Optical Coherence Tomography of the Retinal Nerve Fiber Layer

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Spectralis macular OCT showing the position of a single retinal ganglion cell and its axon
Crossed retinal ganglion cell axons from the nasal RNFL representing the temporal visual field are shown in blue.

Uncrossed retinal ganglion cell axons in the temporal RNFL representing the nasal visual field are shown in red.
A normal Cirrus OCT of the RNFL is shown from a healthy 30-year-old man.

The “optic disc cube” scan protocol is used to image the RNFL over a 6 x 6 mm² peripapillary region using 200 x 200 axial measurements.
Figure 3. Reviewing the Cirrus OCT RNFL printout

**Ensure date of birth is correct**
- thickness measurements are compared against age-matched controls

**Review the signal strength**
- Once signal strength drops below 7 in the Cirrus platform, the segmentation algorithm may fail and produce errors in the RNFL thickness measurements.
Figure 3. Reviewing the Cirrus OCT RNFL printout

RNFL thickness map
- This is a topographical display of the RNFL
- Normally, there is an “hourglass” shape of red and orange colors since the superior and inferior RNFL are thickest

Review key parameters
- Key parameters are compared to normative data
  - **Green** = measurement is between 5% and 95% of that seen in the normative population
  - **Yellow** = measurement is less than 5% of that in the normative population
  - **Red** = measurement is less than 1% of that in the normative population
  - **White** = measurement is greater than 95% of that seen in the normative population
Figure 3. Reviewing the Cirrus OCT RNFL printout

RNFL deviation map
-This is an *en face* fundus image that shows the boundaries of the cup, disc, RNFL calculation circle and the deviation of the RNFL thickness from normal.

Neuro-retinal rim and RNFL thickness profile
-Thickness of the neuro-retinal rim and RNFL are compared to normative data.
Horizontal and vertical B-scans
-these are extracted from the data cube through the center of the disc.
-ILM and cup boundaries are shown in red and RPE and disc boundaries are shown in black

RNFL quadrant and clock hour
-average thickness is matched to normative data
Figure 4. Case 1 - Right homonymous visual field defect

Clinical information:

Visual acuity: 20/20 OD, 20/20 OS

Right mild RAPD

Color vision: 14/14 OD, 14/14 OS correct Ishihara plates

Optic disc photos

Humphrey 24-2 SITA-Fast visual field
There is RNFL loss mostly in the nasal and temporal quadrants in the right eye.

There is RNFL lost mostly in the superior and inferior quadrants in the left eye.

Average RNFL thickness is less than 1% of that seen in the normative population in both eyes.
Figure 5.

There is a right incomplete homonymous hemianopia

There is a homonymous loss of the macular ganglion cell complex corresponding to the visual field defect
The right homonymous hemianopia is from a left optic tract lesion creating a “bow-tie” pattern of RNFL loss OD (nasal and temporal loss OD and superior and inferior loss OS).

Axial T2 MRI shows a left optic pathway glioma in the left optic tract.

Axial T2 MRI shows a left optic pathway glioma in the left optic tract.
Clinical information:

Visual acuity: 20/150 OD, 20/20 OS

Right RAPD

Color vision: 0/14 OD, 14/14 OS correct Ishihara plates

Humphrey 24-2 SITA-Fast visual field

Optic disc photos

Right eye

Left eye
Case 2 - Vision loss and pain with eye movements in the right eye

There is mild elevation of the RNFL in the right eye.
Figure 8.

Presentation

7 weeks after presentation

8 months after presentation
In this patient with right optic neuritis, there is enhancement of the right optic nerve seen on a coronal T1 MRI post-contrast image (red arrow).

There is mild thickening of the RNFL at presentation, but then loss of the temporal RNFL 7 weeks later. This is highlighted on the RNFL deviation maps (blue boxes) and RNFL quadrant thickness values (red boxes). Despite the RNFL loss, she recovered vision.
Case 3 - A case of increased intracranial pressure with worsening papilledema

Clinical information:
Visual acuity: 20/20 OD, 20/20 OS
No RAPD
Color vision: 14/14 OD, 14/14 OS correct Ishihara plates

Figure 10.
Optic disc photos

Humphrey 24-2 SITA-Fast visual field
There is an increased RNFL thickness in both eyes consistent with bilateral disc edema.

The elevated RNFL can be seen on the RNFL thickness map (red box), measurements in the table (green box), and RNFL thickness profile (blue box).
Figure 12.

Presentation

4 weeks after presentation

8 weeks after presentation

10 lbs weight gain

5 lbs weight gain
There is an increase in the RNFL thickness at each visit (red boxes) consistent with worsening of papilledema.
Case 4 - A case of acute vision loss in the right eye

Clinical information:

Visual acuity: HM OD, 20/20 OS
No RAPD

Color vision: 14/14 OS correct
Ishihara plates, no control plate seen OD

Optic disc photos

Goldmann VF
OD
OS
Since this patient’s RNFL thickness is the same as it was at presentation, his vision loss is not due to an optic neuropathy. An optic neuropathy would show RNFL thinning in the affected eye in the first few weeks and certainly by 6-8 weeks after vision loss. A right optic neuropathy must also have a right RAPD, which he did not have.
Potential pitfalls in interpreting OCT of the RNFL

- **Age of the patient** - ensure correct date of birth is entered since thickness measurements are compared against age-matched controls.

- **Check signal strength** - reduction in signal strength can result in loss of retinal features and artifacts in segmentation and interpretation. Signal strength of at least 7/10 is preferable on Cirrus machines.

- **Check for errors in segmentation** - an automated algorithm is used to identify the RNFL and may not be correctly identified in patients with poor signal strength or anomalous optic discs.

- **Check that the RNFL calculation circle is in the correct position** - An off-centered circle may give a falsely low RNFL measurement.
Clinical information:

Visual acuity: 20/20 OD, 20/20 OS
No RAPD
Color vision: 14/14 OD and 14/14 OS correct Ishihara plates
Humphrey visual field (24-2 SITA-Fast) showed enlarged blind spots in both eyes
RNFL calculation circle is off-centered and gives a falsely low average RNFL thickness. This is corrected on the repeat OCT scan and the RNFL thickness increased from 496 um to 711 um OD.
Clinical information:

Visual acuity: 20/20 OD, 20/20 OS
No RAPD
Color vision: 14/14 OD and 14/14 OS correct Ishihara plates
Humphrey visual field (24-2 SITA-Fast) showed enlarged blind spots in both eyes
In this patient with severe optic disc edema, there is an error in segmentation in the temporal optic disc of the right eye (red arrows) and an error in the measurement of RNFL parameters.

There is a non-physiologic decrease of the temporal RNFL to 0 mm in the right eye (blue arrows)
**Case 6 - Bilateral non-arteritic anterior ischemic optic neuropathy**

**Clinical information:**

Visual acuity: 20/20 OD, 20/60 OS

No RAPD (she has bilateral optic neuropathies)

Color vision: 14/14 OD and 14/14 OS correct Ishihara plates
An RNFL thickness within the normal range does not mean that the optic nerve is “normal”.

This patient has resolving optic disc edema in the left eye and is developing optic atrophy.

The residual optic disc edema results in a “normal” RNFL thickness in this atrophic optic nerve.
Summary points:

- Optical coherence tomography (OCT) of the retinal nerve fiber layer (RNFL) provides valuable information when evaluating patients with optic neuropathies, chiasmal or retrochiasmal visual field defects.

- OCT of the RNFL provides an objective way to document the optic disc and follow patients with a number of pathologies.

- OCT of the RNFL should be interpreted with caution since it is prone to a number of errors such as de-centration and segmentation errors.