OCT in the Diagnosis and Follow-up of Glaucoma

Karim A Raafat MD.
Professor of Ophthalmology
Cairo University
Visual Function

- Structure: ~5000 axon/year.
- Function: ~1 dB/decade.

Point of Diagnosis & Treatment

Severe Visual Loss

100%

Age

Glaucoma Progression is *Individual* and *variable*
• Glaucoma suspect.

• Glaucoma workup. $\rightarrow$ Damage at presentation

• Initiate therapy. $\rightarrow$ Rate of progression.

• Follow-up. $\rightarrow$ Progressive change of optic disc or visual field is the hallmark of glaucoma diagnosis.

• Modify/Change treatment.

“The decision to initiate anti-glaucoma therapy is a very serious one that has far-reaching consequences”.

George Spaeth

• Side effects
• Significant cost
• Altered QoL
Rationale for Quantitative Imaging in Glaucoma

- Visual field: subjective, 3 consecutive fields are required to reliably confirm glaucoma.
- **Structural loss precedes functional loss:**
  6 years in 60% of eyes.
- As much as 30-50% of RNFL may be lost before Standard Automated Perimetry (SAP) VF changes.
- Change in the cup represents loss of *thousands of axons*.
Glaucoma affects 3 areas in the posterior segment of the eye.

- Cupping
- Ganglion Cell Loss
- Nerve fiber thinning

Peri-papillary RNFL Thickness

ONH Analysis

Macular GCC Measurement
SD-OCT
“Does any RNFL loss mean Glaucoma?
**Inferior Average:**

- Least affected by age-decay.
- Significantly thinner in glaucoma than in normal.
- Highest sensitivity and specificity in early glaucoma diagnosis.
- Discriminates progressors from non-progressors.

**Inferior Average:**
the best to discriminate healthy from glaucomatous eyes

Sensitivity 84%
Specificity 90%

ISN’T Rule
• Established diagnosis -- uncontrolled disease -- therapy advancement.
• Glaucoma suspect – confirm diagnosis.
Structural Damage Precedes Functional Damage?!
Glaucoma Visual Field Loss, NO corresponding RNFL Defects.

- 1-clock hour is “too wide” for detection of localized loss.

- RNFL defects “not always” result in reduction of RNFL thickness.

- Reduction of RNFL thickness not exceed “normal variation”.

- Order of Glaucomatous Damage vary from patient to patient.
- Localized RNFL defects limited to deeper layers while most superficial layers being intact.
- Physiologic age-decay of the RNFL.
- Diffuse component of RNFL loss so large to mask localized defects.
Quantitative Imaging may detect glaucoma at an earlier stage.


**RNFL thickness after IOP reduction**

- IOP reduction (medical or surgical) ---- *significant increase* of mean RNFL thickness.
- Correlated to the IOP reduction
- **0.5 µ increase of mean NFL thickness/mmHg decrease of IOP**
- Least evident in inferior quadrant

Recovery of the compressed NFL, Retinal swelling, Restoration of normal axoplasmic flow to the RNFL, Changes in the axial length of the globe.

*Clinical implication: obtain new OCT measurements as a baseline for follow up after glaucoma surgery.*
OCT & Early Glaucoma
Moderate Sensitivity and High Specificity

Diagnostic Test

- Highly specific: if +ve ----- Rule IN the disease.
- Highly sensitive: if -ve ---- Rule OUT the disease.

OCT (esp inferior RNFL thickness)
rule IN early glaucoma when +ve
but can not rule OUT when -ve

Inferior Quadrant
RNFL Thickness

≤ 92.5 µ
100% Glaucoma

> 92.5 µ and ≤ 119 µ
56% Normal
44% Glaucoma

> 119 µ
88% Normal
12% Glaucoma
Advanced Glaucoma

OCT has little role!

Location of 2nd order blood vessels within RNFL

- Normal
- Focal RNFL loss
- Diffuse RNFL loss
Location of 2nd order blood vessels within RNFL

- Normal
- Mild RNFL loss
- Severe RNFL loss
ONH Parameters

5 "4 mm" lines for optic disc topography

- 3.4 mm circle
- 512 A-scan
- Interpolation: localized RNFL defects can be missed.

TD-OCT

SD-OCT

- 6 X 6 mm cube
- 512 X 128 B-scan
- Much higher number of measurements.

Can *not* be compared: different tech spcs, imaging protocols and thickness measurement algorithms.
ONH Parameters:

*Poor sensitivity for glaucoma progression:*

- Interpolation.
- Progressive para papillary atrophy in glaucoma.
TD-OCT susceptible to eye movements – scattering of sampling locations.

Manual placement: scan location affects results.

Higher acquisition speed (X100), Higher axial resolution (X2)
How to use speed and resolution to advantage?

Ganglion Cell Complex (GCC)

- **Axons**: NFL
- **Bodies**: ganglion cell layer
- **Dendrites**: Inner plexiform layer

Glaucoma primarily damages the ganglion cell complex (GCC)
Retinal thickness mapping is not sensitive for detecting glaucoma because glaucoma preferentially affects the inner retinal layers (GCC).

**GCC Deviation Map**

\[
\text{% Loss} = \frac{\text{actual} - \text{normal}}{\text{normal}}
\]

- **Blue**: 20-30% loss
- **Black**: > 50% loss

**GCC Significance Map**

- **Green**: within normal limits.
- **Yellow**: Borderline.
- **Red**: outside normal limits.
GCC Progression Analysis (visit every 6 months)

Generalized loss

Localized loss
Male, 58 years-old, IOP 27 mmHg (OD), 26 mmHg (OS) C/D 0.4 (OD), 0.3 (OS).

Ocular Hypertension

Pre-perimetric Glaucoma
Predict future visual field loss

9 months
Near-future: Doppler OCT measurement of Retinal Blood Flow

Double circular scan

Flow profile and direction determined on parallel sections*
Double circular scan transects all retinal branch vessels 6 times per second.

Algorithm for Total Retinal Blood Flow

- Doppler angle measurement
- Flow in a single vessel
- Total Retinal Blood Flow

Flow value: 40.8 to 52.9 μl/min, CV: 10.5%
Glaucoma reduces retinal blood flow

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Subjects</th>
<th>Total retinal blood flow (μl/min)</th>
<th>Average</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Normal</em></td>
<td>8</td>
<td>45.64</td>
<td>40.73-52.91</td>
<td></td>
</tr>
<tr>
<td><em>Perimetric Glaucoma</em></td>
<td>10</td>
<td>33.54</td>
<td>23.6-40.88</td>
<td></td>
</tr>
</tbody>
</table>

P < 0.003
Thank You