The Future of Retinal Imaging Has Arrived!

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Goals of this Course

- To provide an overview of PS Imaging
- Past, Present, and ...
- OCT and other technologies
- Interpretation and clinical use

Imaging Technologies

- Fundus photography
- Wide-field/panoramic
- Angiography
  - Fluorescein (FA)
  - Indocyanine Green (ICGA)
- Microperimetry
  - MP-1
  - MAIA

Imaging Technologies

- Autofluorescence (FAF)
- Scanning lasers
  - HRT
  - OCT
- Ultrasonography (Echography)
- Multi-spectral imaging
- Adaptive optics

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

Richard Spaide, MD
NY Retina Consultants
Digital retinal imaging does not replace a dilated retinal examination.

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

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**Which one is right for my practice**
- Factors to consider:
  - Patient base
  - Mode of practice
  - Staff
    - Acceptance of new technology
  - Networking capability
  - Cost/ROI
  - Space issues
  - Future upgrades and data archiving system
  - Support/training provided by company?
    - Installation and initial training
    - Periodic training

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**The Critical Question**
Will this technology improve patient care?

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**Scanning Laser Match Game**
- **OCT**
- **HRT 3**
- **GDX**
- Low Coherence Interferometry
- Confocal scanning laser ophthalmoscopy (CLSO)
- Scanning laser polarimetry (SLP)
Optical Coherence Tomography

Unlike FANG, OCT is non-invasive.

OCT: The Big Dog in PS Imaging

SD-OCT

Posterior Segment Applications
- Vitreous/Vitreoretinal Interface
- Neurosensory retina, RPE
- Choriocapillaris
- 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.
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.

In time domain, reference mirror is moving, slowing down the scanning rate.
In spectral domain, reference mirror is stationary, which speeds up the scanning process.
The information that was provided by the moving reference mirror is replaced by employing a spectrometer on the detector side of the instrument.
Identification of Retinal Layers-TD

Cross-sectional image of live tissue; a "virtual biopsy"

SD-OCT Healthy Macula

Temporal (time) domain OCT measures light echo from a given time delay.

Spectral/Fourier detection can measure all of the light echoes from all time delays simultaneously.

Spectral/Fourier detects light echoes by using:

- Interferometer
- Spectrometer
- High speed CCD camera

The interference spectrum of the light is detected and digitally processed to construct the Fourier transform.

High Definition and Resolution

Does SD/FD/HD make a difference?
OCT Interpretation: In Order of Increasing Reflectivity (brightness)
- Black = Vitreous, Cystic/Ser. Fluid, Blood
- Blue/Green: Vitreous Debris
- Green/Yellow = Retina, Choroid
- Red = NV, Dense Tissue
- Red/White = NFL, RPE, Scar Tissue
- White = Silicone Oil, Scar Tissue

Bright colors = High reflectivity

Posterior Segment Applications
- Vitreous/Vitreoretinal Interface
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The Vitreoretinal Interface

Complete PVD

Anomalous PVD

Case: 58 y/o WM
Gradual blur, VA 20/60
Is this patient a candidate for Vitreoretinal Interface

The Vitreous

Chemical Vitrectomy for Vitreomacular Adhesions (VMA)

Pharmacologic Vitreolysis - Microplasmin
Pharmacologic Vitreolysis Based on Biochemical Prop.

Enzymatic       Non-Enzymatic
-Non-Specific  Urea/Vitressolve
-Tissue plasminogen  RGD peptides
-Microplasmin
-Nattokinase

Substrate Specific
-Chondroitinase
-Dipase
-Hyaluronidase
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.

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
- 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.
Wet AMD

VMA in DME, RVO

Multiple conditions

Diabetic Retinopathy--ME may occur at ANY stage!

Based on ETDRS, retinal thickening in CSDME is “traditionally” managed with focal or grid laser.

Ischemic CRVO-- get prompt retina consult!

Macular Edema is #1 cause of vision loss in CRVO

- Note disc edema, several CWS
- Capillary non-perfusion on FA
- VA < 20/200, +APD, retinal/macular edema
- More likely to result in NVI/NVA than non-is
- 45% of cases result in NVG
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

New unique ICD-9-CM disease code approved specifically for vitreomacular adhesion (VMA).
ICD-9 = 379.27

Indication
JETREA® (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 400 µm
- 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 Pucker, Pseudohole

ERM Slab Analysis
ERM 3-D

Macular Hole Sx. ILM Peel

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

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

RPE Detachment

48 yo BF
VA 20/20
Pigment Epithelial Detachment

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

18 yo BF Best’s Disease

AMD

Retinitis Pigmentosa

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

Choroid Microstructure
Vascular Layers of the Choroid

Posterior Segment Applications
- Vitreous/Vitreoretinal Interface
- Neurosensory retina, RPE
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A 58-year-old male: chronic ONH edema
DFE OS

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

Analysis Elements

Cirrus RNFL + ON OU Analysis
50 Year Old BF

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

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

Note neuro-retinal rim data
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

3D Volume Rendering with RPE layer exposed

Advanced Visualization

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

QUESTIONS AND COMMENTS?

Milestones in Retinal Imaging

- Fundus Photography 1920s
- Fluorescein Angiography 1950s
- B-Scan Ultrasound 1970s
- ICG Angiography (Digital) 1980s
- CSLO (HRT), SLP (GDX-VCC) 1990s
- Digital Photography 1990s
- OCT first demonstrated 1991
- High-res OCT 2001

Digital Photography

- Features/Advantages
  - Mydriatic
  - Non-mydriatic
  - No film
  - Telemedicine
  - High resolution
  - Documentation
  - Patient education

Digital Imaging Systems

Optomap

Daytona
Wide-field OS Composite vs. AF

Digital Video Imaging

PDR w/Vitreous Heme

FA
- The “gold standard” for the evaluation of new onset choroidal neovascularization (CNV).
- 1 in 5 eyes (20%) w/dry AMD convert to wet.

The Fluorescein Angiogram

- Choroidal Phase (10 sec post-injection)
  - Choroidal "flush" due to free dye in CC
- Arterial phase (12-14 sec)
  - Retinal arteries prominent
- Laminar venous phase (14-20 sec)
  - Dye begins to fill retinal vein

The Fluorescein Angiogram

- Venous phase (20-30 sec)
  - Complete filling of veins
- Recirculatory phase (2-4 min)
  - A & V equal in brightness
- Late phase (5 min +)
  - Elimination of dye from vasculature
  - Hyperfluorescence in abnormalities (CNV)
Fluorescein Angiography in CSC

- Normal Phases
  - Choroidal
    10 - 15 sec after injection
  - Arterial
    0 - 2 sec after choroidal phase
  - Arteriovenous
    5 - 15 sec after arterial phase
  - Late phase
    10 minutes after injection

Optos Wide-Field Angiography

The Fluorescein Angiogram

- Pooling
  - Leakage into space

- Staining
  - Leakage into tissue

FANG and CNVM

- Classic CNVM
  - Well-demarcated, discrete, bright choroidal fluorescence in early phase
  - Late phase shows dye leakage which obscures the boundaries of the membrane

OD
VA 20/400 NIPH
45 yo BF with sickle cell trait
BCVA: 20/20 OD, 20/20 OS

Obstacles in FA Evaluation
- Thick b___________
- Pigment
- Fibrous tissue
- RPE Detachment
- V heme
- Media opacities

Indocyanine Green Imaging
- Deeper choroidal vessels
- Green ICG dye allows for visualization thru:
  - Blood
  - Fluid
  - Pigments that obscure certain conditions from view

Indocyanine Green Angiography
- Clinical CNVM Case

Indocyanine Green Imaging
- A: Red-free
  - Photo of classic CNV.
- B: Early-phase (1-2 sec)
  - Rapid filling of choroidal BVs, retinal arteries.
  - ICG hyperfluorescence of the CNVM.
- C: Mid-phase (3-15 min)
  - Fading of choroidal, retinal vessels.
  - Staining of CNV.
- D: Late-phase (15 min +)
  - Hypofluorescence of choroidal vasculature.
  - Retinal BVs not visible
  - Late staining of the hyperfluorescent CNV.

Indocyanine Green Angiography
- AMD or PCV CNVM?
  **variants of inner choroidal neovascularization (CNV)
  Polypoidal Choroidal Vasculopathy

http://www.retinalphysician.com
ICG Evaluation

ICGA

ICG - early phase shows RPED
late staining of the vascular network and filling of the RPED

QUESTIONS AND COMMENTS?

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:
While Angiography images BRB integrity, FAF captures metabolic activity.
**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.

15 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**

**Autofluorescence (FAF)**

- **Early ID of disease.**
- **ON drusen**
- **CSC**
- **Predictive marker**
  - Increased FAF signal precedes dry AMD progression.
- **Monitor Dx.**
- **Functional correlation.**
To Find Small Ocular Melanoma

\[ T = \text{thickness} \]
\[ F = \text{subretinal fluid} \]
\[ S = \text{symptoms} \]
\[ O = \text{orange pigment} \]
\[ M = \text{margin touches disc} \]

No risk factors (<4%)
1 risk factor (36%)
3 risk factors (50%)
5 risk factors (70%)

DOCUMENTED GROWTH MEANS EVERYTHING!

Using Helpful Hints = Ultrasound hollow, halo

Orange Pigment

Subretinal Fluid

FAF on Choroidal Mass

FAF in Choroidal Melanoma

Echography

- Acoustic hollowness on B-scan of small melanoma.
Echography of Choroidal Melanoma

B-Scan Echogram
Assess topographic features, including tumor shape, surface contour and boundaries

A-Scan Echogram
Internal structure, reflectivity, tumor height (elevation)

Choroidal Melanoma

- B-scan:
  - *collar button shape (mushroom)*
  - *high reflectivity*
  - *regular internal structure*
  - *medium low reflectivity*
  - *possible choroidal excavation*
  - *possible sound attenuation*

- A-scan:
  - *low to medium internal reflectivity*
  - *internal vascularity*

Multi-spectral Imaging

- The RHA (Annidis)
- CCD camera
- Multiple LED light sources
- Automated spatial and spectral filters
- Operates across range of 450 to 900 nm

Pattern Dystrophy of RPE
Pattern Dystrophy of RPE

Pattern Dystrophy of RPE

Pattern Dystrophy of RPE

Pattern Dystrophy of RPE

Pattern Dystrophy of RPE

Pattern Dystrophy of RPE
Pattern Dystrophy of RPE

Pattern Dystrophy of RPE

FUTURE HORIZONS
in PS Imaging

Adaptive Optics

Multimodal Imaging

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

**Geographic Atrophy**

*Blue Peak FAF + OCT*

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

**Multi-modal Imaging**

- e.g. Optos SD-OCT w/micoperimetry

**Milestones in Retinal Imaging**

1909-Thorner’s Stereo Photos
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!