### Disclosures
- Principal investigator for iVue OCT trial
- Principal investigator Topcon FDA trials for Maestro and OCT 2000
- Consultant for Topcon
- Speakers bureau Sanofi- Genzyme, Optovue and Allergan

### Definitions
- “Ocular tissue damage at least partially related to intraocular pressure”
- A chronic, bilateral, often asymmetrical disease in adults, featuring acquired loss of optic nerve fibers and abnormality of visual field with an open anterior chamber angle.

### Goals
- Document status of optic nerve structure and function
- Target pressure - so damage is unlikely to happen
- Maintain IOP below target pressure
- Monitor status of the optic nerve and reset target pressure if deterioration occurs.
- Minimize side effects of management and impact on vision and general health and quality of life.
- Educate and engage the patient in management

### Imaging and glaucoma
- No longer colorful imaging technology!
- Several sophisticated imaging techniques are at different stages of development.
- Most technology are changing rapidly
Gold standard
- Simultaneous stereo photography!
- Problems?

Optical coherence tomography
- It has become the mainstay of all the imaging
- It is indeed at a great point now
  - Prior devices were changing rapidly
  - Did not have good software
  - Many imaging errors
  - Numerous unknowns on how to use technology

**Comparison of Time versus Fourier domain**

**Time Domain OCT**
- Sequential
- 1 pixel at a time
- 1024 pixels per A-scan
- 400 A-scans per second
- 512 A-scans in 1.28 sec
- Slower than eye movements

**Fourier Domain OCT**
- Simultaneous
- Entire A-scan at once
- 2048 pixels per A-scan
- 26 to 70-80K A-scans per second
- 1024 A-scans in 0.04 sec
- Faster than eye movements

Image registration issues
Fourier Domain OCT

Broadband Light Source

SLD

Grating splits signal by wavelength

Spectrometer analyzes signal by wavelength

Interferometer

Combines light from reference with reflected light from retina

Reference mirror stationary

FFT

Spectral interferogram

Fourier transform converts signal to typical A-scan

Entire A-scan created at a single time

Process repeated many times to create B-scan

SPECTRALIS® with TruTrack™
Follows the Eye

The eye moves too fast for any OCT tracking to compensate for all motion artifacts Until Now
Solution: MCT (Motion Correction Technology)

NFL Change Maps

Optovue OCT

SPECTRALIS® with TruTrack™

Interpretation of OCT

VTRAC
from Optovue is the fastest OCT eye tracking option at 30 f/s

Optovue OCT

NFL Change Maps
Ganglion Cell Complex (GCC)

How is GCC measured

GCC output

GCC Change

Case
Screening methods - IOP

- IOP poor screening tool
  - Sensitivity 47.1%, specificity 92.4%
  - Most people with high pressures do not have or never develop POAG

Screening methods

- Screening can be made more effective by including ONH and RNFL assessment.
- Standard visual field is time consuming.
- Frequency doubling technology shows promise as a screening tool

Screening cont...

- Screening can be more efficient if
  - Targeted to specific groups
    - Older population
    - African Americans
    - Relatives of glaucoma patients

Sensitivity and specificity were calculated for identifying normal and abnormal individuals

99% Specificity
95.5% sensitivity in identifying retinal diseases
90% identifying optic nerve disease
Progression

- Consensus is limited

- Visual fields tend to fluctuate in early glaucoma

- Reliable and repeatable structural measurements is very valuable
  - Fourier domain OCT 5 microns accuracy.

Case – 57 YO F
Retinal layers with OCT

Retinal diseases and OCT

Macula hole
Macular hole details
- Retinal hole in the fovea
- Idiopathic, cystoid macular edema, vitreomacular traction, trauma
- Senile idiopathic 83%, trauma 5%, rest other types
- 25-30% bilateral
- Symptoms decreased vision, metamorphopsia

Stages of macular hole
- Stage 1: foveal detachment, absent foveal reflex
- Stage 2, early small full thickness hole
- Stage 3: Full thickness >400 micron, operculum cuff of subretinal fluid
- Stage 4 stage 3 and PVD

Case 70 YO White Male
- H/O macular drusen
- Established patient of practice
- Annual visit for evaluation of retina and eye health.
- Vision complaints none
- NO c/o glare, distortion, headaches.

Personal ocular history
- H/O drusen

Personal medical history
- diabetic, hypertensive and had hypercholestremia and was on medications for the same (10 years)
- Visit to endocrinologist 1 month ago
- HbA1c – 6.3
- Rest was deemed within control

Family medical history
- Diabetes parents

Medications
- Beta blockers b.i.d. - HTN
- Insulin diabetes
- Aspirin
- Fish oil capsules with 1000 mg t.i.d
Allergies – none

At this time it all appeared to be good and routine.

Clinical data

- VA
- 20/40, 20/30 and 20/30 OD, OS and OU respectively
- NI with PH
- Refractive error not significant

Anterior and nerve evaluation

- xanthelasmata OU on his eye lids (superiorly)
- nuclear sclerosis OU.
- IOPs 12 and 15 mmHg OD and OS respectively.
- Healthy Rim
- The cup to disc ratio estimated using a volk 90 D lens and slitlamp was OD 0.3 (H and V) OU.

Drusen embossed images
Visual fields 24-2

- Visual field assessment with Humphrey Field Analyzer II, 24-2 SITA Fast protocol
- Mean deviation (MD) -2.33 dB and pattern standard deviation (PSD) + 2.16 in the right eye
- MD -3.74 and PSD + 3.10 in his left eye.
- The Glaucoma Hemifield Test result was “Outside Normal Limits” for the right eye and “Borderline” for the left eye.
- His visual fields in both eyes revealed a scotoma in the central 5 degrees of his fields.

VF 10-2

- 10-2 visual fields
- MD was -5.50 and -4.40 and PSD was +3.73, +3.25 in the right eye and left eye respectively for 10-2 fields.
- The probability value of all the visual field indices were <1%.

Assessment

- 1) Macular degeneration OU

Plan

- 1) Continue fish oil.
- 1) Perform OCT 200x200 macula examination OU
- Return 03/30/2010

Return visit

- IOP 12 OU
- OCT 200x200 was performed

OD
OS

Assessment
- 1) Macular degeneration OU
- 2) Viteroretinal traction OU
- 3) Premacular hole without foveal detachment OS

Plan
- 1) Continue fish 1000 mg t.i.d. EPA and DHA 1 gram
- Add IPromise capsules with Leutin and Zeaxanthin b.i.d
- 2 and 3 refer to retinal consultant.
- Follow-up 1 year or sooner if conditions change particularly vision

Sub foveal retinal detachment
Central Serous Retinopathy details

- Idiopathic leakage from choroid into subretinal space (94%), under RPE (3%) both 3%.
- Presumably due to RPE or choroid dysfunction.
- Usually males (10:1) aged 20-50
- Associated with stress, type A personalities, associated with pregnancy, steroid use, hypertension

CSR cont...

- Symptoms: Micropsia, meta morphopsia, central scotoma, mild dyschromatopsia
- Signs: Reduced VA, induced hyperopia, abnormal amsler.
- Treatment: No treatment; usually resolves spontaneously over 6 weeks.
- Low-intensity direct focal laser or PDT if required.

Case 1 24 yo BF

- Blur left eye, severe, woke up with blur two days ago.
- Modifying factors none, no injury, blood pressure and blood sugar normal.
- VA OD 20/20 - OS 20/150

24-2 Visual fields Case 1 CSR
Central serous retinopathy

Intact foveal architecture

iWellness Scan Case #1

Case #1 3D

Case#1 3D (Enface)

Case #1 Change
Case #1 Retina Map

Epiretinal membrane

ERM details
- Cellular proliferation across internal limiting membrane and retinal surface.
- Risk factors
  - Prior surgery, inflammation, retinal vascular occlusion, vitreous hemorrhage, tumors

ERM details cont...
- Symptoms
  - Near normal VA early stages, distortion
- Signs
  - Normal or decreased VA, abnormal Amsler grid, thin translucent membrane, dragged vessels, retinal striae, pseudo holes
- Treatment
  - Not necessary unless visual changes become problematic
  - Para plana vitrectomy and membrane peel.

Epiretinal membrane
Epiretinal membrane

iWellness Case #5 Enface

iWellness Case #5 3D (Great Teaching Tool)

Case 2, 66YO WF
- HO DM,
- VA with correction OD 20/25 and 20/40 OS
Cystoid macular edema details

- Accumulation of extracellular fluid in macular region with characteristic cystoid spaces
- Post surgery,
- post YAG, post cataract surgery (Irvine-Gass syndrome),
- diabetic retinopathy,
- medications epinephrine and dipivefrin and prostaglandin analogue in aphakic patients
- AMD

Treatment

- Treat underlying cause.
- NSAIDS or/and steroids (injections)

Diabetic Macular edema

- Edema where underlying pathology is DM

Clinically significant macular edema
Clinically significant macular edema cont...

- Retinal thickening <500 micron from centre of fovea
- or
- Hard exudates < 500 micron from fovea with adjacent thickening
- Or
- Retinal thickening >1 disc size in area < 1 disc diameter from centre of fovea

Vitreous Liquefaction

Vitreo-macular traction

VMT cont...

Macular hole stage 2
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

AngioVue Imaging System

- OCT + OCTA
- Non-invasive vascular imaging
- Extensive retina applications
- Comprehensive glaucoma package
- Proprietary anterior segment applications

Structure + Function: Retina

Structure + Function: Optic Nerve
See The Vessels Like You’ve Never Seen Them Before!
- Segment retinal vasculature into individual layers
- Eliminate effects of dye-based blurring and pooling
- Isolate areas of interest
- View 3x3mm and 6x6mm scans

Non-Invasive, Dye-Free & Fast
- No injection, no fluorescein
- Order test as needed to more closely monitor disease progression and treatment response
- Image acquisition in less than three seconds
- Total time in room approximately 10 minutes

Principles of AngioVue OCTA
- Uses motion contrast to detect blood flow
- Rapidly acquire multiple cross-sectional images from a single location on the retina
- Flow is the difference between two sequential scans
  - Flow = Frame #1 – Frame #2

Auto Segmentation of Retinal Layers

How Does AngioVue Work?

SSADA: Split Spectrum Amplitude Decorrelation Angiography
Generate Multiple OCTA Images in Parallel

The SSADA algorithm was developed by David Huang, MD, PhD at Oregon Health Sciences University.
AngioVue vs. FA & ICGA

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<tr>
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<td>Imaging time</td>
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Terminology of OCT Angiography

Segmentation, Slabs & Slices
- Segmentation allows rapid identification and interpretation of pathological vascular features
- Typically performed on structural OCT images – key reference points:
  - ILM
  - IPL
  - OPL
  - RPE
  - Bruch's membrane
- Slabs are thick tissue sections: inner retina, outer retina
- Slices are thin sections of a few microns used to examine fine details

Artifacts & Motion Correction
- Projection Artifact
  - Flowing blood casts shadows in the superficial capillary plexus
  - Results in appearance of superficial vessels in deeper layers
- Motion Artifact
  - OCTA operates on principle that motion equals blood flow – all motion is imaged
  - Patient movement (loss of fixation) appears as white lines
  - Blinks appear as black lines
- Motion Correction Technology (MCT™)
  - Merges horizontal (Fast X) and vertical (Fast Y) scans
  - Minimizes saccadic motion and improves image intensity
  - MCT processing done post-scan to reduce acquisition time
- Motion Correction Technology (MCT™): Minimizes Saccadic Motion to Enhance Image Intensity
  - With MCT
  - Without MCT
Scan Size Selection
- Retina: 3x3, 6x6, 8x8 mm
- Disc: 3x3, 4.5x4.5 mm
- Smaller scan sizes produce the highest quality images
- Larger scan sizes allow wider area coverage to aid multimodality comparisons

Montage View
- Combines 6x6 retina and 6x6 optic disc for widefield view

Clinical Applications of OCT Angiography

OCTA Clinical Applications
- Inner Retina Disorders
  - Diabetic Retinopathy (DR)
  - Proliferative Diabetic Retinopathy (PDR)
  - Macular Telangiectasia
  - Branch Retinal Vein Occlusion (BRVO)
  - Macular Pucker
  - Coat’s Disease
  - Retinal Ischemia

OCTA Clinical Applications
- Outer Retina Disorders
  - Choroidal neovascularizations (CNV)
    - Type I
    - Type II
    - Type III (RAP)
    - Mixed Type I and II
Follow Treatment More Closely with Non-Invasive Imaging

AngioVue Image Interpretation

Normal Retinal Vasculature

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

Type 2 “Classic” CNV
- New vessels develop in choroid
- New vessels located ABOVE the RPE a ABOVE Bruch’s membrane
Type 2 “Classic” CNV

- Fluorescein Angiography
- Superficial Capillary Plexus
- Choriocapillaris

OCT Angiography

Type 3 CNV

- OCT Angiography
- En Face OCT

Dual-Modality Imaging of Choroidal Neovascularization

Neovascular AMD with CNV

- Late leakage of undetermined source
- Fundus Photo & Fluorescein Angiography
- OCT Angiography

Macular Telangiectasia

- Superficial retinal vessels lose most of the branches and present loop patterns.
- Deep plexus capillaries are irregular
Macular Telangiectasia

6x6 mm Macula Scan

Fluorescein Angiography
Superficial Capillary Plexus

Macular Telangiectasia

3x3 mm Macula Scan

Fluorescein Angiography
Superficial Capillary Plexus
Deep Capillary Plexus

Diabetic Retinopathy

- Retinal capillary non-perfusion – seen as blackened area without blood flow outside FAZ
- Microaneurysms
- Enlarged FAZ

Dual-Modality Imaging of Diabetic Retinopathy

OCT Angiography
En Face OCT

Proliferative Diabetic Retinopathy

Fluorescein Angiography: Macula
Superficial Capillary Plexus: Macula
Deep Capillary Plexus: Optic Disc
Superficial Capillary Plexus: Optic Disc

Non-Proliferative Diabetic Retinopathy

Fluorescein Angiography
Superficial Capillary Plexus
Deep Capillary Plexus
Diabetic Retinopathy

Fluorescein Angiography

OCT Angiography

Previously diagnosed patient. Images courtesy of Pravin Dugel, MD

Branch Retinal Vein Occlusion

6x6 mm Macula Scan

Fluorescein Angiography

Superficial & Deep Capillary Plexus

Previously diagnosed patient. Images courtesy of Pravin Dugel, MD

Branch Retinal Vein Occlusion

4.5x4.5 mm Optic Disc Scan

Fluorescein Angiography

Superficial & Deep Capillary Plexus

Previously diagnosed patient. Images courtesy of Pravin Dugel, MD

Glaucoma

OCT Angiography: Function

OCT: Structure

Trend Analysis: GCC + ONH

Optic Disc: En Face View

Previously diagnosed patient. Images courtesy of Michel Puech, MD, FRCS