Optical coherence tomography and wide field non-mydriatic retinal screening in primary care optometric practice

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Look forward: Optometry in 10 years time

- Automated objective refraction
- Automated subjective refraction

- Optometrists will no longer be the only professions refracting
  - Dispensing opticians
  - Unregistered sellers of spectacles

“All or Nothing” philosophy

- Whoever examines the eyes should be able to do all that is necessary to carry out the routine examinations necessary to determine the health status of the eye
- Responsibility to patients
- Optometry has an important role but unless the profession takes up the challenge it will be pushed squeezed by Medicine and deregulation

• Optometrists need to look outside the box
• Or be squeezed into a corner
A choice

Revolutionary technology

- In the last decade there have been two simultaneous revolutions in diagnostic technology for primary care optometry practice
  - The Optomap wide field laser scanning ophthalmoscope
  - Optical Coherence Tomography (OCT)

Two questions

What is Optomap?
What is OCT?

Together they are the dream team

Optomap

- Laser scanning ophthalmoscope
- Up to 200 degree field
- Pupils as small as 2 mm
- Retina and choroid imaged separately
Red and Green Lasers capture different layers of the retina. The scanning laser light is focused through one point while the patient’s eye is positioned to be coincident with the other focal point.

**The Technology**

- Dual-frequency lasers – Red laser scans down to the choroid (wavelength 633nm) and green laser (wavelength 532nm) scans down to the retinal pigment epithelium (RPE)
- Class 1 cold laser with FDA approval
- Image eye from the inside in a ¼ second

**Virtual Point™ Technology**

- Can view the majority of the retina at one time (up to 200 degrees)
- Virtually place a scan point posterior to the iris plane

**Benefits Of Optomap®**

- Optos technology: P200
- Routine Examination
- 0.25 second
- Digital record
- No dilation required
- Scan the periphery
- Manual
- No record
- Dilation required

**Direct opthalmoscope**

- Aliases
  - “The guessing tube”
  - or the “blind stick”

**Head set indirect opthalmoscope**

- Or fundus camera
Next generation

- Small
- Neat
- Plus autofluorescence

**Features**

- 200 degree widefield retinal imaging – Colour and AutoFluorescence (AF)
- Aimed at Optometrists and General Ophthalmologists
- Small footprint, desktop
- Improved image quality
- Improved user and patient interaction – improved ease of use
- ‘Plug ‘n’ play’ – no complex installation, minimal user training (<1hr)

The Result – A ‘Game Changer’
Daytona
What Colour Will You Choose?

Daytona Image Performance
Clinically Superior Capabilities

Daytona Image Quality Compared to 200Dx

- Brighter in Periphery
- Better Detail in Central Pole
- Addition of AutoFluorescence (AF) capability

Daytona Image Quality Compared to 200Dx

Measurements and Annotations

Measuring Cup/Disc Ratio for Glaucoma

3D Wrap – Interactive Imagery

Viewing image as full colour as well as red/green separations

Diabetic Haems seen in green separation
Autofluorescence

• Fundus Autofluorescence (FAF) allows topographic mapping of lipofuscin distribution in the RPE cell monolayer as well as other fluophores that occur with disease in the outer retina and the subneurosensory space.
• Excessive accumulation of lipofuscin granules, mostly at RPE level, cause autofluorescence.

Autofluoreszenz – normal expectation

Causes for a reduced FAF signal

Reduction in RPE lipofuscin density
• RPE atrophy (e.g. geographic atrophy)
• Hereditary retinal dystrophies (e.g. RPE65 mutations)

Increased RPE melanin content, e.g. RPE hypertrophy

Absorption from extracellular material/cells/liquid anterior to the RPE
• Intraretinal fluid (e.g. macular edema)
• Migrated melanin-containing cells
• Crystalline drusen, or other crystal-like deposits
• Fresh Intra-and subretinal hemorrhages
• Fibrosis, scar tissue, borders of laser scars
• Retinal vessels
• Luteal pigment (lutein and zeaxanthin)
• Media opacities (vitreous, lens, anterior chamber, cornea)
Causes for an increased FAF signal

**Reduction in RPE lipofuscin density**
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**AMD**

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**Optical Coherence Tomography**

Non-contact technique for high-resolution cross-sectional optical imaging of ocular structures
- Analogous to ultrasound, except that OCT measures delay and intensity of back-reflected infrared light rather than acoustic waves
• The velocity of light is extremely high, so direct measurement of optical ‘echoes’ cannot be made electronically as in ultrasound.
• The technique to measure the back reflected light time delay is based on Michelson interferometry.

Optical Coherence Tomography
– Allows a cross sectional view through a structure
– Can image what previously could only be seen on a histology slide
– Technology used in other disciplines e.g. Radiology
– Also used in Art Conservation

• **Optical** - Meaning light
• **Coherence** - Meaning beam type
• **Tomography** - Meaning slice as opposed to topography (Shape)
• **OCT** = Slice of the eye using a controlled beam of light
How does it work?

• Tissue is irradiated by the light
• Each tissue type has different reflectivity
• Returned signals are coloured by the software according to the reflectivity of the tissue
• Some wavelengths penetrate deeper than others

Light Absorption by the Retina

Looking at a Cube

— Axial Depth Scans
• B Scan = A cross sectional tomograph
  — Can be achieved by putting together a series of A scans
• C Scan = En Face
  — Going down through the layers

What Colour?

• Reflections from retina are interpreted and colour coded on the strength of the reflection
  — Warm Colours are highly reflective and dense e.g., Drusen
  — Cooler colours indicate less dense matter e.g., Inner Nuclear Layer
  — Black indicates space or fluid e.g., serous fluid or cystic spaces

Zeiss Cirrus

Zeiss Stratus
Optometrists

Only 3 common conditions to worry about

- Cataract
- Age related macula degeneration
- The glaucomas - 50% of cases are undetected (including in Israel)

• Change Over Time Analysis
  Ability to track retinal thickness change over time and optic nerve head analysis. OCT images automatically registered to the SLO images

• Microperimetry
  Unique Microperimetry module, providing the ability to test and quantifiably monitor changes overtime of the patient’s retinal function in a selected location of the retina

- The Microperimetry test runs simultaneously with the SLO and provides real-time tracking of retinal motion and patient fixation during the exam
- Multiple Microperimetry exams can be stored and compared automatically over time, displaying progression or regression of the retinal function within a specific area of the fundus
Change Over Time Analysis

Glaucoma/optic nerve

Case A. LE
Sita full
R & L 17 mmHg

Case B. LE
Sita Full
R. & L. 25 mmHg

OCT- RNFL analysis
Circular scans around ONH of diameter 3.4mm.
Scan begins temporally.

Optic Nerve Head Analysis
- Optic Disc Scan
- 6mm x 6mm cube
- Information available over whole cube
- Superior Analysis of Optic Nerve Head
- Precise measurement of neuro retinal rim
- Enhance Glaucoma diagnostics and management
Optic Nerve Head Analysis

- Disc Edge = End Bruch’s Membrane
- Tissue above this is considered to be neuro retinal tissue
- Rim Area is determined by measuring the amount of neural retinal tissue in the optic nerve

RNFL OU Analysis

RNFL THICKNESS MAP shows the patterns and thickness of the nerve fiber layer within the full 6mm x 6mm area.

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

RNFL DEVIATION MAP, overlaid on the OCT fundus image, illustrates precisely where RNFL thickness deviates from the normal range. Data points that are not within normal limits are indicated in red and yellow.

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

Analysis Elements

OCT en face fundus image shows boundaries of the cup and disc, and RNFL calculation circle integrated with the RNFL thickness deviation map.

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

Optic Nerve Head and RNFL OU Printout

Combined report using the Optic Disc 200x200 cube scan.

Optic Nerve Head Analysis

- Tilted Disc
- Oblique view of fundus can cause inaccurate measurement
- Version 5 uses whole cube of data so software realigns tilted disc

Optic Nerve Head Analysis

RNFL Peripapillary Thickness profile, OU
• Matched to normative data

RNFL Quadrant and Clock Hour average thickness
• Matched to normative data
Cirrus HD-OCT GPA Analysis

Image Progression Map

- Two baseline exams are required
- Third exam is compared to the two baseline exams
- Sub-pixel map demonstrates change from baseline. Yellow pixels denote change from both baseline exams.
- Third and fourth exams are compared to both baselines. Change identified in three of the four comparisons is indicated by red pixels; yellow pixels denote change from both baselines.

Change refers to statistically significant change, defined as change that exceeds the known variability of a given pixel based on population studies.

Anterior Segment Imaging

Cirrus HD-OCT Anterior Segment Imaging, a new indication for use, received FDA clearance in May, 2009.

“...It is indicated for in-vivo viewing, axial cross-sectional, and three-dimensional imaging and measurement of anterior and posterior ocular structures, including cornea, retina, retinal nerve fiber layer, macula, and optic disc...”

Two new scan patterns:
- Anterior Segment 512x128 cube scan, 4mm
- Anterior Segment 5-line raster 3mm length, adjustable rotation and spacing

• What’s happening
Anterior Segment Imaging

Corneal Topography

Cirrus Anterior Segment Imaging

Caliper tool measures central corneal thickness

Cirrus HD-OCT Anterior Segment Imaging

Images courtesy of Martha Leen, M.D. & Paul Kremer M.D. Achieve Eye and Laser Specialists, Silverdale, WA

Cirrus HD-OCT scan of normal cornea. Layers identified with colored arrows as follows: tear film (blue), epithelium (white), Bowmann’s layer (red), Descemet’s/endothelium (green).

Cirrus HD-OCT Anterior Segment Imaging

Cirrus HD-OCT angle scan. Note: Schlemm’s canal (red arrow), Schwalbe’s line (green arrow) and the scleral spur (white arrow). The angle recess is not very defined in this scan.
Cirrus Anterior Segment Imaging

Cirrus HD-OCT image with a visible angle recess (blue arrow). Schlemm’s canal is very well clearly seen (red arrow).

Case

- 2 days ago
- 47 yr old woman attended for first time
- British African
- Xalacom bds for last 7 years
- IOP GAT 18mm Hg R & L
Asymptomatic – grade 1

Same patient as previous slide
How about narrow angles?
Method and Patients
Clinical records of 886 consecutive patients aged 35 years and above seen between October 2009 and January 2012 for an eye examination were reviewed.
If a patient was seen more than one time during this time period, the most current result has been taken.
500 female; 386 male.

Sensitivity for correct referral
30 from consecutive 886 patients > 35 years referred for narrow angles 23 needed treatment
Sensitivity = 76.7%
Another = 16.7% (5) confirmed needs monitoring
\(93.4\% \text{ (prevalence 3.2\%)}\)
2 Patient outcomes not known.

Macular anomalies
Case History
Patient: Mrs G
Age 63 years
Symptoms: Last 4 days grey patch in right central vision
History: longstanding left macular scar
Refraction & VAs: R. = 6/5 L. = 6/5-

Management?
1. Refer to GP?
2. Refer same day to hospital eye department casualty?
3. Refer to consultant retinal ophthalmologist?
4. No action but review in one month?
My decision was?

1. Refer to GP?
2. Refer same day to hospital eye department casualty?
3. Refer to consultant retinal ophthalmologist?
4. No action but review in one month?

Ophthalmologist confirmed diagnosis and recommended?

1. No treatment?
2. Vitrectomy?
3. Avastin injection?
4. Review in one month?

Ophthalmologist confirmed diagnosis and recommended?

1. Vitrectomy?
2. No treatment?
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And requested a repeat OCT on the day before he sees her

+ 1 month

6/18

The ophthalmologist’s advice was?

1. No treatment?
2. Vitrectomy?
3. Avastin injection?
4. Review in one month?

The patient decided to take a second opinion
Case History
Patient: Mr H
Age: 81 years
History: Longstanding poor vision left eye. Seen a few years ago by retinal specialist. Early cataracts
Symptoms: Routine check
Refraction & VAs: R. = 6/9 L. = 6/36

Management
Refer patient for
(a) Opinion on dry AMD RE and
(b) Partially detached epiretinal membrane LE with macular traction
Drusen

Case History

Patient: Mr H
Age: 78 years
History: Referred by ophthalmologist after cataract surgery
Symptoms: poor vision
Refraction & VAs: R. = 6/6  L. = 6/36

Epiretinal Membrane

Cystoid Macular Edema
Case History

Patient: Mr S M
Age: 72
History: Poor vision in one eye for a year
Symptoms: poor vision LE
Refraction & VAs: R. +0.50DS = 6/6  L. = 6/60

Partial Macular Hole

Case History

Patient: Mr D’S
Age: 41
Symptoms: Last 4 days sees a spot “bubble” in the central vision of his right.
         Notices it more when closes eye
VAs         R.  6/6 L. 6/5
Management

a) Refer urgently?
b) Refer routinely?
c) Steroids?
d) Explain diagnosis to patient and review in 1/12?

Management

• Refer?
• This patient was going on holiday two days later for over three weeks
• Repeat OCT after 4 weeks?

Diagnosis

Central serous retinopathy

• Usually young males
• Stress
• Resolution in weeks/months in most cases
• May have residual visual disturbance

Case history

• 70 year old female lawyer, Mrs BL
• Early cataract
• VAs R. 6/6 L. 6/9
• Refer for cataract surgery?
• Routine OCT prior to referral
Case History

- July 2007
- Mrs D.B. telephones practice. Not seen previously. Actress
- Smokes 60 cigarettes a day
- Age 72 years
- Noticed sudden disturbance of vision RE for last three days. Central distortion of vision

• Requested name of ophthalmologist offering Avastin injections
• Name given
• Suggested attend for OCT prior to appointment with ophthalmologist
• What condition had she self-diagnosed?

RPE Detachment
Case History

• Long standing patient 75 year old; Mrs MK
• Artificial left eye
• Dry AMD RE = 6/9+
• Taking quinine for cramps
• Routine check – slight deterioration in VA
Swollen nerve head?

- Differential diagnoses
  - Pseudopapilloedema (crowding)
  - Drusen
  - Choked disc
    - Papilloedema
    - Papillitis

Swollen optic nerve head

- Raised optic nerve heads are common
- Subtle signs visible with slit lamp BIO
- Important to document appearance for future comparison
- Helpful for disease detection and diagnosis

Congenital

- Typically a small eye but does occur in myopes
- Raised nerve head
- No field defect
- SVP helps suggest “normal”

Choked disc - case history

- 10 year-old boy
- Broken spectacles
- No symptoms

Routine imaging at every exam
Diagnosis - Intracranial tumour

Use OCT to differentiate

Sudden loss of vision

- Sudden loss of vision 6/60
- 74 yr old male
Case history

- Thirty-year old healthy woman presented complaining of a visual disturbance
- Optomap located a lesion
- OCT analysed further
Subtle visual disturbance

- 54 year old male 3 days ago noted a smudge inferior nasal vision RE
- Now its moving on blinking but superiorly - group of black dots
- No flashes of light
- No history of trauma. GH good, No meds
- VAs 6/7.5 L. 6/6
37 yr old female
R. -18.00 DS L. -17.00DS

IOPs R. 15 L. 15 mmHg

Humphrey C40 screening full

Pigment dispersion syndrome
Conclusions

OCT is a phenomenal and powerful diagnostic tool

The biggest revolution since Helmholtz’s invention of the ophthalmoscope in the 19th century

Improves standard of care in primary and secondary care
Naevus – colour composite image

Naevus – Green Laser Separation

Naevus – Red Laser Separation

Systemic Diseases

NPDR in the Periphery
Multiple secondary tumour sites in the choroid – suspected lung cancer

Leukaemic Retinopathy

Prevalence of Leukaemia

Outer Retinal Tubulation

Branching tubules identified in outer retina of 54 patients with AMD and in 9 patients with other diagnoses (24% prevalence)

Round or ovoid hyporeflective spaces with hyper-reflective borders on the B-scans (40 -140 µm high and 40 - 2260 µm wide)

The tubules generally remained stable over time

Degenerating photoreceptors may become arranged in circular or ovoid fashion during a process called outer retinal tubulation

Occur in advanced diseases affecting the outer retina and retinal pigment epithelium.

These findings can be misinterpreted as intraretinal or subretinal fluid, possibly prompting unnecessary interventions

Hey! what more do you want?

THE dream team....

Optomap + OCT