Optical Coherence Tomography

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Too good to be true?

- Non-contact
- Non-invasive
- Painless
- No radiation
- Fast
- Reliable
- Detection of pathology that cannot be seen ophthalmoscopically
- Sensitive…micrometer resolution!

History of Optical Coherence Tomography

1991
OCT is introduced

1993
First in vivo OCT images of human retina are published

1997
First commercial use of OCT in Ophthalmology

2002
Publication shows Spectral Domain OCT has advantages over Time Domain OCT

2015
First commercially available OCT-A introduced in the United States

2018
PubMed search shows over 35,000 publications on OCT

2003
SD OCT gains popularity in clinical practice

2015 Review of Optometry’s annual diagnostic technology survey lists OCT as the #1 most desired piece of equipment

2006
OptoVue RTVue available with 65x speed and 2x resolution than Stratus OCT

2015
First commercially available OCT-A introduced in the United States

Scanning Speed (A-scans per second)

- Cirrus HD-OCT 5000: 27,000-68,000
- 3D OCT – 1 Maestro: 50,000
- Spectralis SD-OCT: 40,000
- Avanti RTVue XR: 70,000

Axial Resolution (µm in tissue)

- Cirrus HD-OCT 5000: 5.5-6
- 3D OCT – 1 Maestro: 3.9
- Spectralis SD-OCT: 3.9
- Avanti RTVue XR: 5

Minimum Pupil Diameter (mm)

- Cirrus HD-OCT 5000: 2
- 3D OCT – 1 Maestro: 2.5
- Spectralis SD-OCT: 2.5
- Avanti RTVue XR: 2.5

Lots of options - Spectral Domain OCT

How does OCT work?

- Uses light rather than sound or radio frequency
- Faster speed = higher resolution
- Uses principle of low-coherence interferometry to measure optical reflectivity of tissues
- The interferometer integrates data points to construct a tomogram of retinal structures
- Layers of different optical densities
**Limitations**

- Mydriasis may be necessary
- Cataracts and poor tear film can degrade the image
- Accuracy is limited by high refractive error and axial length
- Limited to posterior pole
- Caution comparing measurements from one brand of OCT to another

**Indications**

- Diagnosis and detection of pathology
- Monitoring for progression
- Evaluation for need for laser or surgical intervention
- Quantification – evaluation of thickness, volume, surface area
- Monitoring for changes due to medications
- Evaluation of postoperative progress

**Running an OCT**

- Patient fixates on target inside the instrument
- Operator aligns instrument via a camera which allows visualization of the fundus and the scan beam
- Recommended minimum pupil size ~ 3mm, however dilation improves the signal strength and image quality

**Obtaining a scan**

- Numerous scanning protocols
  - Anterior segment and Posterior segment
  - Grid, raster, volume scans, single line, etc
  - Adjustable parameters

- Results
  - Images displayed on monitor representing reflective differences between structures
  - Operator may choose to save image or repeat scan
  - Often compared to normative database

**What can we see with the OCT?**
Know the anatomy!

Anatomy of a retinal OCT image

- Reflective interfaces between structures
- Large reflections are warm colors (red, yellow)
- Mild reflections are cool colors (green, blue)
- Absence of reflection is black

3D imaging of ocular structures

- X, Y, and Z axis
OCT-Angiography

- Allows for better assessment of retinal and choroidal vascular disease and blood flow
- Useful in diseases such as macular degeneration, diabetic retinopathy, and vein occlusions
- OCT-A systems:
  - AngioPlex (Carl Zeiss Meditec)
  - AngioVue (OptoVue)

Retinal examination

Clinical applications

- 1. Macular disorders – especially helpful in confirming those that are not evident clinically
- 2. Macular hole – allows for confirmation of diagnosis and staging and monitoring through treatment
- 3. Macular edema – characterized by areas of increased thickening and decreased reflectivity
  - diabetes, vein occlusion, uveitis, post cataract surgery
  - Quantitative measurements allow for monitoring for progression/resolution
- 4. Macular degeneration
  - Detection of RPE changes and disruption in dry AMD
  - Detection of subretinal fluid and choroidal neovascularization in wet AMD
- 5. Medications
  - Response to treatment
  - Side effects of systemic medications

Vitreous detachment vs. Vitreomacular Traction

Macular hole
26 yo AA F, 34 weeks pregnant
- Type 1 DM
- Pre-eclampsia

68 yo AA M, sudden vision loss OS
76 yo WM, being followed for AMD

20/60
20/40

Recommendations on Screening for Chloroquine and Hydroxychloroquine Retinopathy (2016 Revision)

- Risk of toxicity increases sharply towards 7.5% after 5-7 yrs of use, or cumulative dose of 1000 g HCQ
- Initial baseline exam with DFE, then annual screenings after 5 years
- Screening:
  - Regular exams with DFE
  - 10-2 SS (white stimulus)
  - 24-2 SS or 30-2 SS (white stimulus) for Asian patients
  - SD OCT*, FAF or mfERG
    - Most objective, lowest variability
  - No longer recommending Amsler Grid

“Flying Saucer Sign”

Disruption to the ellipsoid zone line/parafoveal thinning

Optic disc scan

- High resolution imaging with OCT allows for an accurate assessment of:
  - Size of the optic cup
  - Disc area
  - C/D ratio
  - Volume of the cup
  - RNFL thickness
- Serial measurements are useful to monitor for glaucomatous changes

Traditional methods of evaluating a patient for glaucoma

- Measuring IOP
  - The one risk factor that can be controlled
- Stereoscopic optic nerve evaluation
- Visual field testing
  - Patient must cooperate for accurate results

RNFL Thickness Map shows the patterns and thickness of the nerve fiber layer.

The RNFL Deviation Map is overlaid on the OCT fundus image to illustrate precisely where the RNFL thickness deviates from normal. Also, one can see boundaries drawn for cup and disc, along with the RNFL calculation circle.

TSNIT curve compares patient to normative database.

Importance of scan placement

- 2 scans of same eye
  - 1st scan is well centered; 2nd scan is not centered
Function vs. Structure

Guided progression analysis

Papilledema vs. ONH drusen

Anterior Segment Imaging

Anterior Segment OCT

- Tear height
- Pachymetry
- LASIK
- Corneal disease
- Custom design and evaluation of specialty contact lenses
- IOL/implant imaging
- Anterior chamber depth, angles
- Glaucoma
CASE EXAMPLE

- 23 year old Optometry Student
- Ocular history:
  - Suspected latent hyperope
  - Reports a headache after dilation
  - Gets dilated 1-2 times per week !!
- VH angles— 1:1/8 or less
- IOP-16/17

Case Example #2

- 29 Wf, lab tech
- PHx: Turner Syndrome (X)
- FHx: Father melanoma
- Hyperope
- Steady increase in IOPs over last 6 years—11 to 13 to 18 to 21mmHg
- Narrow angles with vh (1:1/4 to 1/8)
- Longstanding Hx large choroidal nevus
Iris Melanoma

- 56 YO Caucasian Female
- Routine eye exam
- Pupil distortion
- (-)Iris transillumination
- IOP: 17/16
- 3-Mirror angle and retinal exam: clear

Tips and Tricks

- Signal strength score is not the same as a scan quality score
  - Make sure image is centered with no missing or weak signal areas
- Know your targets to help you better direct the patient
- Dilation greatly improves the quality of the scan
- Good idea to have artificial tears nearby in case dry eye is contributing to a poor quality scan
- Remind patient to keep eyes open wide between blinks
- In cases of poor central vision in the eye being tested, the external fixation wand can be used for the other eye

Artifacts...watch for the unusual

- Anomalies in the scan that are not actual physical structures, but instead due to an external agent or action
- Examples:
  - Patient blinked during scan acquisition
Shadows

Blood vessels casting a shadow

“Waves” in retinal contour = eye movement

What if the scan isn’t “perfect”? 

- Decentration
- Media opacities
- Lower signal strength/lower quality image
- Blinks/shifts in gaze
- Artifacts

…………………THE SCAN MAY STILL BE USEFUL!!

Insurance/Billing

- Bilateral codes
  - Anterior 92132
  - ONH 92133
  - Retina 92134
- Generally cannot perform same day as fundus photography or as each other
- Check with local carrier for frequency
- Wide variety ICD-10 codes accepted

Helpful Resources
Thank you!