OCT Fundal Angiography
Initial Experience

The new era in Medical Retina Imaging
Based on Cirrus 5000 AngioPlex 2016 Model
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OCT – Angiography
New Era of Dye Less Angiography

• Key is OCT Laser scanners increased from 27,000 to 68,000+ Hz
  • Time to do scans is shorter
    2.6 for 512 image, 1.8 for 200 image and 0.8 for Raster

• 840um Wavelength for resolution
  • Shorter wavelength = higher resolution
  • Longer wavelength = greater depth penetration – eg swept Source

• 5um and 15um Axial/horizontal resolution
  • Limited by wavelength

• 36 x 30 degree view
  • Limited by optics designs
  • Typically 3 to 6 to 8mm squares

• >67 Million data cube points for Cube data analysis
  • Fast i7 chips allow for rapid processing – Near instant now.
Blood Moves!

- Blood flows in veins and arteries
- Detect moving blood highly reflective
- Imaging the vessels where blood moves
- Ultrafast scanners can look for changes = blood flow
- 4 scans taken per slice
- Accurate Live eye tracking is key
- Computers calculate and render the data into images of the blood vessels
OCT Angiography Technique: OMAG (Optical Microangiography)

$\mathbf{I}_{ij} = A \exp(i\theta)$: Complex Value at pixel $(i,j)$ for $k^{th}$ frame

$\text{OMAG}_y = \frac{1}{N-1} \sum_{k=1}^{N} |I_{ij(k)} - I_{ij}|$
Normal OCT-A Enface Blood flow

- As useful as abnormal
- Vitreous – New vessels
- Retinal circulation – Diabetes, Vein occlusions
  - Better resolution than FFA
- Mid retina – Aneurysm, RAP
- Choriocapillaris - AMD, PED
- Choroid – Naevi, Melanoma
What OCT-A Machines are out there

• March 2016 Zeiss 5000 - Solely OCT 78Khz
• 2017 Heidelberg Spectablis – OCT 85Khz
• December 2015 Topcon Triton – Swept source 100Khz + Fundal Camera
• Nidek Rs-3000 Advance (53Khz)
• OptoVue – Haag-Streit, AngioMontage, Angio Anlaysis 70Khz
Different types of algorithms

- **Zeiss**
  - OMAG Optical Microangiography

- **Heidelberg**
  - Full spectrum-Decorrelation angiography

- **Topcon**
  - Full spectrum Ratio Based-amplitude ratio analysis

- **Optovue**
  - Split spectrum amplitude decorrelation angiography

- **Four OCTA Methods**
  - Speckle Variance  SV OCTA
  - Amplitude decorrelation
  - Phase Variance
  - Combination of Amplitude and Phase variance

- **Two Averaging**
  - Split spectrum
  - Volume averaging
The Benefits and Pitfalls of OCT Angiography by Professor Giovanni Staurenghi

Choroidal Neovascularization

SSADA  Complex  Angioplex  FSADA
Angio Retina Change Analysis
Normal Choriocapillaris vs abnormal inactive
Classical SRNVM that has been treated and a new recurrence has fanned out from the edge of the old lesion.
These originate from one central vessel growth and spread like petals of a flower.
High quality Definition of SRNVM in AMD
• Enhanced detail
• ConFocal Image
• Helpful to compare the two FFA and OCT-A at times
• Segmentation adjustments
• Still need Colour Photo
Making a Collage
- Capture Multiple images 6x6 or 3x3 or combination
- Use “Irfanview” Free image software to Crop image
- Use Power point to Collage the images
- Use Group function to lock all the images together
Collage images with Power point
Overlay 3x3 on to 6x6 to enhance the detail
SRVM
Spreading from the disc to the macular
AngioVue

WIDER FIELD OF VIEW

Improves visualisation of abnormalities

AngioMontage combines two 6x6mm scan images to create a wider field of view that improves visualisation of abnormalities in the retinal vasculature. This unprecedented display of microvasculature enables assessment of the essential part of the retina to aid in the early diagnosis and management of sight-threatening diseases.
43 LUCENTIS (ranibizumab) to the Left eye, Since 2011

Undertook OCT-A
OCT-A shows good definition
This is 6x6 with inserted/over layered
3x3 images

3x3 give higher definition than 6x6

However by Collaging 3x3 or 6x6 wider
fields of view can be achieved

Currently manually done using Power point
- easy
One Month apart – Dilation of the blood vessels
Possibility to monitor change/growth
9 months OCT-A change Recurrence s/12754

April 16  

Jan 17 6/9 vision
Equivalent OCT Scans, with Blood flow

Macular OCT

Macular Scan
OCT-A shows this is Retinal to Choroidal Anastomosis - RAP
Move cursor to look at blood flow
Angiography – linked to OCT scan
Precise retinal alignment is essential in all OCT-A’s
Branch retinal vein occlusion - Collaterals
HD
Detail Better than
Fundus fluorescein angiography
BRVO Choroidal views - Normal

Instant differentiation of Choroidal vs Retinal disease
• Small aneurysms too slow to show in OCTA
• FFA vs OCTA
• High contrast
• Fewer MA’s show
Naevus change to Melanoma
Change over one year Previously recommended observation
Now see Vascularisation present For Plaque
Changed management
8 x8 mm AngioPlex Image of vitreous
PVD – Weiss Rings on SLO
12 mm 100x HD scans Negative Image

1 Feb 17

6 Jan 16
Evolution of a pvd
HD Negative Images
Slab sections helpful in GEA
Diabetic IRMA or NVE?
AngioPlex Metrix V10™

**Clinical Value**

- Retinal vascular density is known to be affected by the presence of Diabetic Retinopathy (DR).
- DR is also characterized by an irregular, large foveal avascular zone (FAZ)

**AngioPlex Metrix**

- *Objectively* assess change over time
  - Vascular density
  - Perfusion density
- Help flag patients with early diabetic retinopathy changes.
  - Automatic detection of FAZ Area and Circularity

New Vascular Metrics for Diabetic Retinopathy Management

Visits 1 and 2 show that vessel density is worse in Visit 2 compared to Visit 1. Baseline FAZ Circularity and diabetic FAZ Circularity are also illustrated.
Angiography Change Analysis with AngioPlex Metrix

Clinical Value: Track changes across visits to monitor disease progression and the efficacy of treatment
AngioPlex Metrix™ Parameters

• **FAZ Parameters**
  - Area (mm$^2$)
  - Perimeter (mm)
  - Circularity (unit less)

• **Density Parameters (ETDRS Grid based)**
  - Vessel Density (mm$^{-1}$)
  - Perfusion Density (unit less)

• Absolute and percentage change over time for all the above parameters is available in Angiography Change Analysis
• **Min-IP** *(Minimum intensity projection)* **Value Proposition:**

• Fluid build-up in retina or disruptions in outer retina may generally be presented as hypodense regions.

• Going through all the cube b-scans to look for these regions is cumbersome.

• Min-IP provides a quick and easy visualization of minimum intensity (hypodense) regions.
Importance of Focusing
The Benefits and Pitfalls of OCT Angiography by Professor Giovanni Staurenghi
• Youtube
• The Benefits and Pitfalls of OCT Angiography by Professor Giovanni Staurenghi

IMAGE ARTIFACTS IN OPTICAL COHERENCE TOMOGRAPHY ANGIOGRAPHY

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What can OCT-A DO and Not DO

**DO**
- High resolution of Retinal Circulation
  - Ischaemia, Collaterals, Aneurysms
- Identify NVE growing above Retina
  - Differentiating IRMA VS NVE
  - Epiretinal membranes
- Mid retina circulation - RAP
- Choriocapillaris
  - New Vs Abnormal
  - SRNVM type and Size
  - Vascularised vs non vascularised PED
- Choroid – large vessels
- Doppler Blood flow
  - Retinal & Choroid
- Metrics
  - Fovea avascular areas measurements
  - Change analysis

**Not DO**
- Can not see Leak like FFA
  - No help for:
    - CSR, Irvine-Gass,
    - Optic disc leak
    - NVD / NVE leak - activity
- Narrow field
  - FFA wide field – Surveys
  - Spectral domain Vs Swept source
- Poor ocular Media clarity degrades image
  - ? FFA any better
- ? Sizing for PDT ?
- No colour photograph (Topcon dose Provide)
  - No Auto fluorescence
  - ICG vs OCT-A – not worked out
- Limited Experience of intrepreation
<table>
<thead>
<tr>
<th>OCT-A</th>
<th>VS FFA</th>
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<tbody>
<tr>
<td>• Non-Invasive – no side effects</td>
<td>• Clinical Experience since 1960</td>
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<tr>
<td>• Repeatable as often as needed – Follow Change</td>
<td>• Side effects 5 – 10%</td>
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<td>• Limited Clinical experience - 2016</td>
<td>• Yellow urine – 100%</td>
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<td>• Limited availability</td>
<td>• Nausea – Common</td>
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<td>• Currently Hot-topic for publications</td>
<td>• Urticaria – 1 in 300, Bronchospasm, Hypotension, syncope</td>
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<td>• Rapid diagnosis</td>
<td>• Anaphylaxis – 0.4%, MI/Cardiac arrest</td>
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<td>• Same day Scans with normal OCT</td>
<td>• Death 1 in 220,000 7 in 50 years reported</td>
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<tr>
<td>• Reduce diagnosis to treatment time</td>
<td>• Clinic to FFA appt can vary – often delays</td>
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<tr>
<td>• Colour print out summary or Computer</td>
<td>• Delay in clinic to diagnosis to treatment</td>
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<tr>
<td>• Duration of test – 5 minutes</td>
<td>• Review usually on Computer only</td>
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<tr>
<td>• 5 seconds per scan</td>
<td>• Duration of test – 1 Hour+</td>
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<tr>
<td>• Cost</td>
<td>• Consent required</td>
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<tr>
<td>• Per test 0 (Operator only)</td>
<td>• Unlicensed drug</td>
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<tr>
<td>• Low skill set to operate</td>
<td>• Cost</td>
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<tr>
<td>• Community / Optometrist practices</td>
<td>• Per Test +++</td>
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<tr>
<td>• Mobile – K9</td>
<td>• High Skill set - Photographer, nurse, doctor</td>
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<td>• Capital – New equipment £80K</td>
<td>• Capital £40K &amp; All units have one</td>
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<td>• Situate OCT in any room/area</td>
<td>• Dark Photographic room</td>
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Dawn of a New Era in Imaging

• New Clinic Diagnostic pathway
  • Spectral Domain/Swept OCT
  • OCT-A
  • Colour Photograph / Auto fluorescence
  • FFA
  • ICG

• Patient safety issue
  • Informed consent about options
    • Medico-legal situation

• Developing Technology