# OCT and Glaucoma

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**The Leicester OCT instructional Course**
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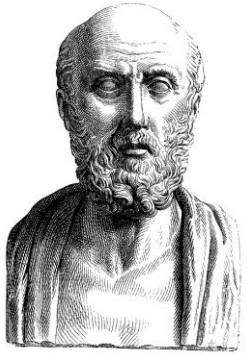
# Glaucoma

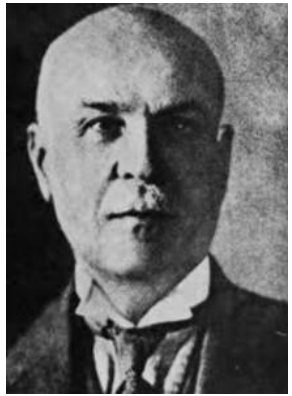


- Hippocrates “Aphorisms” 400 BC
  - *“glaucosis”* dimness of vision and blindness
- Aristotle (384-322 BC) “De Generatione Animalium”
  - *“color of the eye depends of the amount of water”*
- Galen (129-216 AD)
  - *“glaucoma: the pupils became discolored because of changes in the fluids in the eye”*

Table 1. Early Historical Events in the Evolution of Glaucoma Diagnosis

| Date | Event |
|---|---|
| 400s BC | Hippocrates' *Aphorisms* includes the first written record of glaucoma. |
| 300s BC | Aristotle proposes that the color of an eye is dependent the amount of water within it. |
| 100s AD | Galen defines glaucoma as a discoloration of the pupils due to fluid shifts in the eye; he draws the optic nerve as a hollow structure. |
| 500s | Aetius describes 2 categories of glaucoma: a defect of the lens and a defect of the pupil. |
| 1510s | da Vinci notes the cornea and aqueous bend light and the temporal VF extends 90° from fixation. |
| 1626 | Banister suggests the relevance of eye pressure to glaucoma. |
| 1668 | Mariotte describes the blind spot. |
| 1673 | van Leeuwenhoek draws first illustration of a peripheral nerve. |
| 1752 | Daviel presents results of more than 200 cataract extractions. |
| 1755 | Zinn contests the notion that the optic nerve is a hollow structure. |
| 1807 | Young specifies the dimensions of the VF. |
| 1826 | St Yves describes clinical features of advanced glaucoma in *Nouveau traité des Maladies des Yeux*. |
| 1830 | Mackenzie delineates 6 stages of glaucoma in *Practical Treatise on the Diseases of the Eye*. |
| 1851 | von Helmholtz invents the ophthalmoscope. |
| 1851 | Mueller describes depression of the optic disc in glaucoma. |
| 1854 | Jaeger illustrates swelling of the optic disc in glaucoma. |
| 1855 | Weber describes the glaucomatous optic disc as "cupped." |
| 1856 | von Graefe proposes incorporation of VF assessment into clinical practice. |
| 1860 | Schwalbe discovers anatomic connection between anterior chamber and ciliary veins. |
| 1867 | Weber invents the first applanation tonometer. |
| 1870 | Leber describes the aqueous pathway. |
| 1879–1890 | Priestley Smith suggests that glaucoma damage is due to vascular and metabolic changes in addition to mechanical forces; he later proposes that narrowing of the angle predisposes to glaucoma. |
| 1907 | Trantas promotes gonioscopy as routine diagnostic technique. |
| 1920 | Seidel refines Leber's filtration theory to account for colloidosmotic pressure of plasma proteins. |
| 1945 | Hans Goldmann invents the hemispheric bowl perimeter. |
| 1950 | Hans Goldmann introduces the Goldmann tonometer. |

VF = visual field.



# OCT and glaucoma

**Advantages**

- Non invasive
- Objective
- Accurate
- Rapid
- Reproducible
- Quantitative

**Points of measure**

- RNFL
- Optic nerve head
- Macula
- Retina and Optic nerve vasculature
- Anterior chamber angle
- Aqueous outflow system

# What OCT has changed in glaucoma management?

- Before OCT
  - Glaucoma diagnosis and progression relied on both optic disc examination and VF test
  - Both very subjective examinations
  - High rate of undiagnosed glaucoma

# Underdiagnosis of OAG

- Population studies suggest that at least half of all glaucoma cases have not been diagnosed[1]

| | |
|---|---|
| Blue Mountains Eye Study | 51% |
| Rotterdam Eye Study | 53% |
| Baltimore Eye Survey | 56% |
| Proyecto VER | 62% |

| | |
|---|---|
| Latino Eye Study | >75% |
| Egna-Neumarkt Study | 87% |
| Aravind Eye Study (India) | 93% |

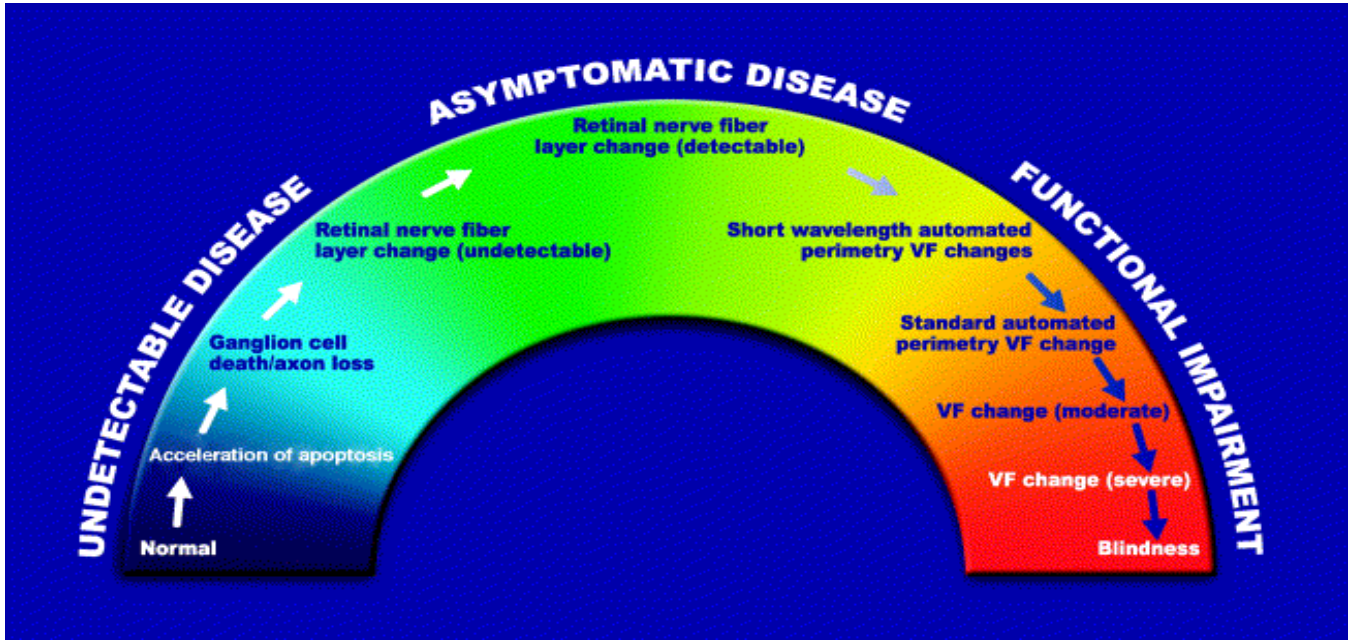

1. Leske MC. Ophthalmic Epidemiology. 2007;14:166-172.
2. Gillespie BW. Invest Ophthalmol Vis Sci. 2003;44:2613-2620

# Rates of undiagnosed glaucoma

| Type of glaucoma | Rates of undiagnosed cases | p value |
|---|---|---|
| OAG | 50.4% (n=71/141) | p=0.017 |
| POAG | **57.1%** (n=56/98) | |
| PEXG | **34.9%** (n=15/43) | |

Topouzis F et al. Factors associated with undiagnosed open-angle glaucoma: the thessaloniki eye study. Am J Ophthalmol. 2008;145:327-335.

# Glaucoma Continuum



# OCT and glaucoma

- Detection of early glaucoma
- Early detection of glaucoma
- Screening for glaucoma
  - General population?
  - High risk population

# Accuracy of OCT

**Table 1** Summary of selected glaucoma diagnostic accuracy studies

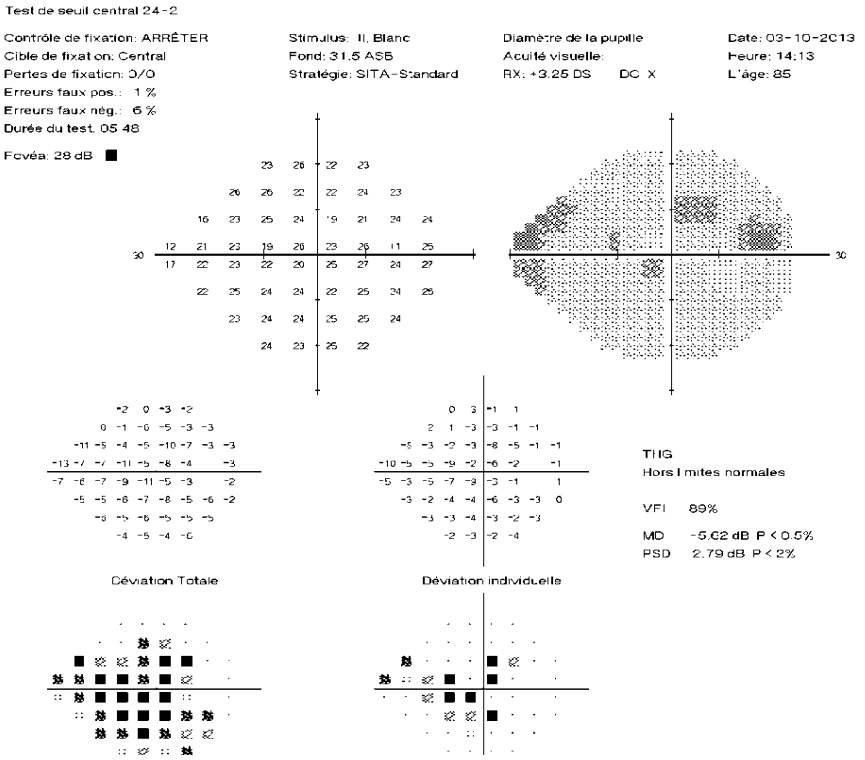
| Study, year (reference) | Subjects | Number of eyes | Baseline MD (dB) | Device | Scan region | Parameter | AUC |
|---|---|---|---|---|---|---|---|
| Mwanza 2011[8] | Glaucoma | 73 | −10.4 | Cirrus SD-OCT | ONH | Vertical rim thickness | 0.96 |
| | Healthy | 146 | NA | | RNFL | Rim area | 0.96 |
| | | | | | | RNFL average thickness | 0.95 |
| Sung 2012[9] | Glaucoma | 229 | −6.64 | Cirrus SD-OCT | ONH | Rim area | 0.87 |
| | Preperimetric glaucoma | 405 | −0.66 | | RNFL | RNFL average thickness | 0.96 |
| | Healthy | 109 | −0.45 | | | | |
| Kotowski 2012[10] | Glaucoma | 63 | −2.21 | Cirrus SD-OCT | Macular | GCC average | 0.90 |
| | Glaucoma suspect | 49 | −0.32 | | RNFL | GCIPL average | 0.90 |
| | Healthy | 51 | −0.18 | | | RNFL average thickness | 0.91 |
| Mwanza 2012[11] | Glaucoma | 58 | −3.2 | Cirrus SD-OCT | Macular | GCIPL minimum | 0.96 |
| | Healthy | 99 | 0.08 | | ONH | GCIPL average | 0.94 |
| | | | | | RNFL | Vertical cup to disc ratio | 0.96 |
| | | | | | | Cup to disc ratio | 0.93 |
| | | | | | | Rim area | 0.91 |
| | | | | | | RNFL average thickness | 0.94 |
| Jeoung 2013[12] | Glaucoma | | | Cirrus SD-OCT | | | *Mild, moderate/severe* |
| | Mild | 164 | −2.68 | | Macular | GCIPL minimum | 0.90, 0.96 |
| | Moderate/severe | 142 | −12.41 | | ONH | GCIPL average | 0.82, 0.91 |
| | Healthy | 119 | −0.22 | | RNFL | Rim area | 0.86, 0.94 |
| | | | | | | Cup to disc ratio | 0.72, 0.86 |
| | | | | | | RNFL average thickness | 0.90, 0.96 |
| Takayama 2012[13] | Glaucoma | | | Cirrus SD-OCT | | | *All, early, advanced* |
| | Early | 38 | −2.33 | | Macular | GCIPL minimum | 0.94, 0.90, 0.99 |
| | Advanced | 20 | −14.2 | | RFNL | GCIPL average | 0.87, 0.82, 0.96 |
| | Healthy | 48 | −0.07 | | | RNFL average thickness | 0.92, 0.89, 0.96 |
| Lisboa 2013[14] | Preperimetric glaucoma | 48 | −0.81 | RTVue SD-OCT | Macular ONH | GCC average | 0.79 |
| | Healthy | 94 | 0.02 | | RNFL | Vertical cup to disc ratio | 0.74 |
| | | | | | | Rim area | 0.72 |
| | | | | | | RNFL average thickness | 0.89 |

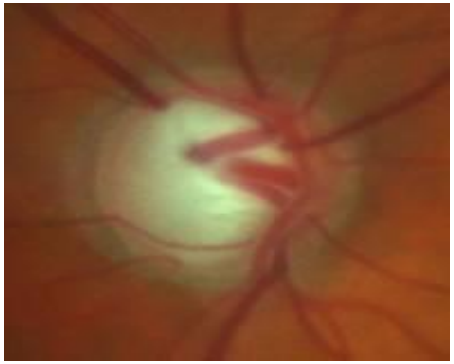
AUC, area under receiver operating characteristics curve; GCC, ganglion cell complex; GCIPL, ganglion cell inner plexiform layer; MD, mean deviation; ONH, optic nerve head; RNFL, retinal nerve fibre layer; SD-OCT, spectral domain-optical coherence tomography.

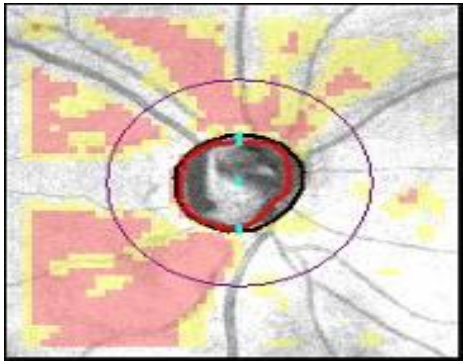
# Screening strategies

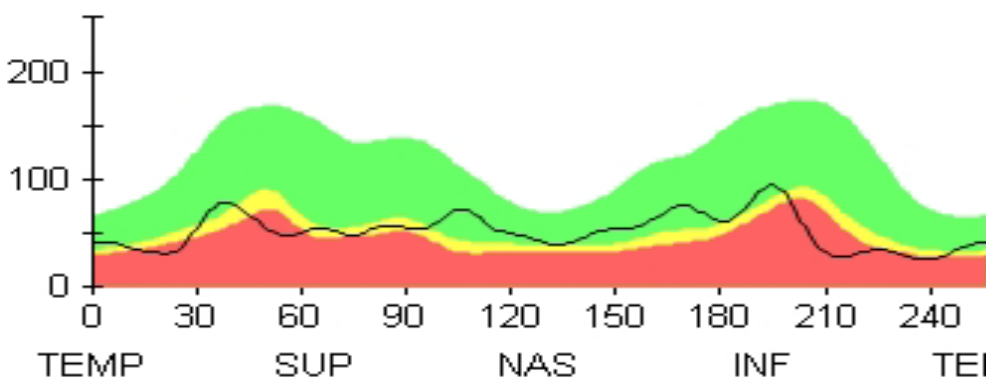
- **IOP**
  - Sensitivity: 79%
  - Specificity: 64%
- **Optic nerve examination**
  - Examiner skill
  - Patient characteristic
  - Sensitivity and specificity: 70%-80%
- **Visual field testing**
  - Sensitivity and specificity: 70%
  - By the time a defect is noted > 50% of ganglion cell loss
- **Optic nerve and ganglion cell imaging**
  - High accuracy in case/controls studies
  - In real life condition?

# Agreement Between Optic Nerve Appearance, Visual Fields and Structural Measurements?



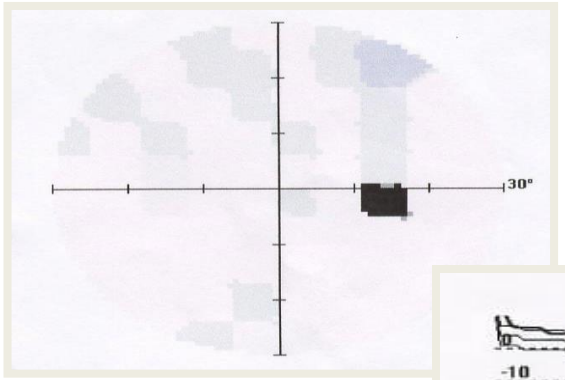








03-11-2004


20° Right #6 03-11-2004
20° Left #27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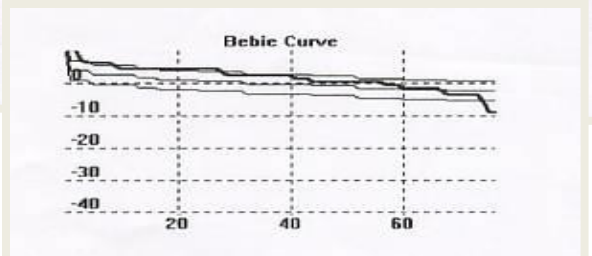
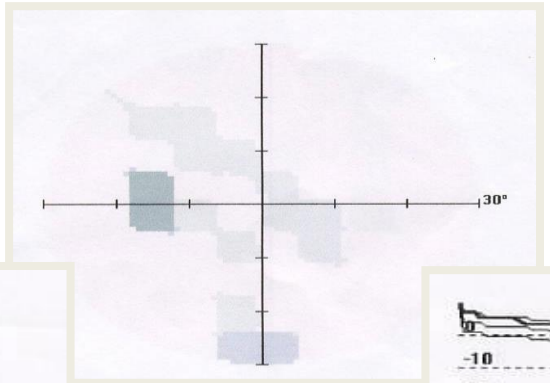

Bebie Curve
0
-10
-20
-30
-40
20
40
60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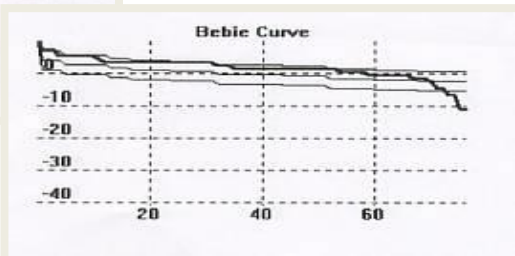
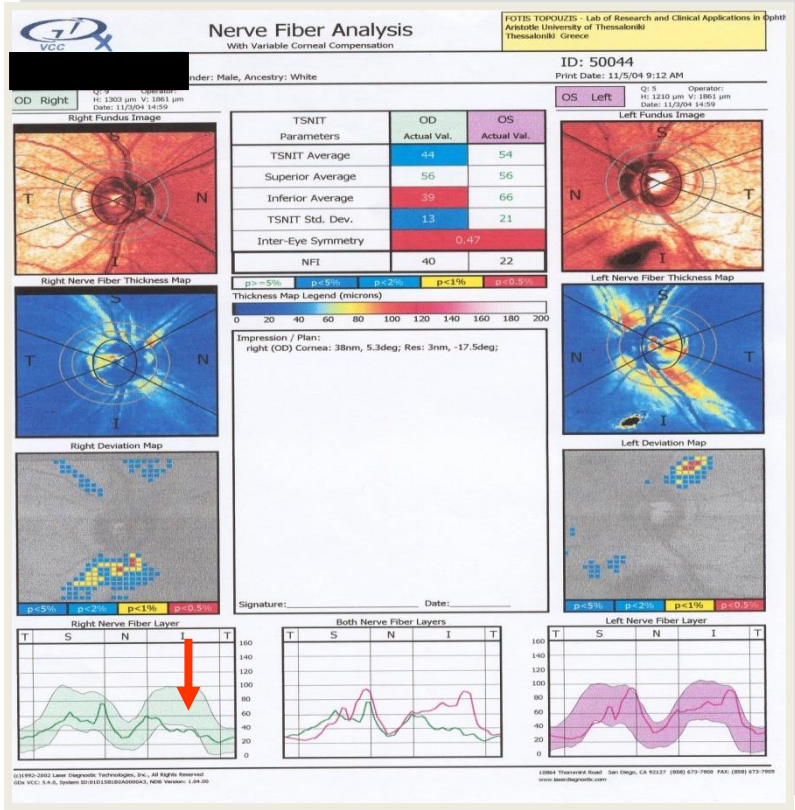
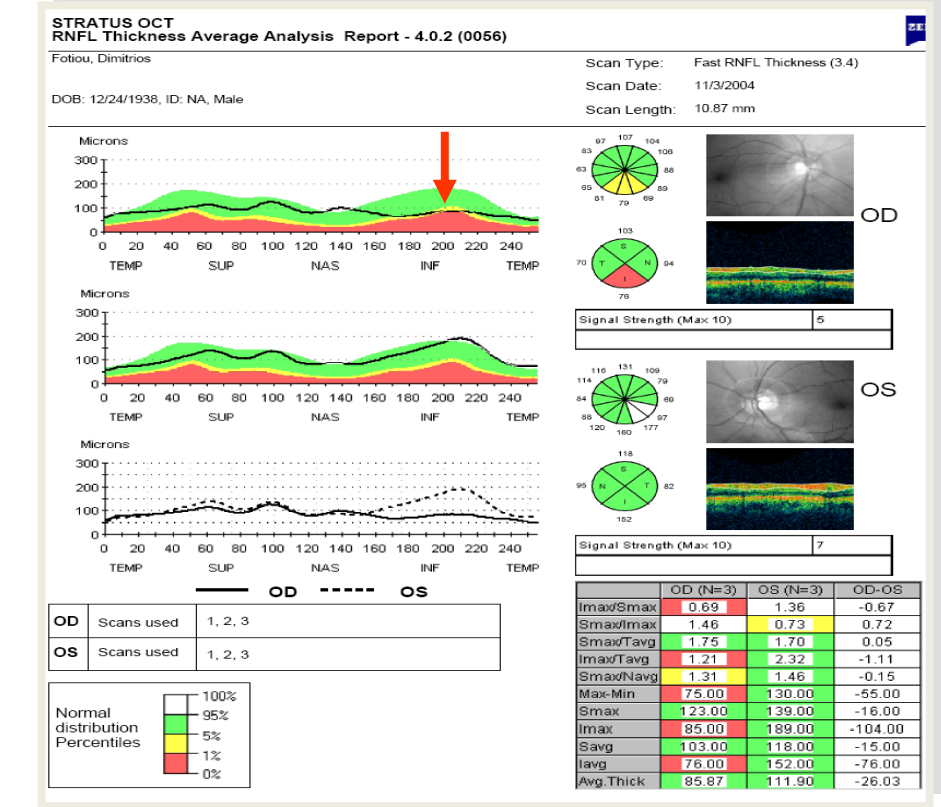
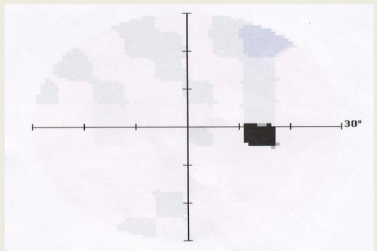

Bebie Curve
0
-10
-20
-30
-40
20
40
60


Nerve Fiber Analysis
With Variable Corneal Compensation
FOTIS TOPOUZIS - Lab of Research and Clinical Applications in Ophth
Aristotle University of Thessaloniki
Thessaloniki Greece
ID: 50044
Print Date: 11/5/04 9:12 AM
OD Right
OS Left
Right Fundus Image
Left Fundus Image
TSNIT Parameters
OD Actual Val.
OS Actual Val.
TSNIT Average 44 54
Superior Average 56 56
Inferior Average 39 66
TSNIT Std. Dev. 13 21
Inter-Eye Symmetry 0.47
NFI 40 22
Right Nerve Fiber Thickness Map
Left Nerve Fiber Thickness Map
Thickness Map Legend (microns)
Impression / Plan:
right (OD) Cornea: 38nm, 5.3deg; Res: 3nm, -17.5deg;
Signature:
Date:
Right Deviation Map
Left Deviation Map
Right Nerve Fiber Layer
Both Nerve Fiber Layers
Left Nerve Fiber Layer


STRATUS OCT
RNFL Thickness Average Analysis Report - 4.0.2 (0056)
Fotiou, Dimitrios
DOB: 12/24/1938, ID: NA, Male
Scan Type: Fast RNFL Thickness (3.4)
Scan Date: 11/3/2004
Scan Length: 10.87 mm
Microns
TEMP SUP NAS INF TEMP
OD
Signal Strength (Max 10) 5
OS
Signal Strength (Max 10) 7
OD OS
OD Scans used 1, 2, 3
OS Scans used 1, 2, 3
Normal distribution Percentiles
100%
95%
5%
1%
0%
OD (N=3) OS (N=3) OD-OS
Imax/Smax 0.69 1.36 -0.67
Smax/Imax 1.46 0.73 0.72
Smax/Tavg 1.75 1.70 0.05
Imax/Tavg 1.21 2.32 -1.11
Smax/Navg 1.31 1.46 -0.15
Max-Min 75.00 130.00 -55.00
Smax 123.00 139.00 -16.00
Imax 85.00 189.00 -104.00
Savg 103.00 118.00 -15.00
Iavg 76.00 152.00 -76.00
Avg.Thick 85.87 111.90 -26.03

OD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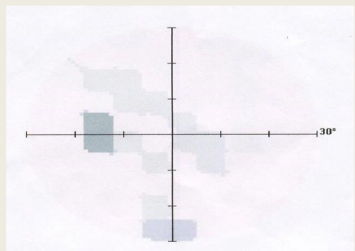
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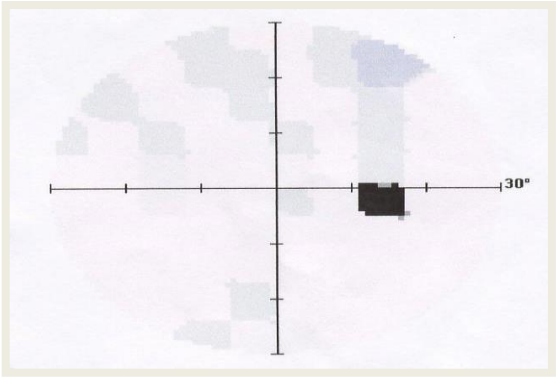
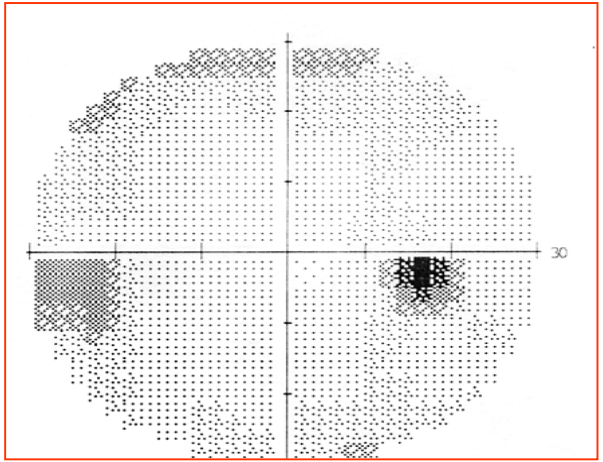
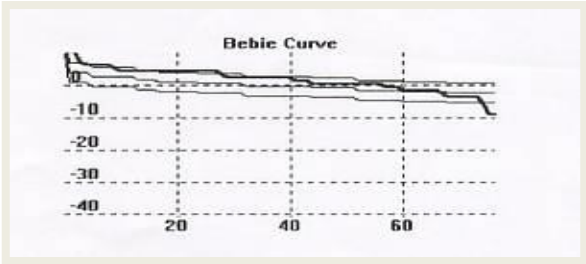
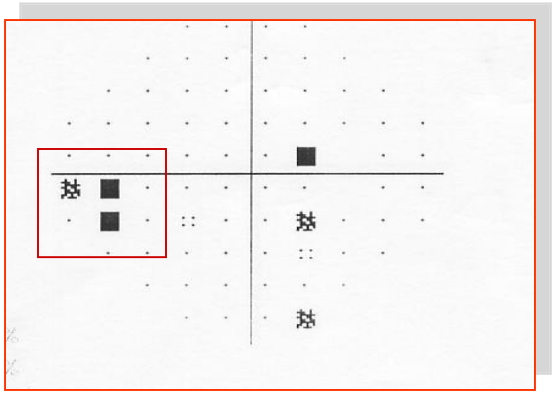


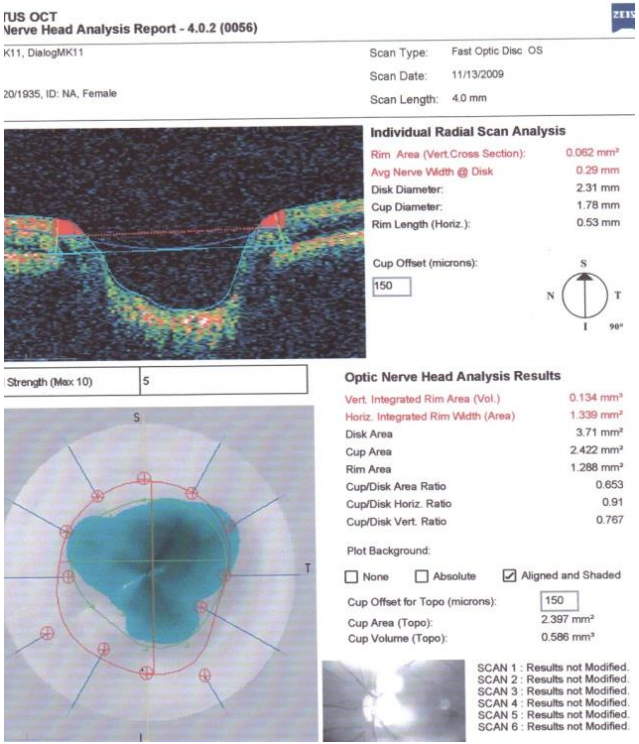




8 months later



# Define normals



TUS OCT
Nerve Head Analysis Report - 4.0.2 (0056)

K11, DialogMK11

20/1935, ID: NA, Female

Scan Type: Fast Optic Disc OS
Scan Date: 11/13/2009
Scan Length: 4.0 mm

Individual Radial Scan Analysis

| | |
|---|---|
| Rim Area (Vert.Cross Section): | 0.062 mm² |
| Avg Nerve Width @ Disk | 0.29 mm |
| Disk Diameter: | 2.31 mm |
| Cup Diameter: | 1.78 mm |
| Rim Length (Horiz.): | 0.53 mm |

Cup Offset (microns): 150

Strength (Max 10) 5

Optic Nerve Head Analysis Results

| | |
|---|---|
| Vert. Integrated Rim Area (Vol.) | 0.134 mm³ |
| Horiz. Integrated Rim Width (Area) | 1.339 mm² |
| Disk Area | 3.71 mm² |
| Cup Area | 2.422 mm² |
| Rim Area | 1.288 mm² |
| Cup/Disk Area Ratio | 0.653 |
| Cup/Disk Horiz. Ratio | 0.91 |
| Cup/Disk Vert. Ratio | 0.767 |

Plot Background:
☐ None ☐ Absolute ☑ Aligned and Shaded

Cup Offset for Topo (microns): 150
Cup Area (Topo): 2.397 mm²
Cup Volume (Topo): 0.586 mm³

SCAN 1 : Results not Modified.
SCAN 2 : Results not Modified.
SCAN 3 : Results not Modified.
SCAN 4 : Results not Modified.
SCAN 5 : Results not Modified.
SCAN 6 : Results not Modified.

STRATUS OCT
RNFL Thickness Average Analysis Report - 4.0.2 (0056)

DialogMK11, DialogMK11

DOB: 8/20/1935, ID: NA, Female

Scan Type: Fast RNFL Thickness (3.4)
Scan Date: 11/13/2009
Scan Length: 10.87 mm

Microns
TEMP SUP NAS INF TEMP

OD

Signal Strength (Max 10) 5

OS

Signal Strength (Max 10) 4

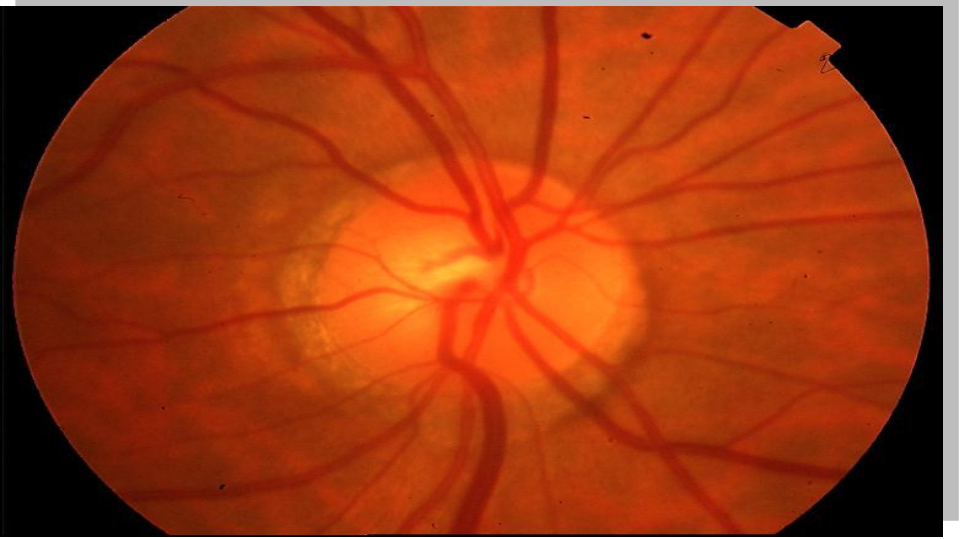
OD ----- OS

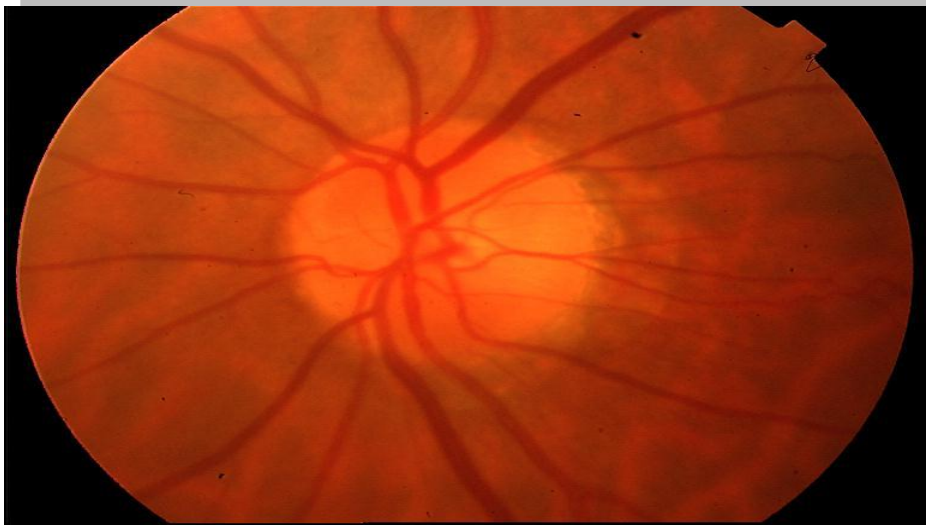
| | | |
|---|---|---|
| OD | Scans used | 1, 2, 3 |
| OS | Scans used | 1, 2, 3 |

Normal distribution Percentiles: 100% 95% 5% 1% 0%

| | OD (N=3) | OS (N=3) | OD-OS |
|---|---|---|---|
| Imax/Smax | 1.06 | 0.94 | 0.22 |
| Smax/Imax | 0.94 | 1.19 | -0.24 |
| Smax/Tavg | 2.20 | 2.90 | -0.70 |
| Imax/Tavg | 2.34 | 2.45 | -0.11 |
| Smax/Navg | 2.22 | 2.55 | -0.33 |
| Max-Min | 122.00 | 130.00 | -8.00 |
| Smax | 153.00 | 162.00 | -9.00 |
| Imax | 163.00 | 137.00 | 26.00 |
| Savg | 132.00 | 134.00 | -2.00 |
| Iavg | 126.00 | 115.00 | 11.00 |
| Avg.Thick | 99.09 | 92.01 | 7.08 |

# Define normals





Single Field Analysis

[redacted] ILIKI | ID: | Eye: Right | DOB: 01-01-1936

Central 30-2 Threshold Test

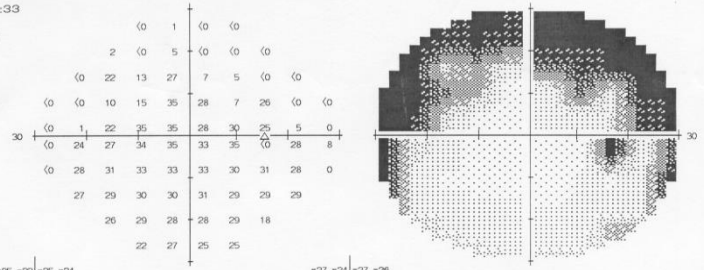
Fixation Monitor: Gaze/Blindspot
Fixation Target: Central
Fixation Losses: 5/22
False POS Errors: 22 %
False NEG Errors: 26 %
Test Duration: 13:33

Stimulus: III, White
Background: 31.5 ASB
Strategy: SITA-Standard

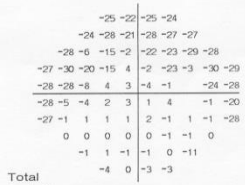
Pupil Diameter:
Visual Acuity:
RX: +3.75 DS DC X

Date: 23-02-2005
Time: 10:32
Age: 69

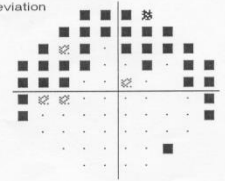
Fovea: 14 dB

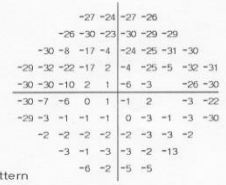




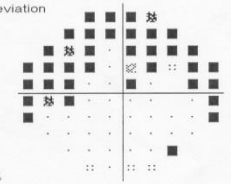


Total Deviation





Pattern Deviation



GHT
Outside normal limits

MD -7.26 dB P < 0.5%
PSD 13.34 dB P < 0.5%

:: < 5%
▒ < 2%
▓ < 1%
■ < 0.5%

Single Field Analysis

[redacted] | ID: | Eye: Left | DOB: 01-01-1936

Central 30-2 Threshold Test

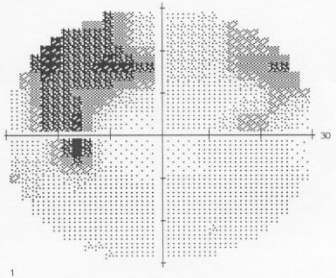
Fixation Monitor: Gaze/Blindspot
Fixation Target: Central
Fixation Losses: 3/21
False POS Errors: 20 %
False NEG Errors: 16 %
Test Duration: 11:57

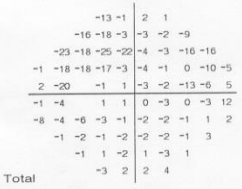
Stimulus: III, White
Background: 31.5 ASB
Strategy: SITA-Standard

Pupil Diameter:
Visual Acuity:
RX: +4.25 DS DC X

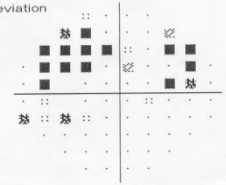
Date: 23-02-2005
Time: 10:55
Age: 69

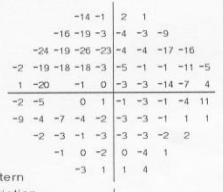
Fovea: 33 dB



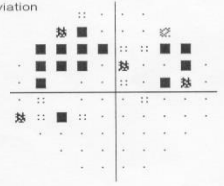


Total Deviation





Pattern Deviation



GHT
Outside normal limits

MD -3.98 dB P < 2%
PSD 7.78 dB P < 0.5%

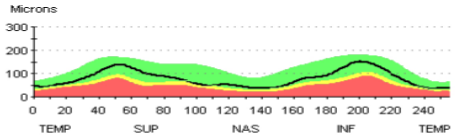
:: < 5%
▒ < 2%
▓ < 1%
■ < 0.5%

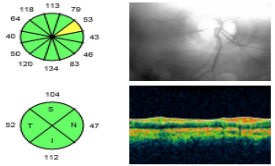
**STRATUS OCT**
**RNFL Thickness Average Analysis Report - 4.0.2 (0056)**

[redacted]

DOB: 3/15/1936, ID: FI, Female

Scan Type: Fast RNFL Thickness (3.4)
Scan Date: 2/23/2005
Scan Length: 10.87 mm

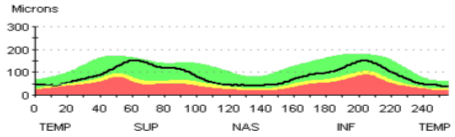


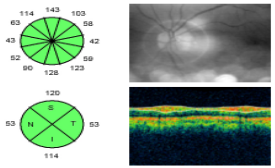






OD

| Signal Strength (Max 10) | 7 |
|---|---|

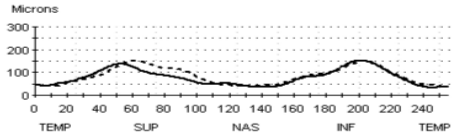




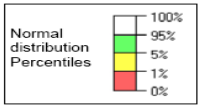

OS

| Signal Strength (Max 10) | 7 |
|---|---|

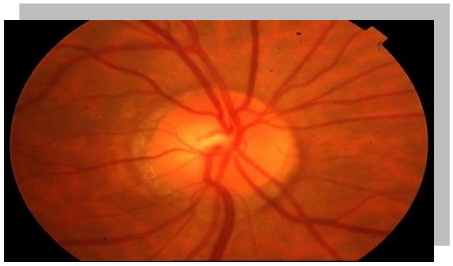


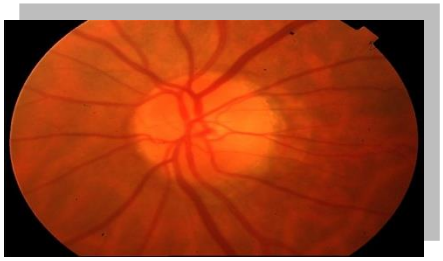

OD ----- OS

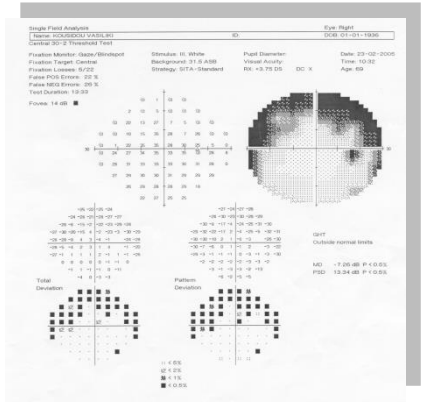
| | | |
|---|---|---|
| OD | Scans used | 1, 2, 3 |
| OS | Scans used | 1, 2, 3 |

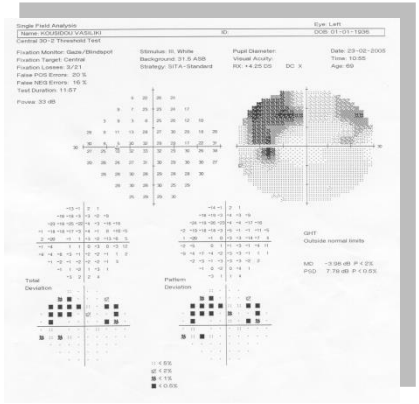


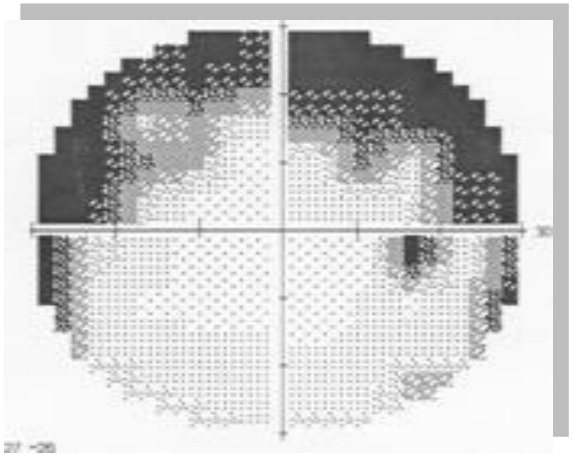

| | OD (N=3) | OS (N=3) | OD-OS |
|---|---|---|---|
| Imax/Smax | 1.09 | 0.99 | 0.10 |
| Smax/Imax | 0.92 | 1.01 | -0.09 |
| Smax/Tavg | 2.69 | 2.84 | -0.15 |
| Imax/Tavg | 2.94 | 2.82 | 0.12 |
| Smax/Navg | 2.95 | 2.88 | 0.07 |
| Max-Min | 118.00 | 114.00 | 4.00 |
| Smax | 139.00 | 151.00 | -12.00 |
| Imax | 152.00 | 150.00 | 2.00 |
| Savg | 104.00 | 120.00 | -16.00 |
| Iavg | 112.00 | 114.00 | -2.00 |
| Avg.Thick | 78.67 | 84.96 | -6.29 |



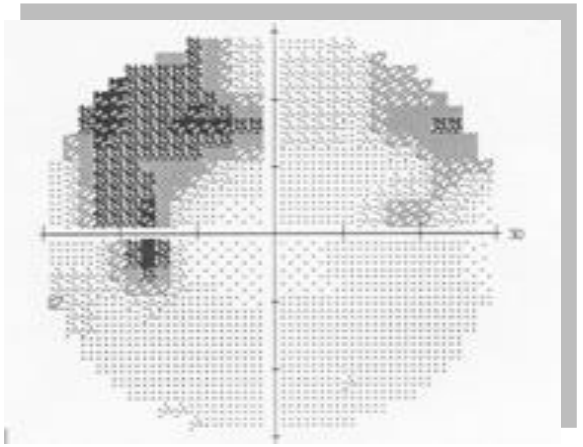




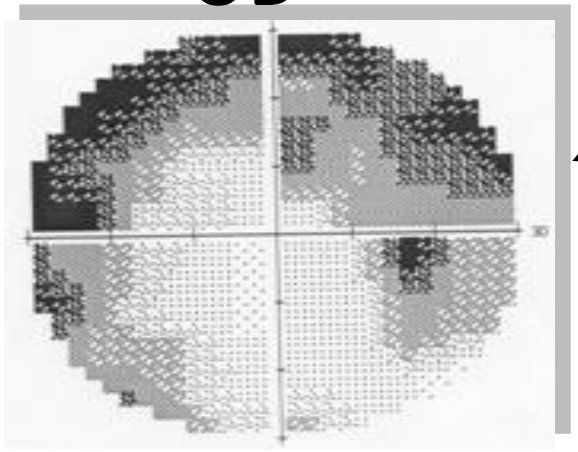




2005



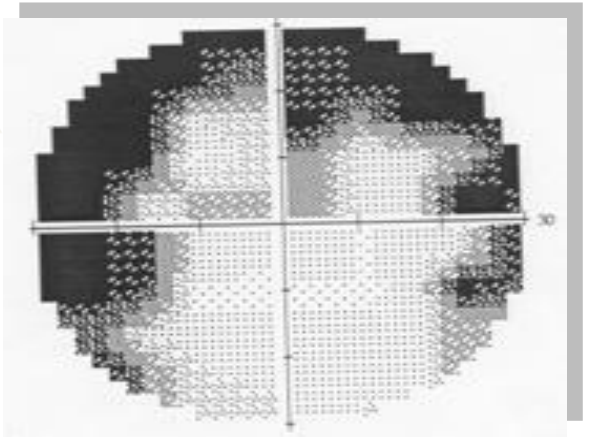
OD



Unreliable

2006

OS

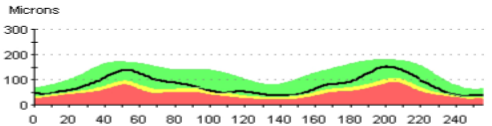


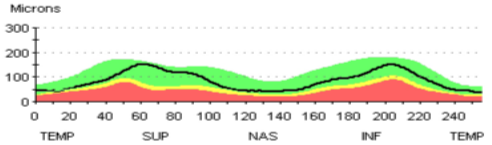
STRATUS OCT
RNFL Thickness Average Analysis Report - 4.0.2 (0056)

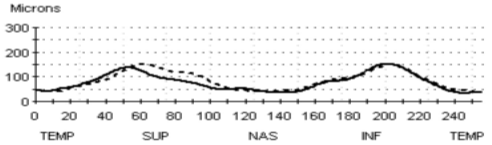
[redacted]

DOB: 3/15/1936, ID: FI, Female

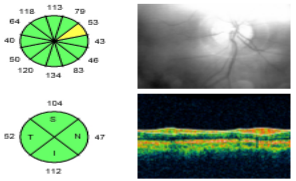
Scan Type: Fast RNFL Thickness (3.4)
Scan Date: 2/23/2005
Scan Length: 10.87 mm



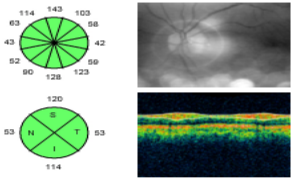




OD ----- OS



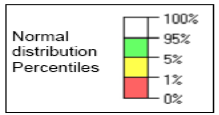

| Signal Strength (Max 10) | 7 |
|---|---|




| Signal Strength (Max 10) | 7 |
|---|---|

| | OD (N=3) | OS (N=3) | OD-OS |
|---|---|---|---|
| Imax/Smax | 1.09 | 0.99 | 0.10 |
| Smax/Imax | 0.92 | 1.01 | -0.09 |
| Smax/Tavg | 2.69 | 2.84 | -0.15 |
| Imax/Tavg | 2.94 | 2.82 | 0.12 |
| Smax/Navg | 2.95 | 2.88 | 0.07 |
| Max-Min | 118.00 | 114.00 | 4.00 |
| Smax | 139.00 | 151.00 | -12.00 |
| Imax | 152.00 | 150.00 | 2.00 |
| Savg | 104.00 | 120.00 | -16.00 |
| Iavg | 112.00 | 114.00 | -2.00 |
| Avg.Thick | 78.67 | 84.96 | -6.29 |

| | | |
|---|---|---|
| OD | Scans used | 1, 2, 3 |
| OS | Scans used | 1, 2, 3 |



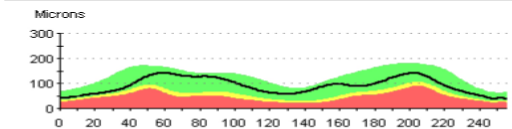

2/2005

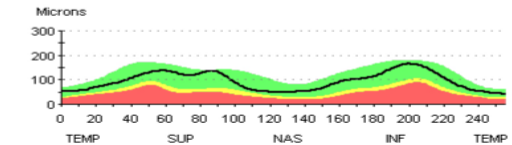
STRATUS OCT
RNFL Thickness Average Analysis Report - 4.0.2 (0056)

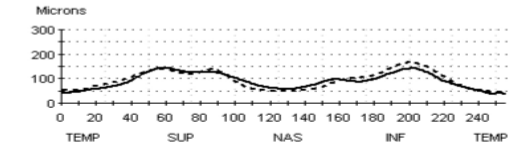
[redacted]

DOB: 3/15/1936, ID: FI, Female

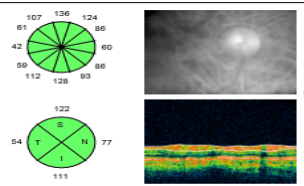
Scan Type: Fast RNFL Thickness (3.4)
Scan Date: 1/12/2006
Scan Length: 10.87 mm



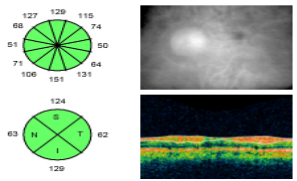




OD ----- OS



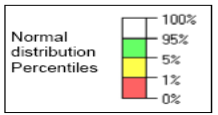

| Signal Strength (Max 10) | 9 |
|---|---|




| Signal Strength (Max 10) | 8 |
|---|---|

| | OD (N=3) | OS (N=3) | OD-OS |
|---|---|---|---|
| Imax/Smax | 0.99 | 1.20 | -0.21 |
| Smax/Imax | 1.01 | 0.83 | 0.18 |
| Smax/Tavg | 2.65 | 2.21 | 0.44 |
| Imax/Tavg | 2.62 | 2.64 | -0.03 |
| Smax/Navg | 1.84 | 2.18 | -0.33 |
| Max-Min | 104.00 | 122.00 | -18.00 |
| Smax | 143.00 | 138.00 | 5.00 |
| Imax | 141.00 | 165.00 | -24.00 |
| Savg | 122.00 | 124.00 | -2.00 |
| Iavg | 111.00 | 129.00 | -18.00 |
| Avg.Thick | 91.17 | 94.69 | -3.52 |

| | | |
|---|---|---|
| OD | Scans used | 1, 2, 3 |
| OS | Scans used | 1, 2, 3 |




1/2006

Single Field Analysis

[redacted] ID: Eye: Right

DOB: 01-01-1936

Central 30-2 Threshold Test

Fixation Monitor: Gaze/Blindspot
Fixation Target: Central
Fixation Losses: 4/20
False POS Errors: 24 %
False NEG Errors: 9 %
Test Duration: 11:33

Stimulus: III, White
Background: 31.5 ASB
Strategy: SITA-Standard

Pupil Diameter:
Visual Acuity:
RX: +4.75 DS DC X

Date: 05-05-2006
Time: 08:28
Age: 70

Fovea: 34 dB

GHT
Outside normal limits

MD +0.61 dB
PSD 6.62 dB P < 0.5%

Total Deviation

Pattern Deviation

:: < 5%
▒ < 2%
▓ < 1%
■ < 0.5%

Final Visual Fields

Single Field Analysis

[redacted] ID: Eye: Left

DOB: 01-01-1936

Central 30-2 Threshold Test

Fixation Monitor: Gaze/Blindspot
Fixation Target: Central
Fixation Losses: 5/16
False POS Errors: 12 %
False NEG Errors 10 %
Test Duration: 09:45

Stimulus III, White
Background: 31.5 ASB
Strategy: SITA-Standard

Pupil Diameter:
Visual Acuity:
RX +4.50 DS DC X

Date: 05-05-2006
Time 08:48
Age 70

Fovea: 36 dB

GHT
Borderline

MD +1.09 dB
PSD 2.21 dB

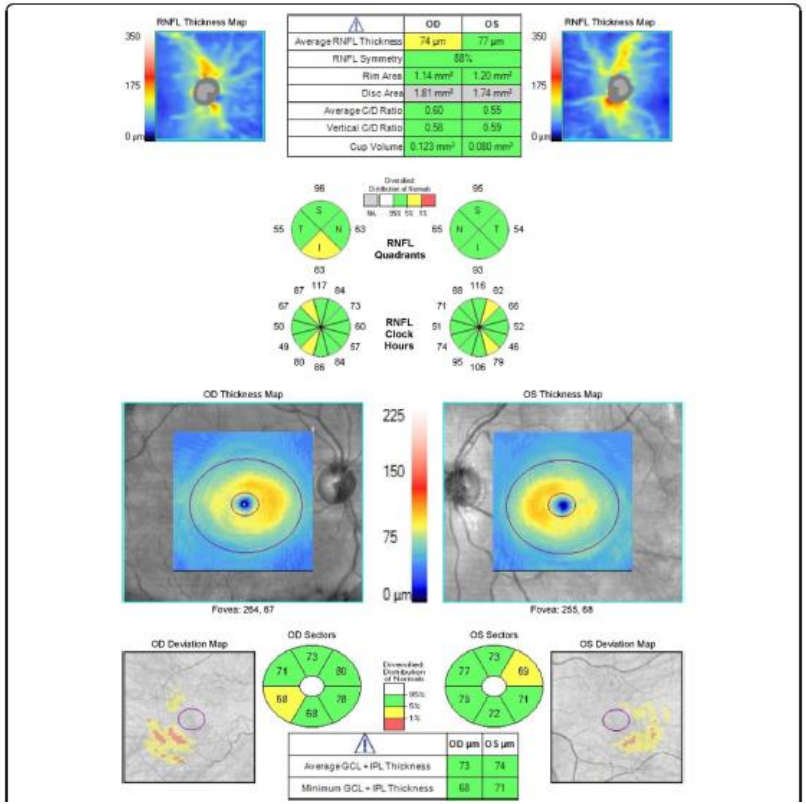
Total Deviation

Pattern Deviation

:: < 5%
▒ < 2%
▓ < 1%
■ < 0.5%

Initial Visual Fields

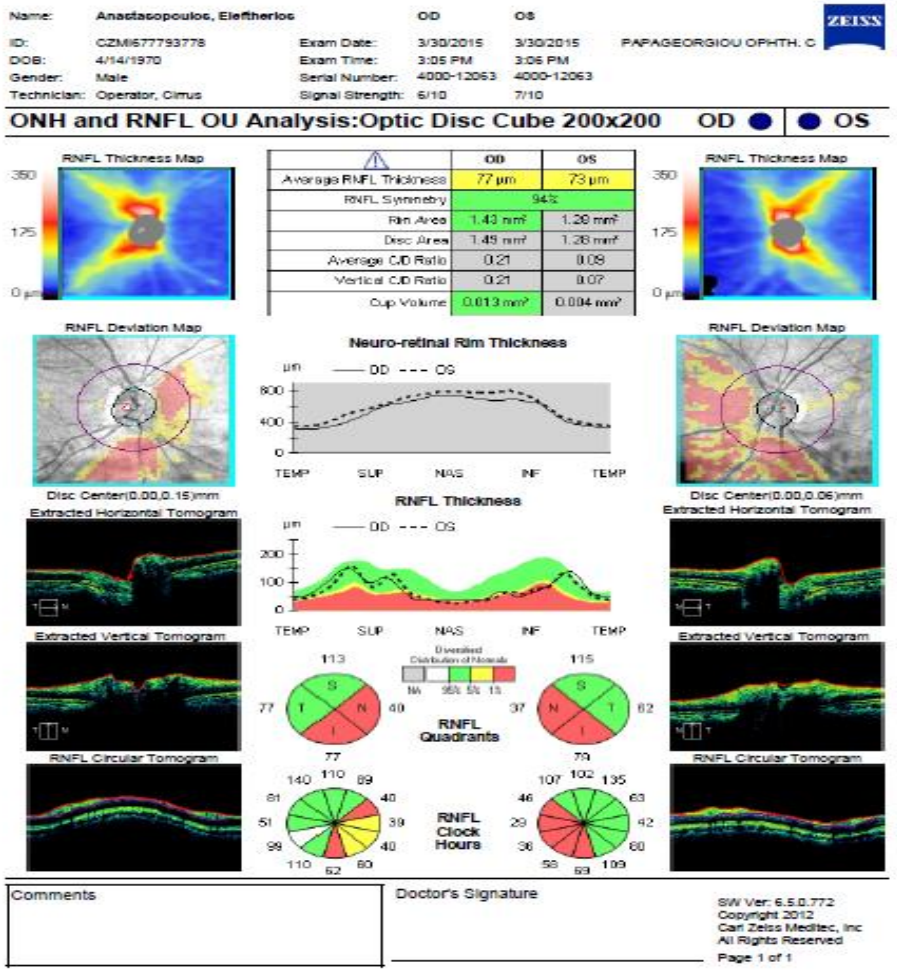
# Early glaucoma or normal?



# Myopia

False positive results

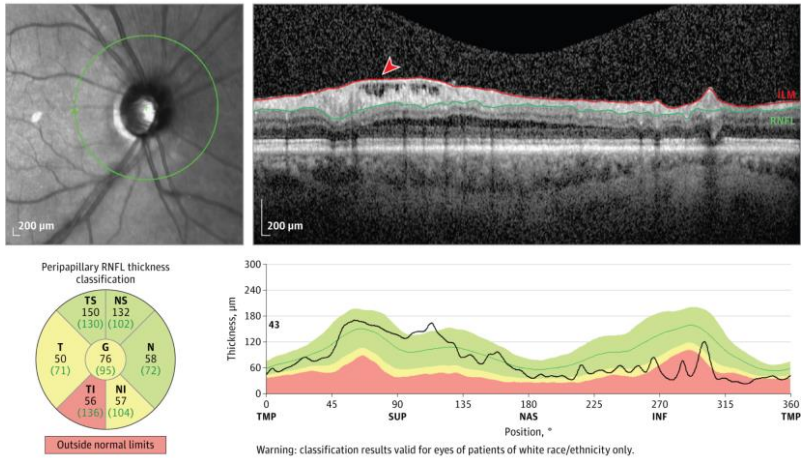
- Myopic refractive error
- Longer axial length
- Tilted disc

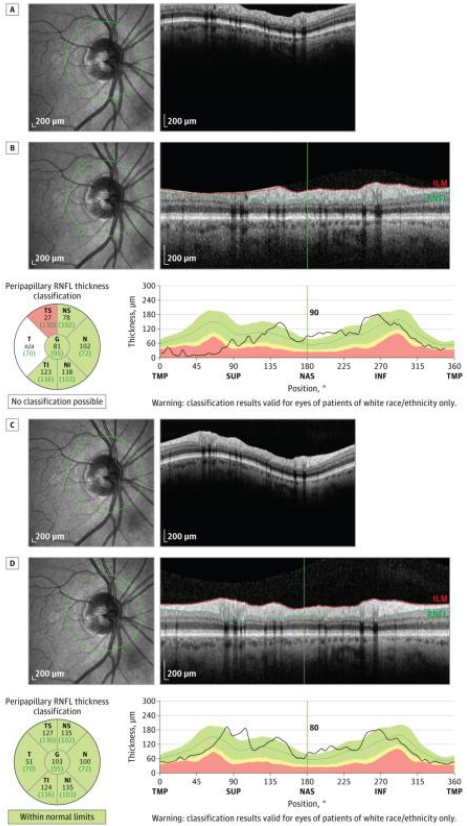


# Artifacts

20%-45% of scans have artifacts

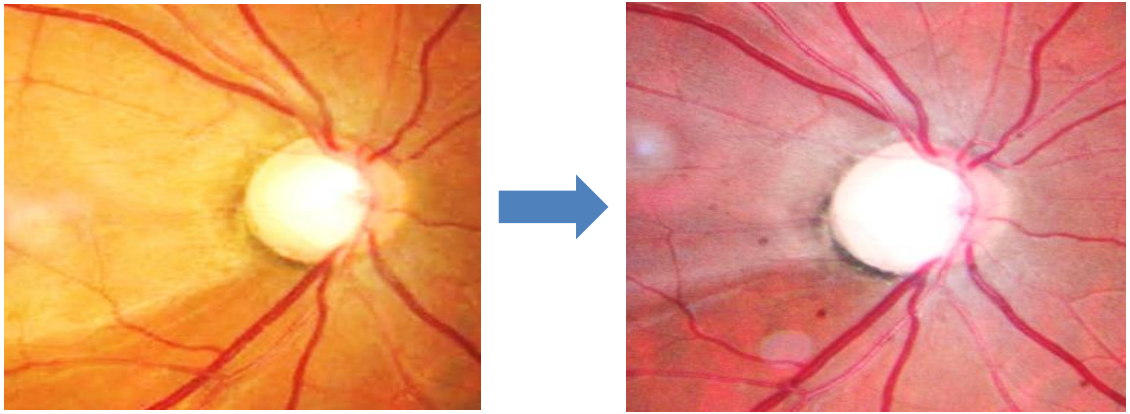
1. Decentration
2. Motion artifacts
3. Poor signal
4. Segmentation errors
5. Vitreomacular traction, ERM and PVD

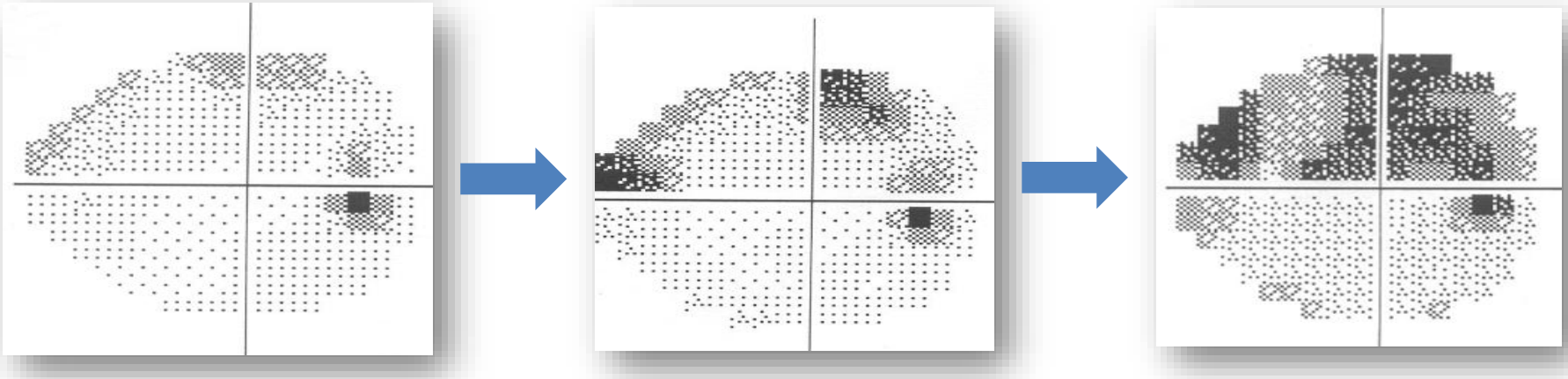



CAUTION
THIS MACHINE
HAS NO BRAIN
USE YOUR OWN

# Glaucoma progression





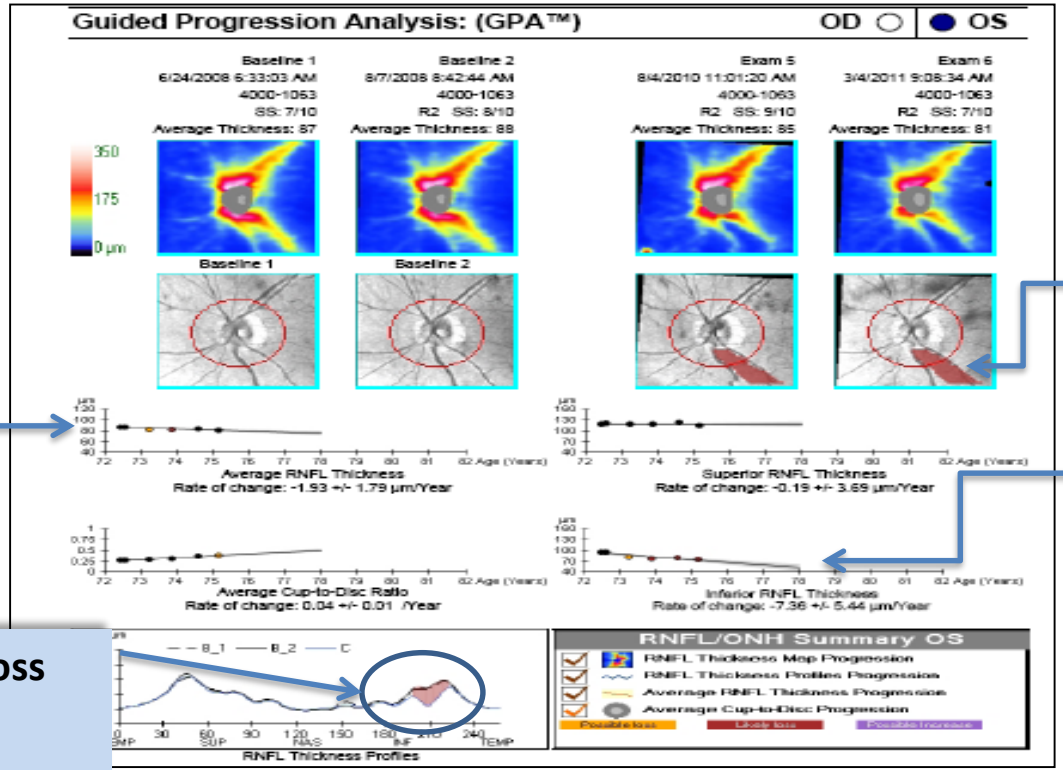
# OCT: Retinal Nerve Fiber Layer Thickness Assessment

**Trend**

**Average RNFL thickness rate of change 1.93 µm/year**

**Event**

**Focal thickness loss depicted in RNFL thickness profile**



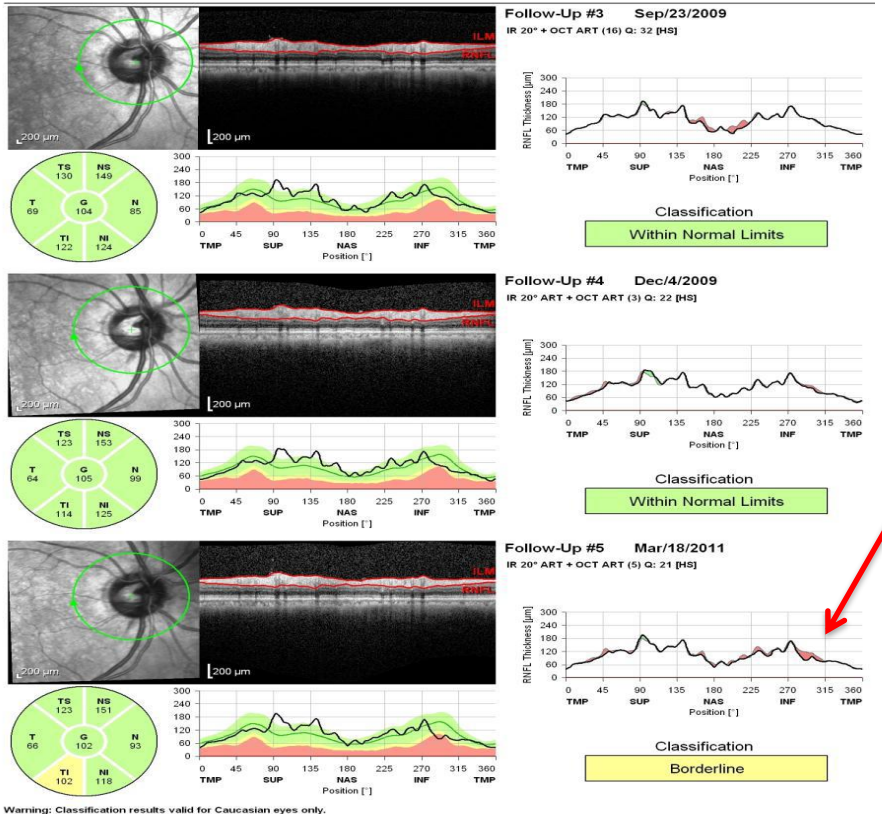

**Event**

**RNFL thickness decrease as typical bundle pattern**

**Trend**

**Fast negative trend in inferior RNFL thickness**

RNFL, retinal nerve fiber layer; OCT, Optical coherence tomography.




# Spectralis RNLF progression analysis

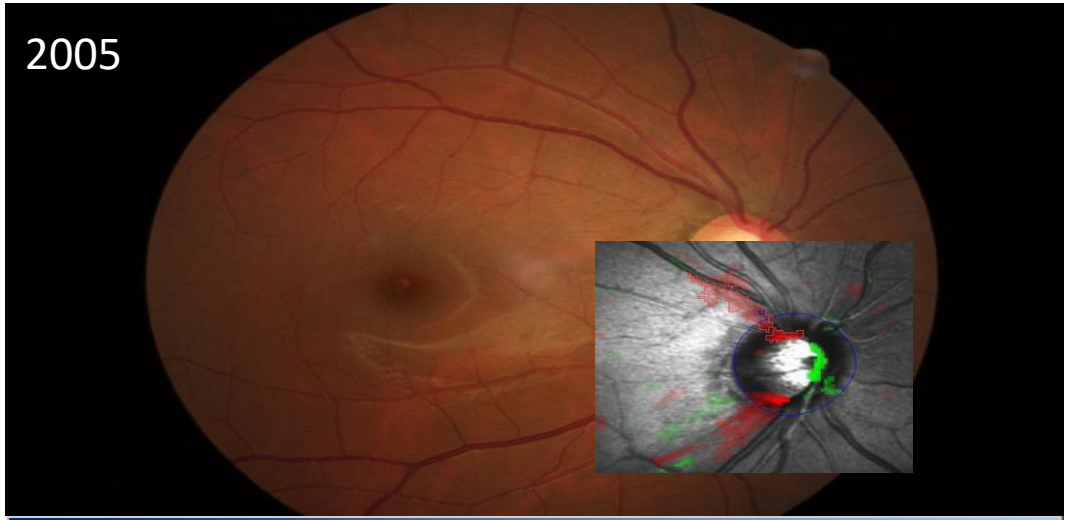
Focal defect

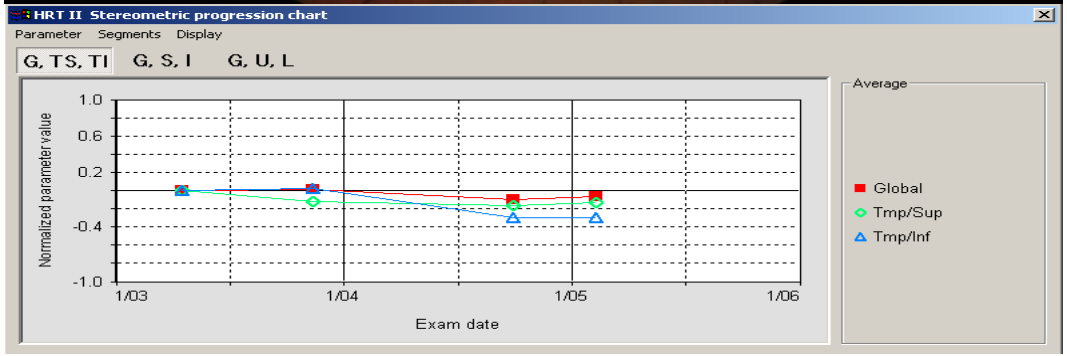
P>5% within normal

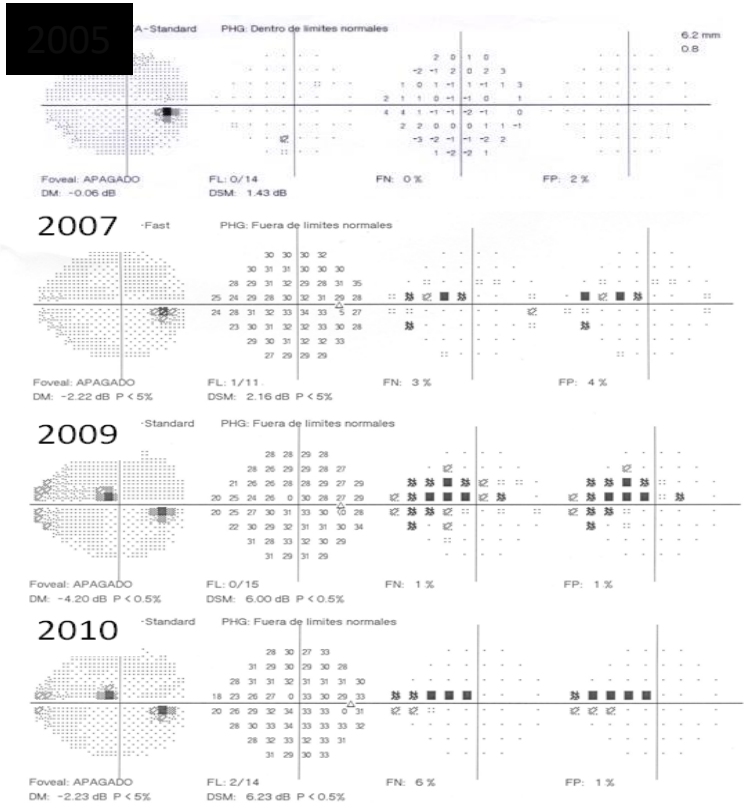
1%<P<5% Bordeline

P< 1% Outside normal

# Structural progression may precede VF changes



ARTICLE IN PRESS

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OF OPHTHALMOLOGY

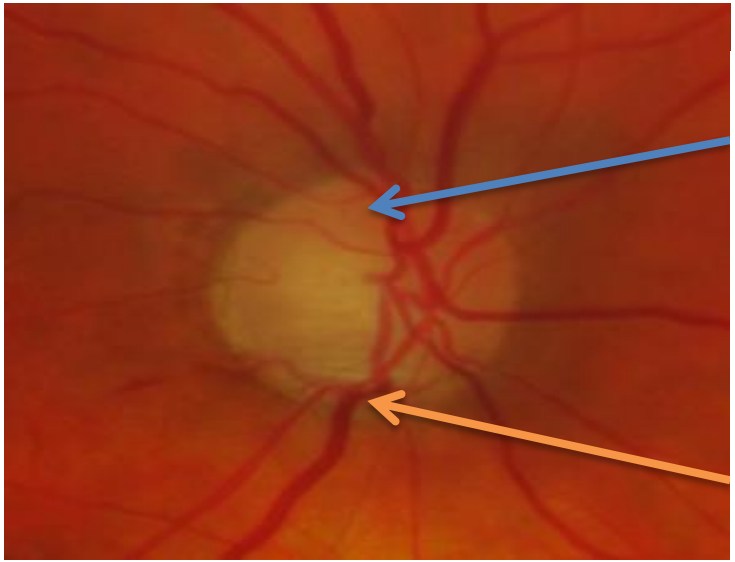
# Will Perimetry Be Performed to Monitor Glaucoma in 2025?

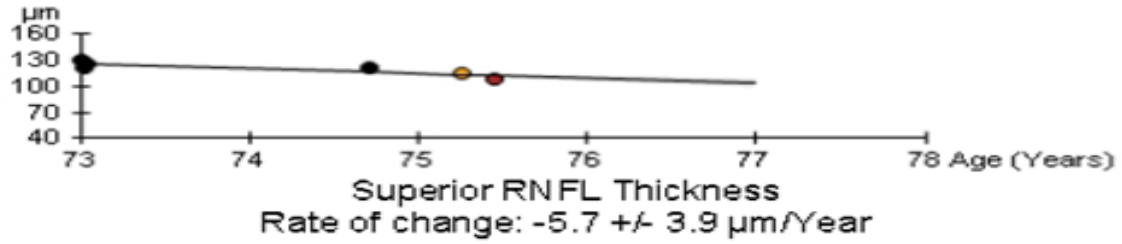
*Andrew S. Camp, MD, Robert N. Weinreb, MD*

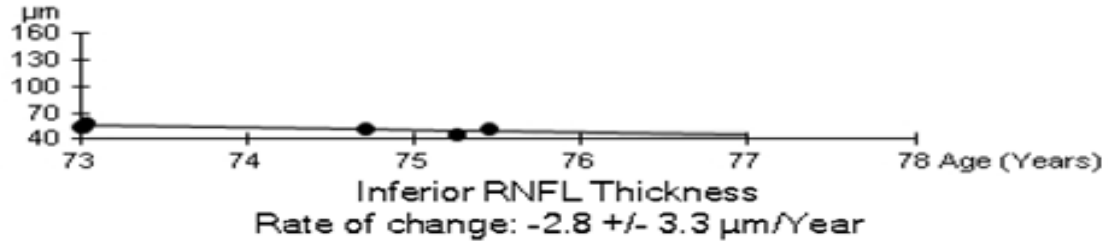
Visual field testing has played an essential role in the diagnosis and management of glaucoma for more than a century. Methods to examine the visual field have been refined from early kinetic perimetry to current standard automated perimetry (SAP). Clinicians now use SAP for the diagnosis and management of glaucoma throughout the world. Various testing paradigms and analytic methods have been developed to simplify the diagnosis of glaucoma and the interpretation of progression. Moreover, strategies have been implemented to improve patient experience with visual field testing and to increase reliability. Objective functional tests, such as electroretinography, provide an alternative to subjective visual field testing but are not yet ready for widespread adoption. Standard automated perimetry is being adapted and improved constantly. New devices may allow patients to complete visual field tests at home, which could relieve patients and clinicians from in-office testing and allow for more frequent examinations. Glaucoma detection and progression analysis also are incorporating progressively more information and will be improved as deep learning strategies are applied. Finally, perimetric and structural testing likely will become more closely intertwined as testing platforms and progression analysis incorporate both of these measures. Visual field testing will continue to have an important role in the diagnosis and management of glaucoma. *Ophthalmology 2017;■:1–5 © 2017 by the American Academy of Ophthalmology*

**Visual field testing will continue to have an important role in the diagnosis and management of glaucoma**

# OCT Ability to Measure Change Will Show a Floor Effect in Structural Zones, Indicating Advanced Damage

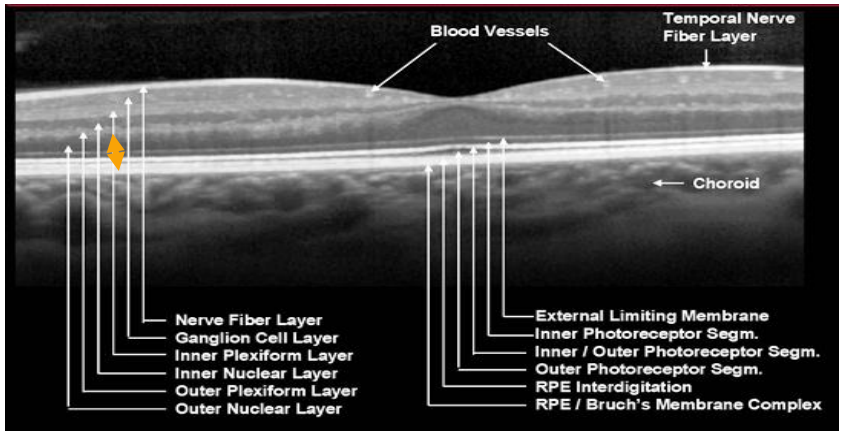




# macular thickness

- Ganglion cell complex-GCC



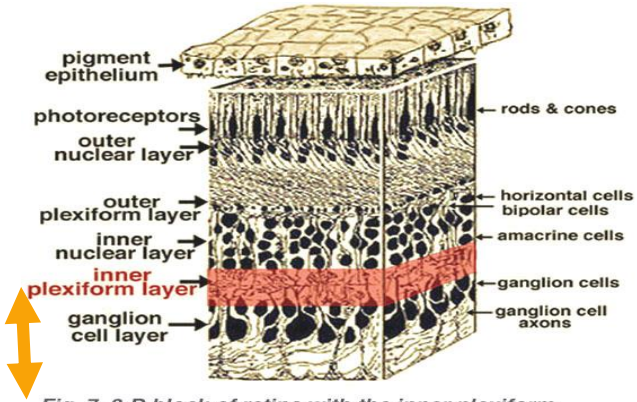
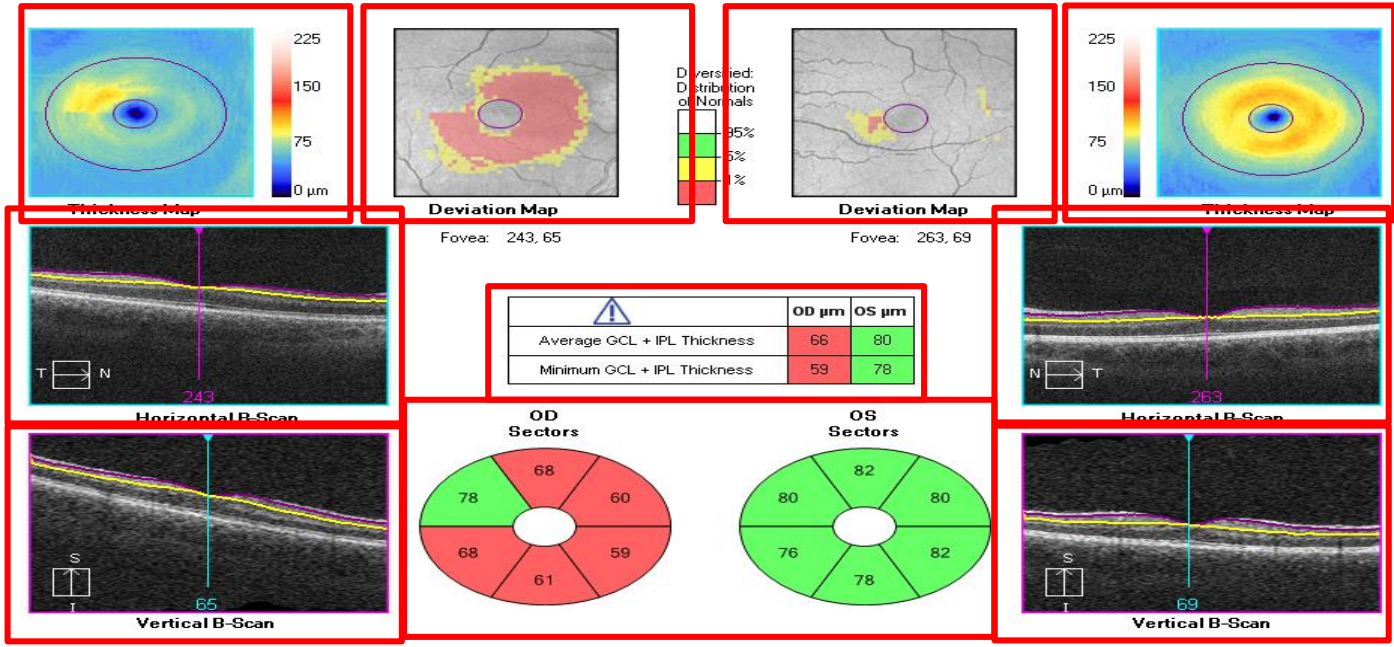




*Fig. 7. 3-D block of retina with the inner plexiform layer highlighted (red).*

# Ganglion Cell Analysis

## Key Elements

- **Deviation Maps** Show a comparison of GCL + IPL thickness to normative data.
- **Thickness Map** Show thickness measurements of the GCL + IPL in the 6mm by 6mm cube and contains an elliptical annulus centered about the fovea.
- **Thickness table** Shows average and minimum thickness within the elliptical annulus.
- **Sector maps** - divide the elliptical annulus of the Thickness Map into 6 regions: 3 equally sized sectors in the superior region and 3 equally sized sectors in the inferior region. Values are compared to normative data.
- **Horizontal and Vertical B-scans.**



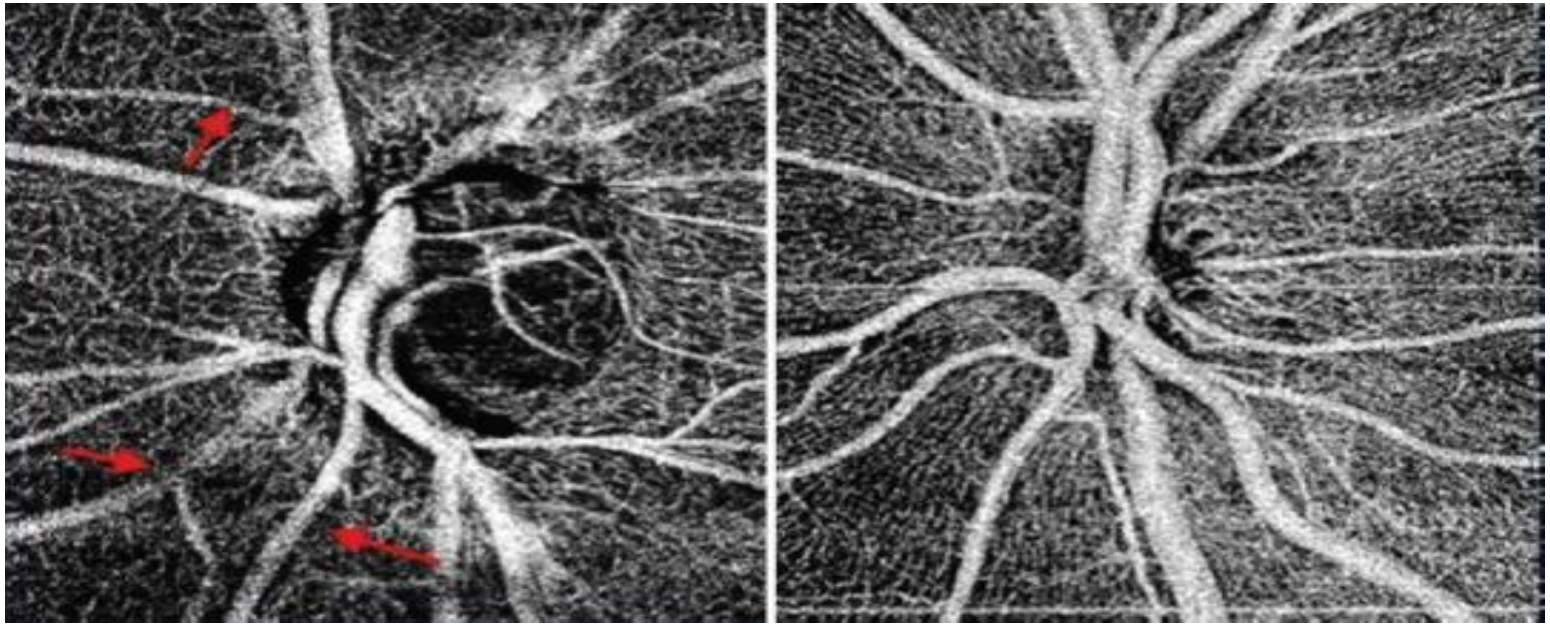
# OCT-Angiography

- Novel technology: 1st approval by FDA in 2016
- Wide use in retinal diseases
- Faster image acquisition and higher resolution than OCT
- 3-D vascular maps
- En face technique
- Images of deep retinal vascular plexus and choriocappilaries
- Uses motion contrast, not exactly blood flow

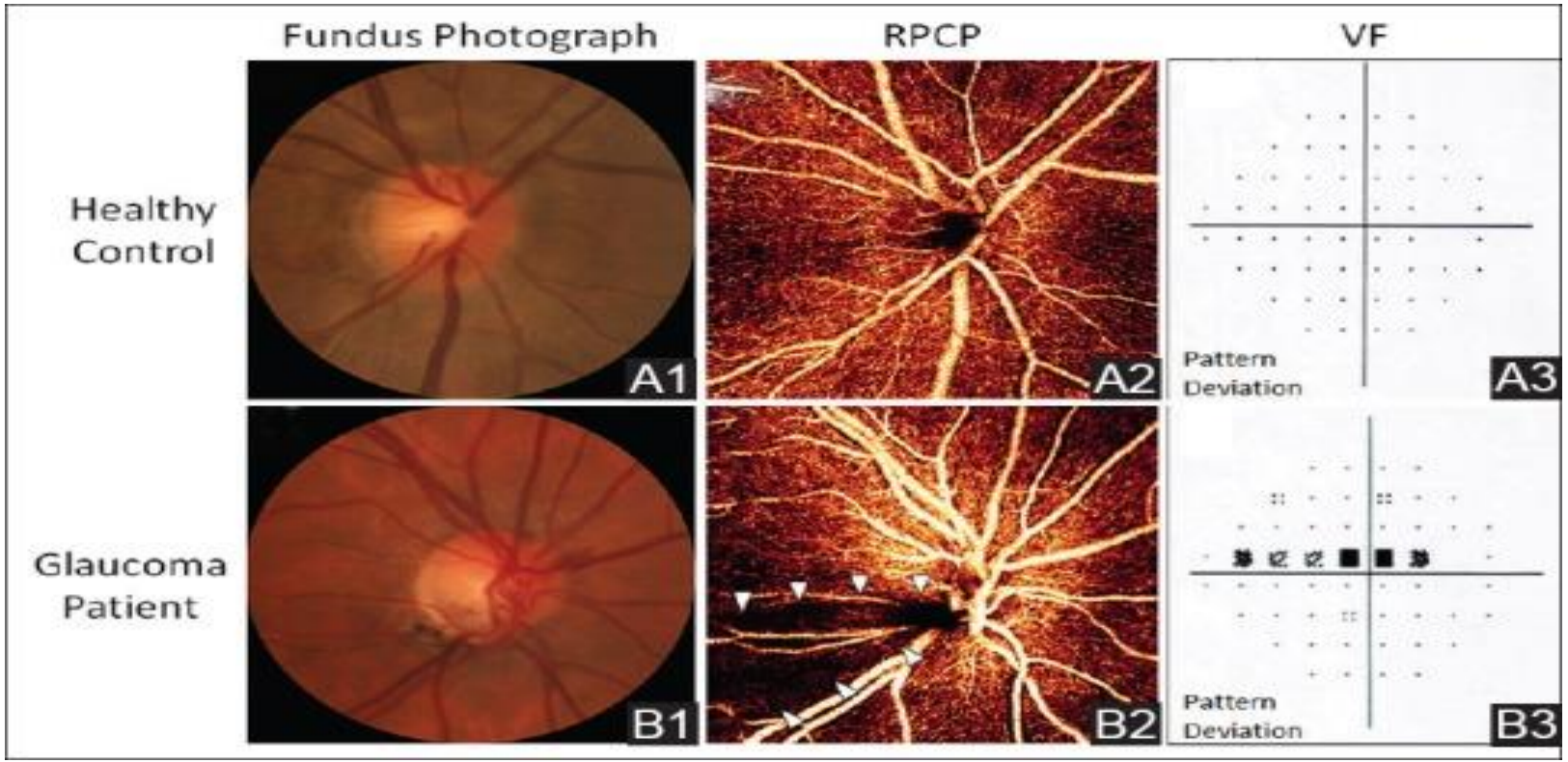
# OCTA and optic disc

## papillary microvasculature

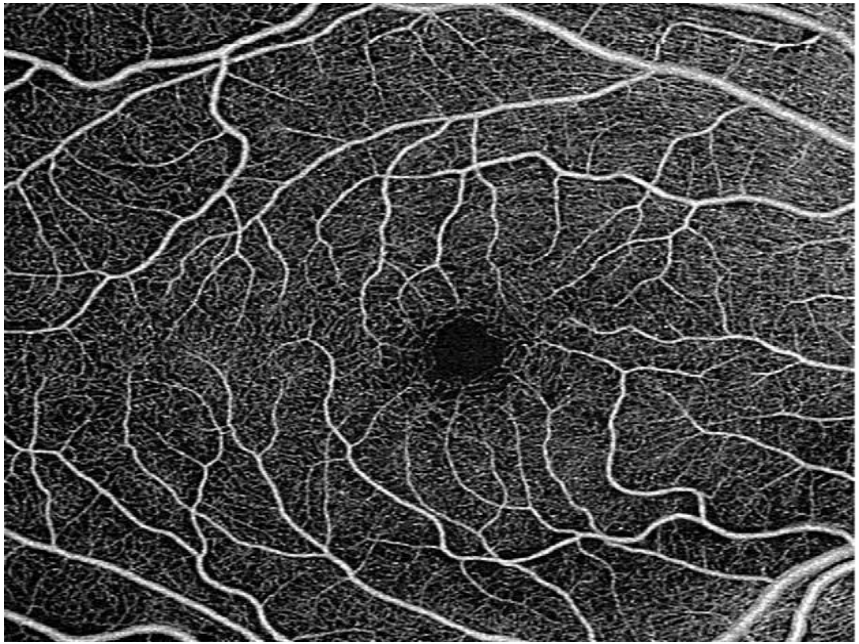
## peripapillary microvasculature

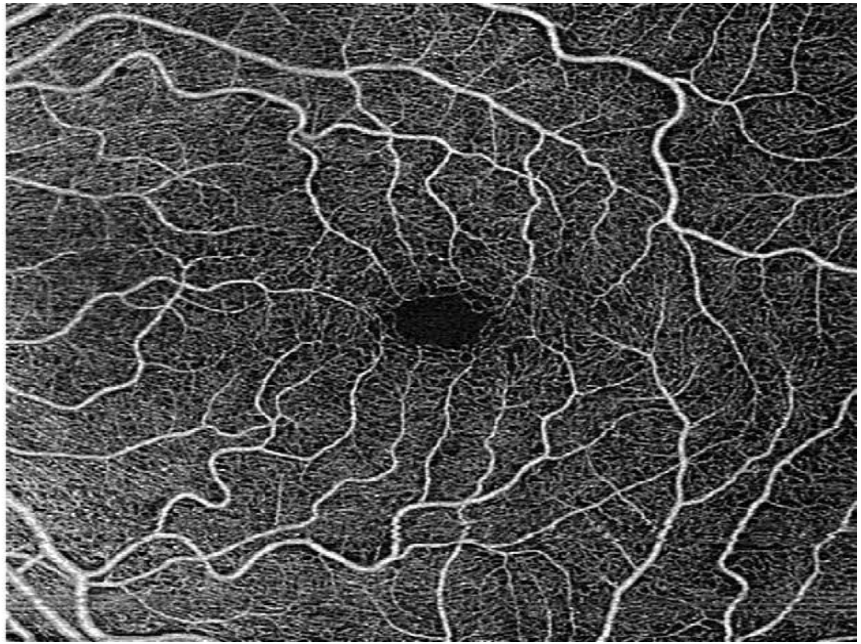


# Peripapillary area



# OCTA on macula





# Major results of OCTA on optic disc in glaucoma

- Good reproducibility and repeatability
- Reduction in **ONH** flow index (25%) in glaucoma compared to controls (100% sensitivity/100% specificity) *Jia et al Ophthalmology 2014*
- Reduction in **peripapillary cappilaries** flow index and vessel density in glaucoma eyes compared to controls) *Liu et al. JAMA 2015*
- Correlation of **peripapillary cappilaries** vascular density dropout with VF MD and PSD and corresponding location of visual field defects
- Correlation of **peripapillary cappilaries** vascular density dropout with RNFL defects by OCT in both location and extent *Lee et al. IOVS 2016*
- Association of **peripapillary deep retina** dropout in glaucoma with focal lamina cribrosa defects, thinner choroidal thickness, low diastolic pressure
- Evidence of glaucoma damage detection in OCTA prior to the perimetric changes or even prior to structural changes in RNFL (differences among normals, ocular hypertensive, glaucoma suspects, preperimetric and perimetric glaucoma eyes)

Patient: Aggou, Antwnia
Physician:
Operator:
Disease: Glaucoma

**UNIVERSITY EYE CLINIC PA**

Gender: Female ID:

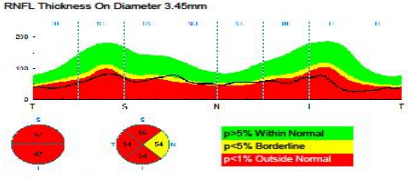
Exam Date: 18/10/2017
DOB(age): 08/09/1943 (74)
Ethnicity: Caucasian
Algorithm Ver: A2016, 2, 0, 35

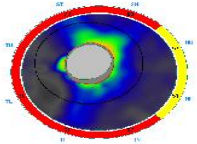
## ONH

Right / OD

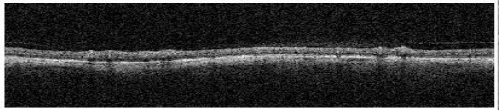
Signal Strength Index : 55

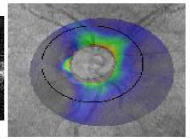
RNFL Thickness On Diameter 3.45mm



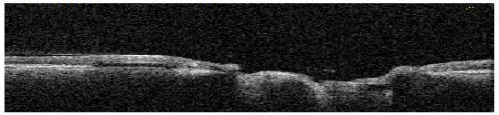
RNFL On Diameter 3.40mm





Baseline

Radial Line Diameter 3.40mm 3D Guided



| RNFL Analysis | µm |
|---|---|
| Avg RNFL Thickness | 52 |
| Avg Superior RNFL | 57 |
| Avg Inferior RNFL | 47 |
| Superior - Inferior | 10 |

| ONH Analysis | |
|---|---|
| Cup/Disc Area Ratio | 0.76 |
| Cup/Disc V. Ratio | 0.86 |
| Cup/Disc H. Ratio | 0.95 |
| Rim Area (mm²) | 0.51 |
| Disc Area (mm²) | 2.13 |
| Cup Volume (mm³) | 0.236 |

Report Date: Tuesday 27/02/2018 13:23:44
Software Version: 2016.2.0.35
Comment:
Signature:

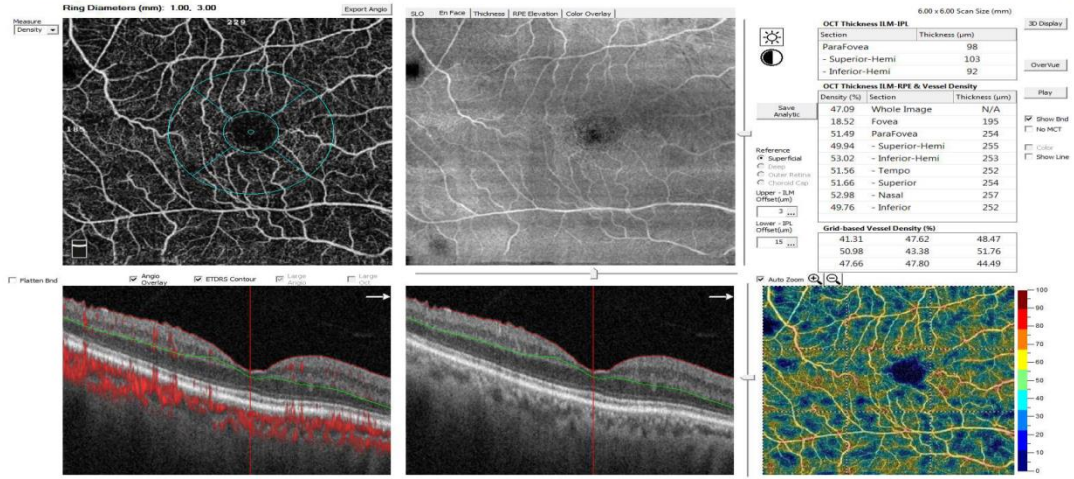
Defining the OCT Revolution

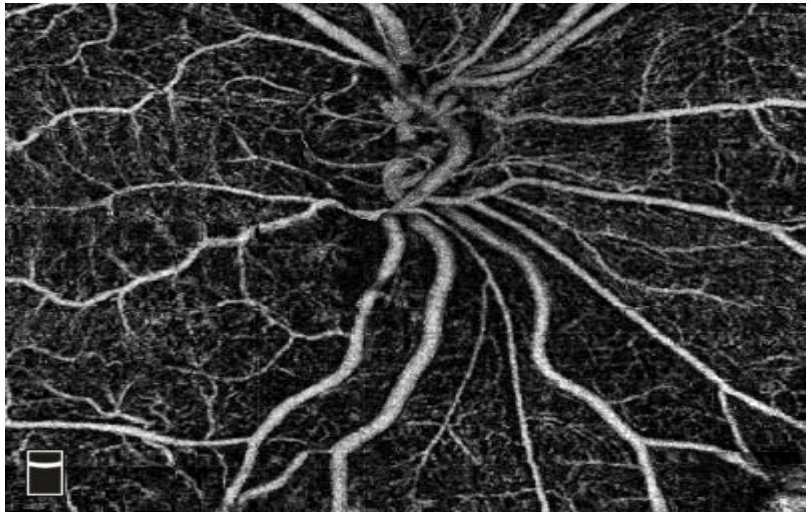
optovue

## HD Angio Retina

Signal Strength Index 60

Right / OD

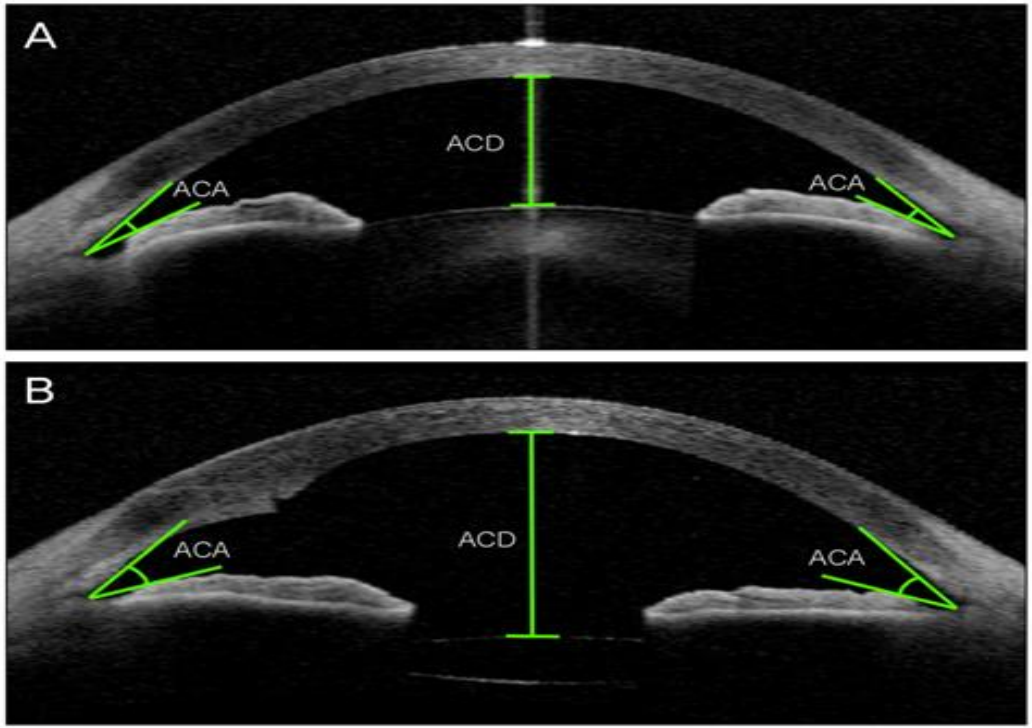


# Anterior chamber OCT

**Pre-op**

**Post-op**



# Aqueous angiography

# Aqueous angiography-Aqueous Humor Outflow

Spectralis HRA+OCT  FLEX module

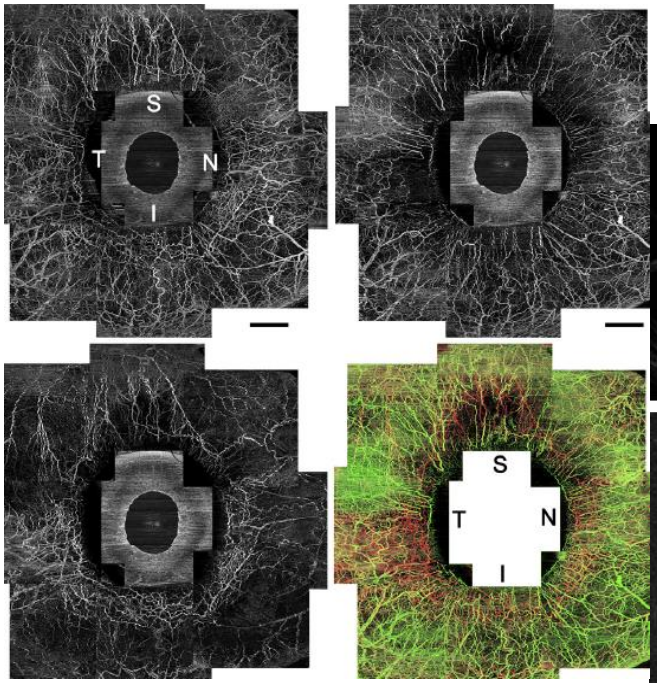
- FA intravenous
- ICG  0.4% intracameral
- Episcleral venous plexuses
- Segmental patterns

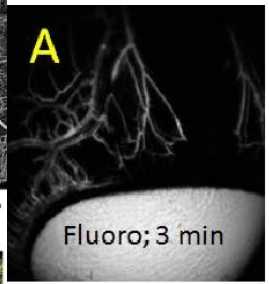
*Huang AS et al. Ophthalmology 2017*

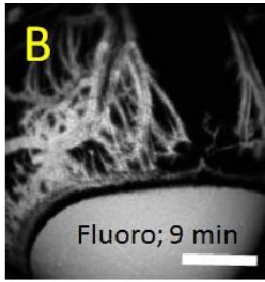
Swept source OCT, PLEX, Zeiss

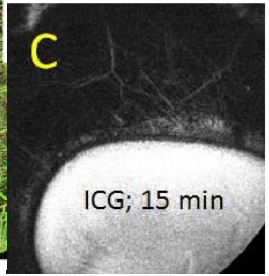
- AS OCTA
- Intrascleral and conjuctival vessels
- Deep layer OCTA flow images similar characteristics to aqueous angiography images

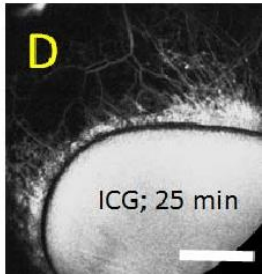
*Akagi T et al. Am J Ophthalmol 2018*



# Thank you

*“glaucoma: the pupils became discolored because of changes in the fluids in the eye”*