What’s New in Optic Nerve Imaging

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Glaucoma Progression: Structure vs. Function

Make Definitive Diagnosis at A

“Doctor, do I have glaucoma?”

Make Definitive Diagnosis at A
OR
Document Progression at B

“Doctor, am I getting worse?”

CHANGE = A - B
What’s OLD in Optic nerve imaging

Scanning Laser Tomography (HRT)  
(Heidelberg Engineering, Heidelberg, Germany)

Scanning Laser Polarimetry (GDx®)  
(Carl Zeiss Meditec, Jena, Germany)

Time-Domain  
Optical Coherence Tomography (OCT)  
(Carl Zeiss Meditec, Jena, Germany)

Time Domain OCT (OCT3)

Optic Nerve Head Analysis

Topography (interpolated)
Nerve Fiber Layer Thickness Normative Database

Green = Within normal limits
Yellow = Borderline
Red = Outside normal limits

OCT RNFL scan circle misalignment

Inferior NFL increased
Scan circle too HIGH

Progression plot

What’s New in Optic Nerve Imaging:
Spectral Domain OCT

Vizzeri et al., Journal of Glaucoma 2008; 17:341-349
Time Domain
Signal amplitude varies with time

Frequency A = 1/t

Frequency Domain

Time Domain
Frequency Domain

Time Domain
Frequency Domain

Frequency Domain
Spectral Domain OCT

Advantages of Spectral Domain OCT

- More scans in less time
  - 20,000 to 40,000 A-scans per second
- Better resolution
  - 5 micron
- Less motion artifact
  - Blinking, saccades, fixation losses
- 3D scans = cube of data
## Comparison of Models

<table>
<thead>
<tr>
<th>Model</th>
<th>Scanning speed (A scans/sec)</th>
<th>Axial Resolution</th>
<th>3-D Bscan</th>
<th>Fundus imaging, misc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cirrus</td>
<td>27,000</td>
<td>5 microns</td>
<td>Yes</td>
<td>SLO</td>
</tr>
<tr>
<td>Optovue</td>
<td>26,000</td>
<td>5 microns</td>
<td>Yes</td>
<td>Near IR non-myd AS OCT</td>
</tr>
<tr>
<td>Spectralis</td>
<td>40,000</td>
<td>7 microns</td>
<td>Yes</td>
<td>SLO, FA, ICG, autofluo, IR</td>
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<tr>
<td>Stratus OCT3</td>
<td>400</td>
<td>10 microns</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Glaucmatous damage occurs at 3 levels in the posterior segment:

- **Optic nerve head** (Axon + connective tissue)
- **Retinal nerve fiber layer** (Axon)
- **Ganglion cells** (Cell body)
- **Highest concentration in the macula**

SD OCT allows us to scan the macula for glaucoma:

- **Ganglion cell complex (GCC) scan**
  - Nerve fiber layer + Ganglion Cell layer + inner plexiform layer
**Cirrus™ HD-OCT**
Carl-Zeiss Meditec (Dublin, CA)

- **Scan type**
  - Optic disc cube 200 x 200 scan
  - 200 line scans each consisting of 200 A scans each
  - Covers 6 mm² area

www.meditec.zeiss.com

**RNFL analysis with SDOCT**

- TSNIT graph based on circle scan 3.45 in diameter centered on optic disc
  - Unlike TDOCT, centration of TSNIT circle can be performed post-scan acquisition with SDOCT
- RNFL maps with comparison to normative database

Cirrus Normal OD Early glaucoma OS
Stratus
Advanced glaucoma OS

Cirrus
Advanced glaucoma OS

Glaucoma suspect
Disc and cups are asymmetrical
Normal NFL and GCC

Optovue RTVue™
(Fremont, CA)

- Scan types
  - 3D Disk (covers 4mm² area)
  - ONH (Grid pattern with circular and radial scans)
  - GCC (Ganglion cell complex scan, covers 7mm² area)

OD shows superior NFL loss
OS normal
OD and OS both Show severe NFL loss

High myope With tilted discs Unable to analyze optic disc OD but GCC normal

Spectralis
Heidelberg Engineering (Heidelberg, Germany)

• Unique features
  – Eye tracking technology
  – Image noise reduction
  – Can add capability for FA, ICGA, red free & infrared imaging, autofluorescence

www.heidelbergengineering.com
RNFL Circle Scan / RNFL Progression

RNFL fibers can be seen following the blood vessel arcades on the infrared image.

OCT scan shows a normal distribution of RNFL thickness around the ONH.

Case 1 – Loss visible on multiple tests

Fundus photo has a clearly defined wedge of RNFL loss.

Retinal thickness map correlates with other tests showing a wedge shaped thickness loss.

Case 2 – Thinning beyond circle scan

The infrared image shows a darker wedge defect in the inferior temporal area.

The wedge defect is not very wide at the circle scan location and is not easily seen in the RNFL – OCT thickness graph.

The posterior pole thickness map shows asymmetrical thinning in this inferior temporal area.
Case 3 – Thickness Map Confirmation

The RNFL - OCT shows thinning in the inferior temporal area on the thickness graph but the defect is not significant enough to trigger the sector classification.

The posterior pole thickness map shows a clearly defined area of thinning in this inferior temporal area and thinning around the macula is not picked up by the other tests.

New reports – Asymmetry OU

New Reports – RNFL & Post. Pole

Glaucoma analysis

<table>
<thead>
<tr>
<th></th>
<th>RNFL (TSNIT/Map)</th>
<th>Macular Inner Retinal Layer</th>
<th>Optic disc</th>
<th>Normative database</th>
<th>Progression</th>
</tr>
</thead>
<tbody>
<tr>
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Conclusions

- High-tech imaging enhances *but does not replace* good clinical skills in diagnosing glaucoma
- Potentially useful in following optic nerve progression in early glaucoma
  - AIGS (Advanced Imaging in Glaucoma Study)
  - HRT2, GDx, OCT3, Optovue
  - www.AIGStudy.net

Conclusions

- Do not base treatment decisions on a single imaging study
- Interpret imaging data in a clinical context
- Reliable criteria for progression are lacking
- Prospective validation is needed

Technology progresses faster than most optic nerves.

The time required to prove a technology is superior for monitoring glaucoma may render that technology obsolete.

Has Optic Nerve Imaging Made Stereo Disc Photography Obsolete?

Not yet.