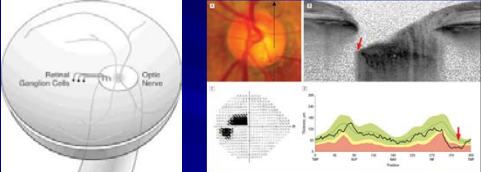# OCT Evaluation for Glaucoma Diagnosis and Progression
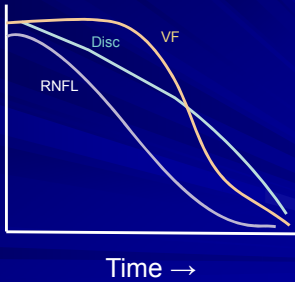

Gregory D. Searcy, M.D.
Erdey Searcy Eye Group

OCT vs Perimetry

- As tests for glaucoma progression,
  OCT and visual fields often share the top spot

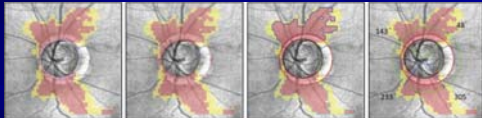- Glaucoma structural damage often precedes VF damage

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OCT vs Perimetry

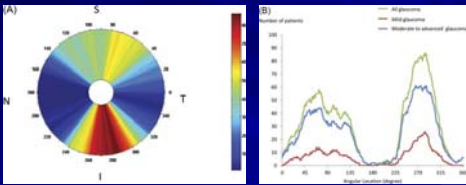

Time →

RNFL Damage Typical for Glaucoma

- Prospective, cross sectional study: 113 normal subjects and 116 glaucoma patients by spectral domain OCT of RNFL over 6 x 6 mm

- Characteristic distribution pattern, angular width, and area of RNFL defects in early glaucoma (yellow < 95%, red < 99%)

Leung et al. *Ophthalmology. 2010:117:2337-2344.*

RNFL Damage Typical for Glaucoma

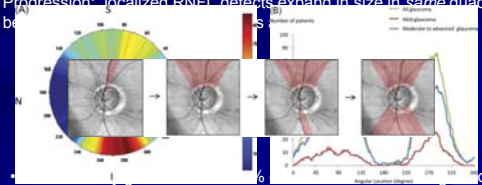- Preferential RNFL frequency distribution of early glaucoma

- 80% inferotemporal meridian   average 284°
- 54% superotemporal meridian   average   73°

Leung et al. *Ophthalmology. 2010:117:2337-2344.*

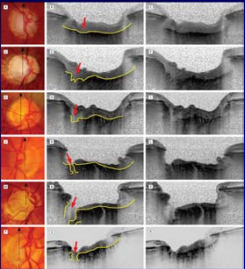## RNFL Damage Typical for Glaucoma

- Initial damage: localized inferotemporal or superotemporal RNFL loss

- Progression: localized RNFL defects expand in size in *same* quadrant

demonstrate damage in 2 quadrants

Leung et al. *Ophthalmology. 2010:117:2337-2344.*

RNFL Damage Typical for Glaucoma

- Superior and inferior LC contain larger pores and thinner connective tissue

- In particular, inferior and inferotemporal regions of the LC have considerably lower collagen density compared with other regions
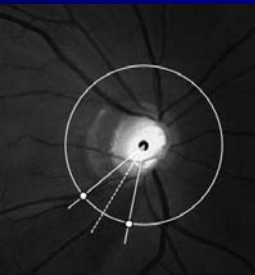
[Brain Res Bull 2010;81(2-3):339-348]

OCT Advantages

- Advantage of OCT testing = objectivity

- VF rely on subjective responses
- Disc photos rely on clinician's judgment
- OCT provides quantitative measurement of structures integral to the mechanism of glaucoma

- But is OCT accurate?

Ability of Cirrus OCT Clock-Hour, Deviation, and Thickness Maps in Detecting Photographic RNFL Abnormalities

- Ophthalmology

- 295 eyes with ... -domain OCT RNFL de... defects observed in re...

- 200 age-, sex- ... healthy eyes

- Width and loca... aluated using red-free ...

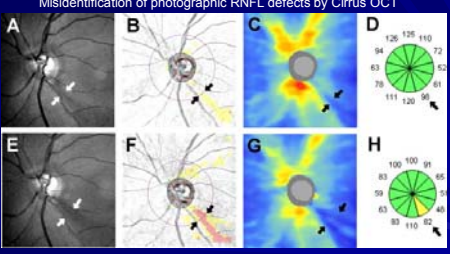## Ability of Cirrus OCT Clock-Hour, Deviation, and Thickness Maps in Detecting Photographic RNFL Abnormalities

- OCT misdiagnosis despite glaucoma RNFL defect on fundus photography in 295 eyes

Clock-hour	28%	(83)
Deviation	9%	(27)
Thickness map	0%	

- False-positive RNFL color codes in 200 healthy eyes

Clock-hour	13%	(25)
Deviation	15%	(30)
Thickness map	6%	(12)

Ability of Cirrus OCT Clock-Hour, Deviation, and Thickness Maps in Detecting Photographic RNFL Abnormalities
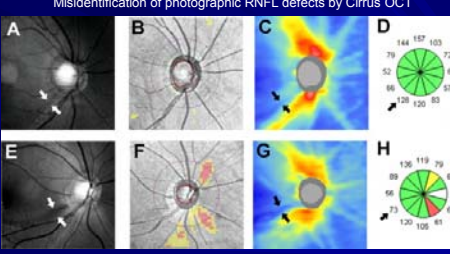
Misidentification of photographic RNFL defects by Cirrus OCT

- A-D: At 1st visit, an inferotemporal RNFL defect was found in (A) a red-free photograph, (B) RNFL deviation map, and (C) thickness map; however, it was not identified in (D) a clock-hour map of Cirrus OCT.
- E-H: 6 months later, the photographic RNFL defect was identified in (H) clock-hour map after RNFL progression.

Ability of Cirrus OCT Clock-Hour, Deviation, and Thickness Maps in Detecting Photographic RNFL Abnormalities

Misidentification of photographic RNFL defects by Cirrus OCT

- A-D (emmetrope): Inferotemporal RNFL defect observed in (A) red-free photograph and (C) RNFL thickness map. However, it was not identified in (B) an RNFL deviation map or (D) clock-hour map.
- E-H (-7 myope): Inferotemporal RNFL defect observed in (E) red-free photograph and (G) RNFL thickness map. However, it was not identified in (F) an RNFL deviation map or (H) clock-hour map.
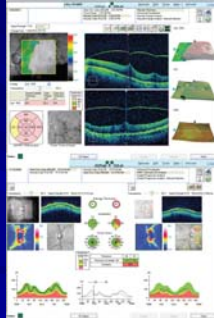
Cirrus OCT Normative Database

- If OCT is not always accurate …
  - What is the origin of OCT's information?

- 5 um axial resolution
- Scans 27,000 A-scans/second

- Deviation map, overlaid on an OCT fundus image, illustrates where NFL thickness deviates from a normative database
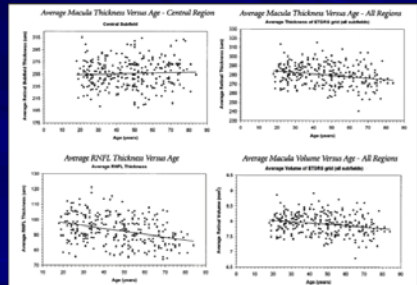
Cirrus OCT Normative Database

Normative database
- 7 centers
- Prospective study
- 284 subjects
- Age 18-84 (mean 46.5)
- Healthy (no ocular disease)

- From these scans, normative databases for optic disc (RNFL) cube and macular cube 200 x 200 were created

Cirrus OCT Normative Database

At mean age … mean RNFL thickness = 93 um

mean macular thickness = 256 um
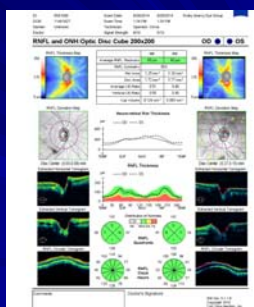
Cirrus OCT Normative Database

Age

17 or less:	None
70-79:	28 subject
80-84:	3 subjects
85+:	None

Refractive error

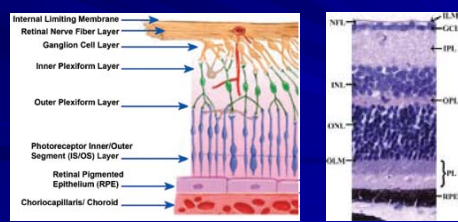No patients beyond -12 or +8

Keep patient demographics in mind

The Floor Effect

- The Floor effect: Despite OCTs increasing accuracy, there comes a time when RNFL is too thin to be used as a reliable indicator of glaucoma progression

- RNFL: retinal ganglion cell axons
          vessels
          support cells (glial/Muller cells)

- Even in end stage glaucoma, these other structures remain in "RNFL layer" which are unrelated to glaucoma and which can still be measured

The Floor Effect

- Spectral-domain OCT floor = 50 um
- When following a glaucoma patient and RNFL reaches the RNFL floor, tracking average RNFL thickness no longer becomes useful

The Floor Effect

- Spectral-domain OCT floor = 50 um
- In areas < floor, possible to use RNFL quad or clock-hr analysis, but do not follow avg RNFL thickness any more

The Floor Effect

- Spectral-domain OCT floor = 50 um
  - Case #1

The Floor Effect

- Spectral-domain OCT floor = 50 um
  - Case #1

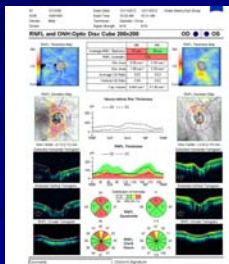## The Floor Effect

- Spectral-domain OCT floor = 50 um
  - Case #1

The Floor Effect

- Spectral-domain OCT floor = 50 um
  - Case #2

The Floor Effect

- Spectral-domain OCT floor = 50 um
  - Case #2

The Floor Effect
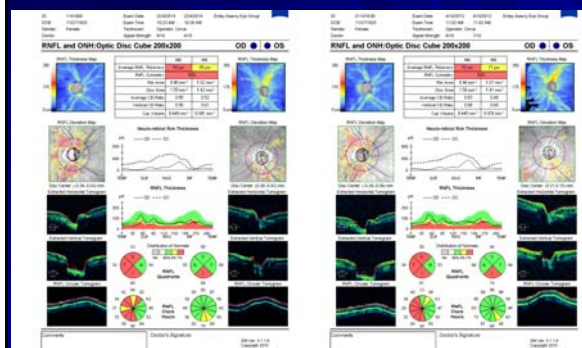
- Spectral-domain OCT floor = 50 um

  Case #2

Test/Retest Reliability

- Test/retest reliability (repeatability): Variation in measurements taken by a single person or instrument on the same item and under the same conditions

- Intervisit test/retest variability to all imaging devices

- In medicine, monitored values have a "critical difference" beneath which the possibility of test/retest reliability must be considered as the cause/contributing factor
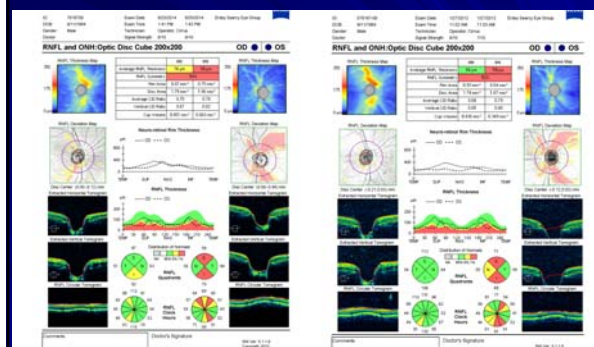
Test/Retest Reliability

- IOVS 2010;51:11:5724-30

- Cirrus OCT variability:
  - Mean deviation (overall):   4 um
  - Quadrant analysis: 8 um
  - Clock hour analysis: 12 um

- Glaucoma RNFL progression does not occur until OCT intervisit test/test variability is clearly exceeded

OCT Variability
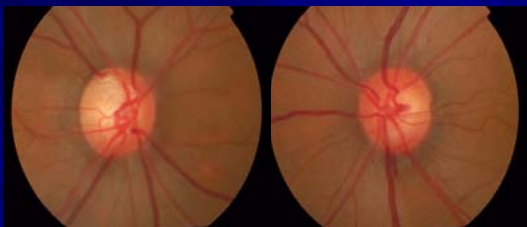

OCT Variability

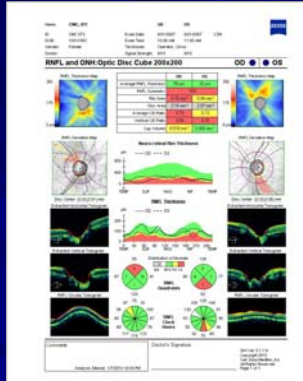

Guided Progression Analysis

- Introduced in 2009
- Compares RNFL thickness b/w baseline and follow-up RNFL thickness maps to estimated test-retest variability

- Local pixels exceeding test-retest variability are coded in yellow at the first event, and in red if the same changes are seen on three consecutive images

- Trend plot: 2 baseline scans, 3 follow up scans needed
- Linear regression line in µm/yr = rate of change

Guided Progression Analysis
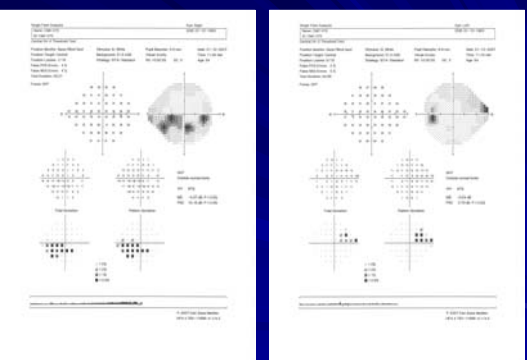
- Case study: 59 year-old female with NTG
- Baseline IOP 15/14 mmHg   CCT 527/526 µm
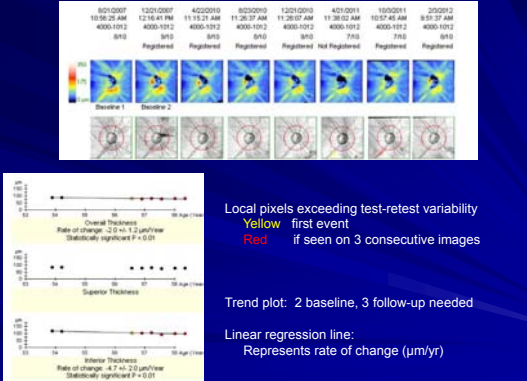

August 2007

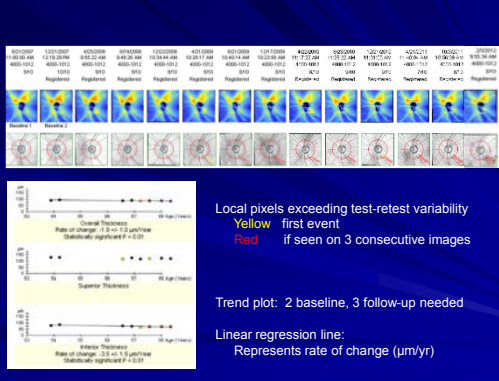
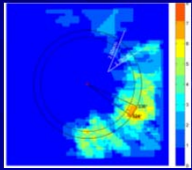August 2007

August 2007

September 2011

Local pixels exceeding test-retest variability
Yellow   first event
Red   if seen on 3 consecutive images

Trend plot: 2 baseline, 3 follow-up needed

Linear regression line:
Represents rate of change (µm/yr)

Local pixels exceeding test-retest variability
Yellow   first event
Red   if seen on 3 consecutive images

Trend plot: 2 baseline, 3 follow-up needed

Linear regression line:
Represents rate of change (µm/yr)

Summary

- VF progression is easily understood, but the definition of glaucoma does not include VF or OCT

- AAO: "A group of diseases with certain features including an intraocular pressure that is too high for the continued health of the eye"


Summary

- VF progression is easily understood, but the definition of glaucoma does not include VF or OCT

- AAO: "A group of diseases with certain features including an intraocular pressure that is too high for the continued health of the eye"

- As clinicians we are becoming more comfortable and knowledgeable regarding OCT analysis for glaucoma

Summary

- Normative Database
  - Age 18-84 (limited 70+)   Refractive error -12 or +8

- Floor Effect
  - 50 um

- Test/Retest Reliability
  - 4 (mean), 8 (quadrant), 12 (clock hour) = 10 um

- Guided Progression Analysis
  - Patterns exceeding test/retest reliability

Summary

The appeal of glaucoma lies in early diagnosis and early identification of disease progression, realizing the limitations of our current technology

Structure

Early Glaucoma	Moderate Glaucoma	Severe Glaucoma

Function

Thank you !!!