15th (20th) Year Anniversary of OCT – Inventor’s Perspective

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Financial Interests:
Optovue, Inc.: stock options, patent royalty, grants, speaker honorarium & travel support
Carl Zeiss Meditec, Inc.: patent royalty

Financial Disclosure

I have the following financial interests or relationships to disclose:

Dr. D. Huang has a significant financial interest in Optovue, a company that may have a commercial interest in the results of this research and technology. This potential individual conflict of interest has been reviewed and managed by OHSU.

Low-Coherence Interferometry

Optical coherence-domain reflectometry: a new optical evaluation technique

Optical Photographers’ Society Meeting
Orlando, Florida, 23 October 2011

Femtosecond optical ranging in biological systems

OCT Scanning

Axial Scan

Transverse Scan

OCT started with retinal imaging

Prof. James Fujimoto
MIT

OCT and the Eye: A Perfect Match

OCT

- High resolution
- Shallow penetration

Eye

- Thin layers (retina, cornea)
- Clear media

The First Corneal OCT

Joseph Izatt, PhD
(MIT, Case Western Reserve U, Duke)


The First Clinical Retinal OCT

Michael Hee, MD, PhD
(Harvard-MIT, UC San Francisco)

Carmen Puliafito, MD, MBA
(Harvard, Tufts, U Miami, USC)


The First Glaucoma OCT

Joel Schuman, MD
(Harvard, Tufts, U Pittsburgh)

OCT prototype -1994
45 A-Scan/sec, 16µm

Jay Wei, OCT project leader, Humphrey Instruments, 1994
CEO, Optovue, Inc. 2006-present

2006: A Generational Leap

- A jump of 65x speed & 2x resolution

Commercial Ophthalmic OCT Evolution

Frame registration and averaging further enhances image quality

Fourier-Domain Technology Lead to An Explosion of New OCT Products
OCT procedures surpassed the sum of other ophthalmic imaging procedures.

- Estimated 9,000,000 Medicare CPT 92135 procedures
- Estimated 8,289,000 Medicare OCT procedures (92% of CPT 92135)
- Estimated 16,257,000 U.S. OCT procedures (Medicare = 51% of total in 3 surveyed centers)
- Average reimbursement $48 per procedure
- Estimated $780M OCT charges in U.S.A.
- Worldwide utilization likely surpass $1B

Swanson EA, Huang D. Ophthalmic OCT reaches $1 billion per year. Retina Physician, 2011.

OCT charges likely surpassed $1 Billion worldwide in 2010

The next generation of ophthalmic OCT systems may use different technologies

More Speed & Penetration

Ultrahigh-speed OCT provides full-sampled 3-dimensional volumetric scans
Ultrahigh-speed OCT provides detailed layer-by-layer view of the retina and choroid

- Retinal Nerve Fiber Layer
- Ganglion Cell Layer
- Inner plexiform & Inner Nuclear Layers
- Outer plexiform & Outer Nuclear Layers
- Photoreceptors & Retinal Pigment Epithelium
- Outer Choroid
- Inner Choroid

Swept-source OCT at 1050 nm provides higher speed & penetration

- 12x12 mm area
- 1100x1100 A-scans
- 10 registered volumes
- 200 kHz SS-OCT

Double circular scan transects all retinal branch vessels 6 times per second

Retinal Angiography & Blood Flow Measurement

Semi-automated grading software was developed for Doppler OCT reading center

Glaucoma, PDR and NAION Show Different Patterns of Retinal Blood Flow Change
Visual field was independently correlated with both blood flow and neural tissue loss

<table>
<thead>
<tr>
<th>Model</th>
<th>Blood Flow</th>
<th>NFL</th>
<th>R²</th>
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<tbody>
<tr>
<td>BF</td>
<td>1.91 (0.001)</td>
<td>3.29 (0.01)</td>
<td>0.29</td>
</tr>
<tr>
<td>NFL</td>
<td>3.29 (0.01)</td>
<td>0.13</td>
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</tr>
<tr>
<td>BF + NFL</td>
<td>1.62 (0.001)</td>
<td>2.56 (0.03)</td>
<td>0.33</td>
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</tbody>
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Regression coefficients (p-value) in the perimetric glaucoma group

BF = blood flow; NFL = nerve fiber layer thickness

All values in dB scale normalized against 27 normal eyes.

Both NFL and Doppler scans were performed on the Optovue RTVue FD-OCT system.

Blood flow has a direct effect on visual function independent of neural structural loss

Elevated IOP

Decreased blood flow

Loss of retinal ganglion cells & nerve fibers

Loss of visual field

Both NFL and Doppler scans were performed on the Optovue RTVue FD-OCT system.

OCT Angiography of The Macula Using Decorrelation Technique

Cross section
Reflectance: gray scale
Flow: color scale

Retinal Circulation

OCT Angiography of The Optic Nerve Head Using Decorrelation Technique

Total Circulation

Cross section
Reflectance: gray scale
Flow: color scale

OCT Angiography of The Optic Nerve

Head Using Decorrelation Technique

Reflectance: gray scale
Flow: color scale

Retinal Circulation

www.COOLLab.net

www.AIGStudy.net