyes achieved full-thickness macular hole closure, compared with only 17% of placebo eyes.

Questions and Comments?
Vitreomacular Adhesion in AMD
- May hasten the AMD process.

The Posterior Hyaloid in AMD
- If microplasmin can successfully produce a PVD, there may be some future therapeutic benefit in the prevention of progression to wet AMD.

- Sebag J, Binder S. Posterior hyaloid adhesion is significantly increased in NV AMD. Program and abstracts of the 40th Annual Scientific Meeting of the Retina Society; September 27-30, 2007; Boston, Massachusetts.

VMA may precipitate Macular Edema in DR, RVO

Multiple conditions:
- VMTS
- VPTS
- Subretinal fluid (Serous RD)
- Sub-RPE fluid

Wet AMD
With serous RD

Diabetic Retinopathy--ME may occur at ANY stage!

Macular Edema is #1 cause of vision loss in CRVO
Status of Ocriplasmin Pharmacologic Vitreolysis

- ThromboGenics gained FDA approval and brought Ocriplasmin to market in the U.S. in January 2013.
- New unique ICD-9-CM disease code approved specifically for vitreomacular adhesion (VMA).
- ICD-9 = 379.27

Indication
JETREAx® (ocriplasmin) Intravitreal Injection, 2.5 mg/mL, is a proteolytic enzyme indicated for the treatment of symptomatic vitreomacular adhesion.

Good Candidates for Jetrea
- Small VMA area
  - <1,500 microns
- No ERM
- Stage 2 MH
- Younger
  - < 65 y/o
- Phakic

Poor Candidates for Jetrea
- Eyes w/multiple VMAs
- High myopia (greater than 8.00D)
- Hx of prior RD
- Macular hole greater than 400µm
- ERM
- Ischemic retinal disease

S/P Jetrea
Most patients experience worsening of symptoms, i.e., flashes, floaters and/or reduced vision, before they improve.

Anti-Integrin Peptide for VMA
- Phase II study of anti-integrin oligopeptide (ALG-1001) in patients with vitreomacular traction (VMT).
- Also treats CNV.
- David Boyer, MD
Case: 72 y/o WF
Gradual central blur OS
VA = 20/100

Stage 3 Macular Hole

Watzke-Allen Test
- Subjective
- Purpose: identify full-thickness v. lamellar
- Fundus lens at SL
- Vertical beam
- Central break indicates full-thickness
- Maddox rod, direct scope

Macular Hole (Stage 4)

ERM With Mac Pucker, Pseudohole

ERM en Face (Slab Analysis)
ERM 3-D

Posterior Segment Applications
- Vitreous/Vitreoretinal Interface
- Neurosensory retina, RPE/Bruch’s
- Choriocapillaris
- Optic Nerve/NFLA
Central Serous Chorioretinopathy

- 36 y/o WM
- CC: Sudden central blur OS
- VA OD 20/20
- VA OS 20/200

Central Serous Chorioretinopathy

RPE Detachment

- 48 y/o BF
- VA 20/20

Pigment Epithelial Detachment
18 yo BF 20/80
Bests Disease-confirm with EOG

Dry AMD

Retinitis Pigmentosa

18 yo BF  Best’s Disease

Questions and Comments?

Posterior Segment Applications
- Vitreous/Vitreoretinal Interface
- Neurosensory retina, RPE/Bruch’s
- Choroid
- Optic Nerve/NFLA

Choroid Microstructure
Vascular Layers of the Choroid

Posterior Segment Applications
- Vitreous/Vitreoretinal Interface
- Neurosensory retina, RPE
- Choriocapillaris
- Optic Nerve/NFLA

A 58-year-old male: chronic ONH edema
Demyelinating Optic Neuropathy

58 y/o WF w/ MS
VA 20/25 OD/OS APD -

Ganglion cell analysis in MS
Posterior Segment Applications

- Vitreous/Vitreoretinal Interface
- Neurosensory retina, RPE
- Choriocapillaris
- Optic Nerve/NFLA

SD-OCT Glaucoma in HD

2-D and 3-D volumetric data cubes

TSNIT w/comparison

Analysis Elements

<table>
<thead>
<tr>
<th></th>
<th>OD</th>
<th>DD</th>
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<tbody>
<tr>
<td>Average RNFL Thickness</td>
<td>2.85 mm</td>
<td>2.87 mm</td>
</tr>
<tr>
<td>RNFL Average OD/OD</td>
<td>29.5</td>
<td>0.7</td>
</tr>
<tr>
<td>Average OD/OD</td>
<td>0.23</td>
<td>0.25</td>
</tr>
<tr>
<td>Cup Volume</td>
<td>0.25 mm^3</td>
<td>0.20 mm^3</td>
</tr>
</tbody>
</table>

Optic Nerve Head calculations are presented in a combined report with RNFL thickness data. Key parameters are displayed in table format.

Cirrus RNFL + ON OU Analysis
50 Year Old BF

RNFL thickness and comparison to normative data is shown in circle, quadrants and clock hour display.

TSNIT RNFL thickness along the calculation circle is displayed in graphic format and compared to age-matched normative data.

GDx RNFL OU Analysis
50 Year Old BF
GDx vs. Cirrus OCT Analysis

Cirrus OCT Progression Analysis
50 Year Old BF

Cirrus OCT RNFL + ON Analysis
75 Year Old WM Plateau Iris Syndrome

Note neuro-retinal rim data

Plateau Iris Syndrome

Cirrus Ganglion Cell OU Analysis
75 Year Old WM Plateau Iris Syndrome

Pigmentary GLC Pre/Post LPI

Note “back-bowing” of the iris
Questions and Comments?

Advanced Visualization Analysis
Manipulation of Images on OCT

Advanced Visualization
HD Cross Sectional Image
Vitreomacular Traction
HD Fundus Image
Central Serous Chorioretinopathy
HD Layer Map of ILM
Central Serous Chorioretinopathy
HD Thickness Map
Central Serous Chorioretinopathy
HD Layer Map of RPE
Age Related Macular Degeneration

Advanced Visualization
3D Volume Rendering with RPE layer exposed

Advanced Visualization
3D Volume Rendering

Choroidal Neovascular Membranes (CNVM)
OCT shows increased retinal thickness due to leakage.
**Macular Change Analysis**

Provides visual and quantitative comparison of two exams. Post-acquisition registration and the unique Fovea Finder function allows the accuracy and precise repeatability of macular thickness measurements.

**Pre and Post Avastin Treatment**

VA 55 L

VA 78 L

**Case**

- 65 Year old Female
- Comes in with complaints of blurred and dimmed vision
- PMH: Rheumatoid Arthritis x 15 years
- OcHx: S/P CE and IOL OU

**Ophthalmic Exam**

- **VA:**
  - OD: 20/40
  - OS: 20/40
- **IOP**
  - OD: 14
  - OS: 13
- **SLE:**
  - OD: PCIOL
  - OS: PCIOL
- **DFE:**

**DFE/OCT**

**OS**
Additional Testing?

Visual Fields

Fundus Autofluorescence
While Angiography images BRB integrity, FAF captures metabolic activity.

Auto Fluorescence

Likely Diagnosis?

Plaquinil Maculopathy
- Co-management team includes eye care provider, rheumatology
- Testing guidelines for patients on Plaquinil
- Repeat testing
Fundus Autofluorescence

While Angiography images BRB integrity, FAF captures metabolic activity.

Imaging Technologies: FAF

Hyper-AF

Hypo-AF

Imaging Technologies: FAF

What is autofluorescence in the retina?
- It is the fluorescence of the lipofuscin molecule within the RPE cell layer that fluoresces with a certain wavelength.

19 years

64 years

Autofluorescence (FAF)

- Principle
  - When stimulated with light in the blue range, lipofuscin granules emit yellow fluorescence.
  - Patterns of fundus autofluorescence may predict which eyes will progress more quickly.

Autofluorescence

- Early ID of disease.
- ON drusen
- CSC
- Predictive marker
  - increased FAF signal precedes dry AMD progression.
- Monitor Dx.
- Functional correlation.
What is the future?

- Adaptive optics
- An instrument capable of compensating for the large aberrations present in the human eye.
- Visualize the retina at the cellular scale.
  - Cones, nerve fiber bundles, capillaries, lamina cribrosa

Adaptive Optics

- Swept Source OCT
  - 1,050nm wavelength
  - 100,000 A-scans/sec
  - Allows deeper imaging of choroid, sclera, intra-orbital ON

Multi-modal Imaging

- e.g. Spectralis SD-OCT w/Blue Peak AF, FA/ICGA
- mf-ERG + OCT
- Adaptive optics retinal camera/SD-OCT

Multi-modal Imaging

- SD-OCT
- Color digital imaging
- FAF
Blue Peak FAF + OCT

Multi-modal Imaging
- e.g. Optos SD-OCT w/microperimetry

FAF + Microperimetry
Atrophy associated with hypo-AF (GA) correlates to severe VFD

Digital Video Imaging

PDR w/Vitreous Heme

ERM Surgery
Summary and Conclusions

- No imaging technology replaces the skills of a good historian, diagnostician, clinician.
- Clinicians are better equipped than ever to detect and characterize sight-threatening posterior segment disease early.
- Timely treatment with more effective therapies enhance the potential for improved visual outcomes.

Thank you!

Joe