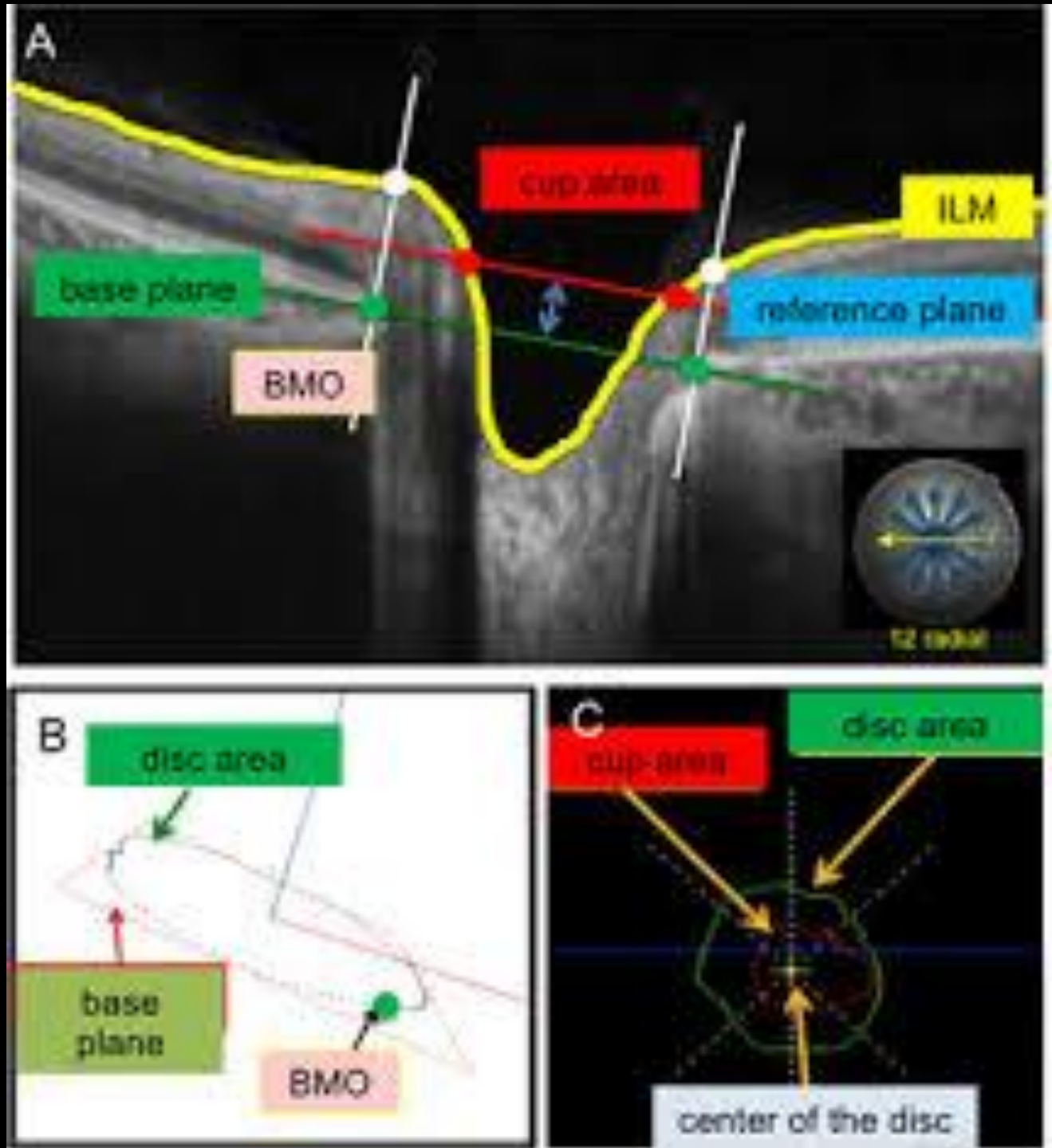
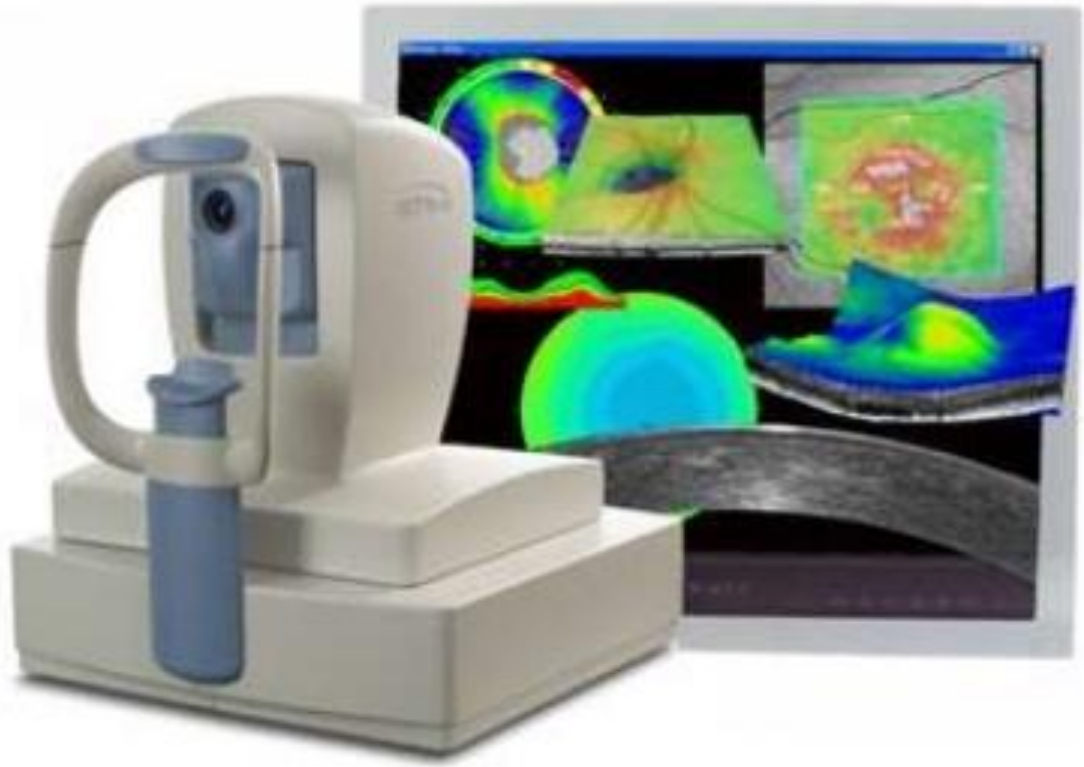
Imagining techniques in glaucoma


A
cup area
ILM
base plane
reference plane
BMO
B
disc area
base plane
BMO
C
cup area
disc area
center of the disc

OPTICAL COHERENCE TOMOGRAPHY



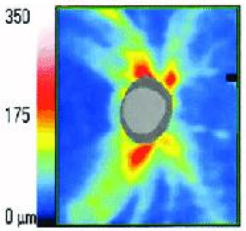
ID:	590127-02-5153	Exam Date:	4/23/2012	4/23/2012
DOB:	1/27/1959	Exam Time:	5:13 PM	5:17 PM
Gender:	Male	Technician:	Operator, Cirrus	
Doctor:		Signal Strength:	8/10	8/10

P1

RNFL and ONH:Optic Disc Cube 200x200

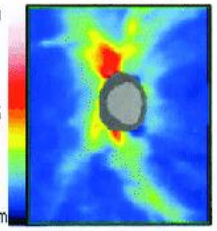
OD ● | ● OS

RNFL Thickness Map

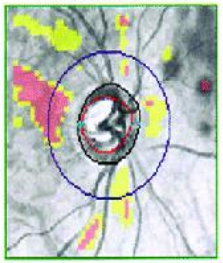


	OD	OS
Average RNFL Thickness	75 µm	70 µm
RNFL Symmetry	50%	
Rim Area	1.06 mm²	1.08 mm²
Disc Area	2.53 mm²	2.13 mm²
Average C/D Ratio	0.75	0.69
Vertical C/D Ratio	0.69	0.69
Cup Volume	0.460 mm³	0.371 mm³

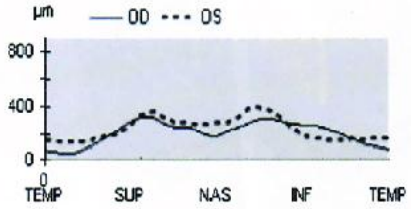
RNFL Thickness Map



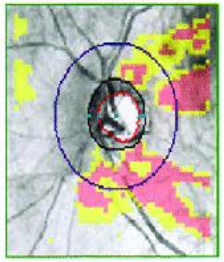
RNFL Deviation Map



Neuro-retinal Rim Thickness

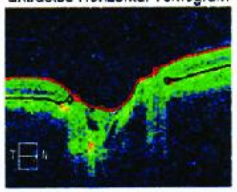


RNFL Deviation Map

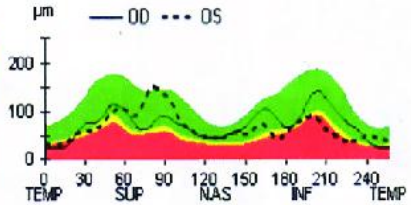


Disc Center (-0.09,0.18) mm

Extracted Horizontal Tomogram

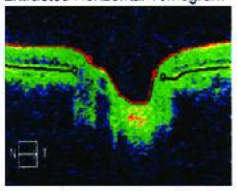


RNFL Thickness

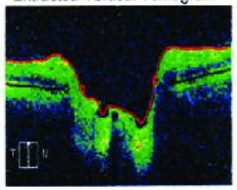


Disc Center (0.09,0.36) mm

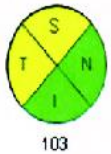
Extracted Horizontal Tomogram



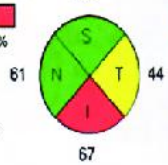
Extracted Vertical Tomogram



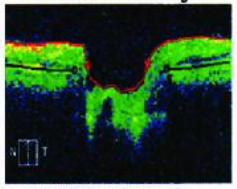
Distribution of Normals



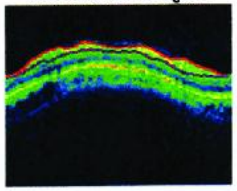
RNFL Quadrants

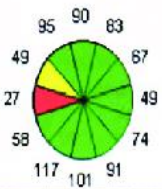


Extracted Vertical Tomogram

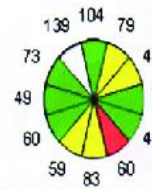


RNFL Circular Tomogram

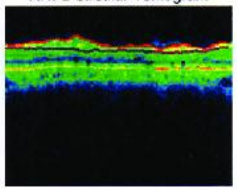




RNFL Clock Hours



RNFL Circular Tomogram



LIMITATIONS:

- Results less reliable when signal strength is poor.
- RNFL thickness values are affected by age, axial length, disc size.
- Eye blinking or saccade – alignment is poor – unreliable RNFL measurement.
- Age related loss confound with identification of glaucoma.

Imaging Techniques for optic Disc and RNFL evaluation in glaucoma

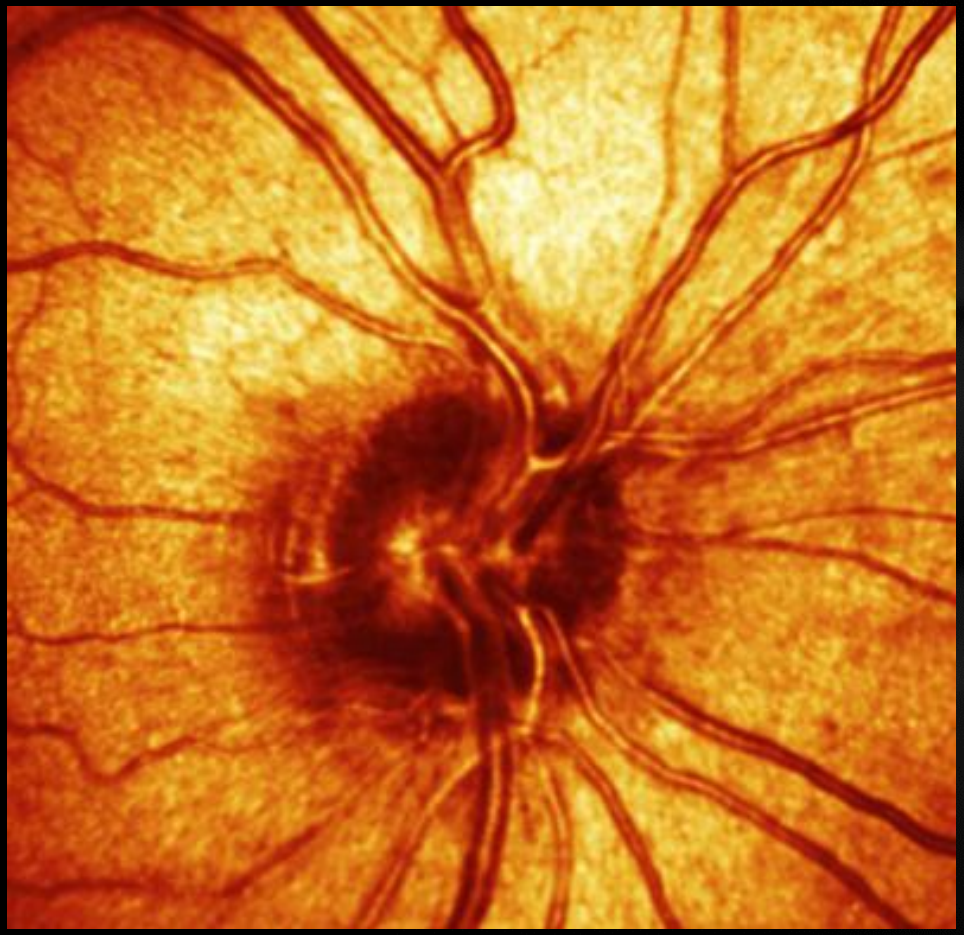
- Confocal scanning laser ophthalmoscopy (HRT ; Heidelberg Retinal Tomography ;Heidelberg Engineering, Heidelberg, Germany)

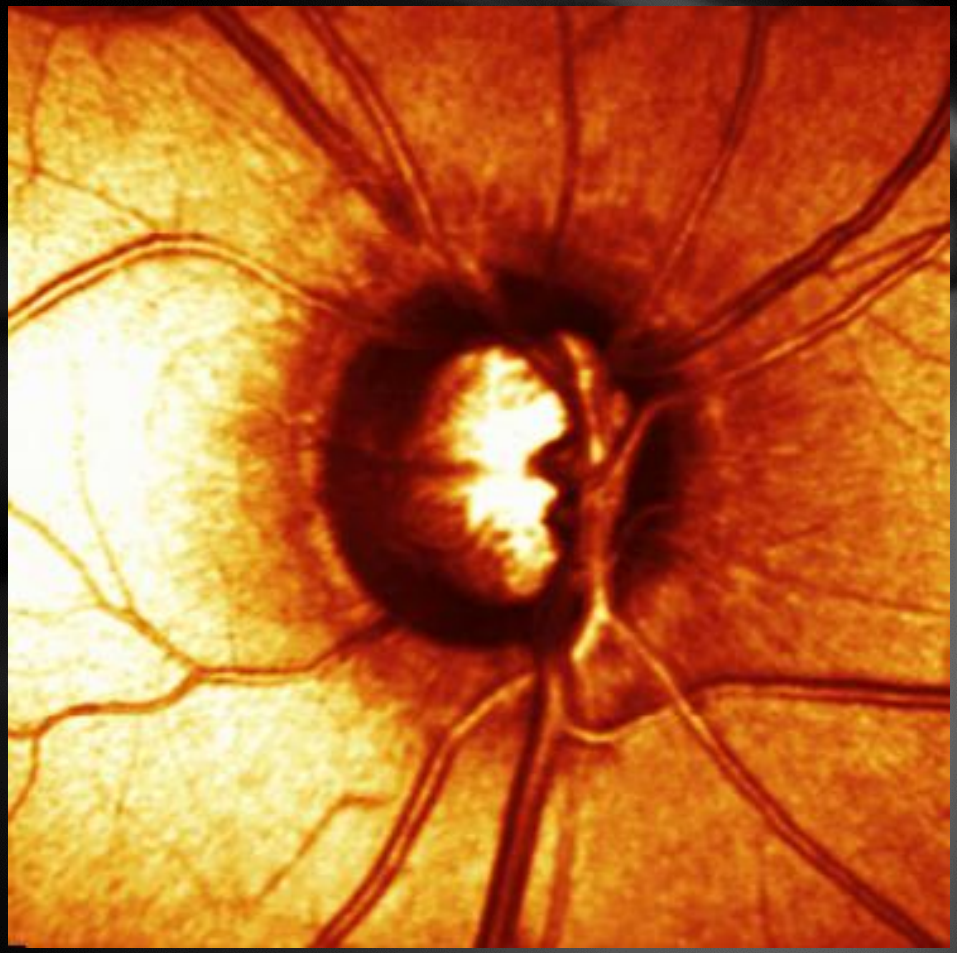
- Scanning Laser polarimetry (GDx ; Carl Zeiss Meditec , Dublin , California , USA)

- Optical Coherence Tomography (OCT ; Carl Zeiss Meditec)

CONFOCAL SCANNING LASER OPHTHALMOSCOPE - HRT

- HRT enables quantitative evaluation of all relevant anatomical structures – cup, rim and RNFL (retinal nerve fiber layer). With highest spatial resolution of any imaging device for glaucoma diagnosis, HRT provides comprehensive data for glaucoma detection and follow-up assessment



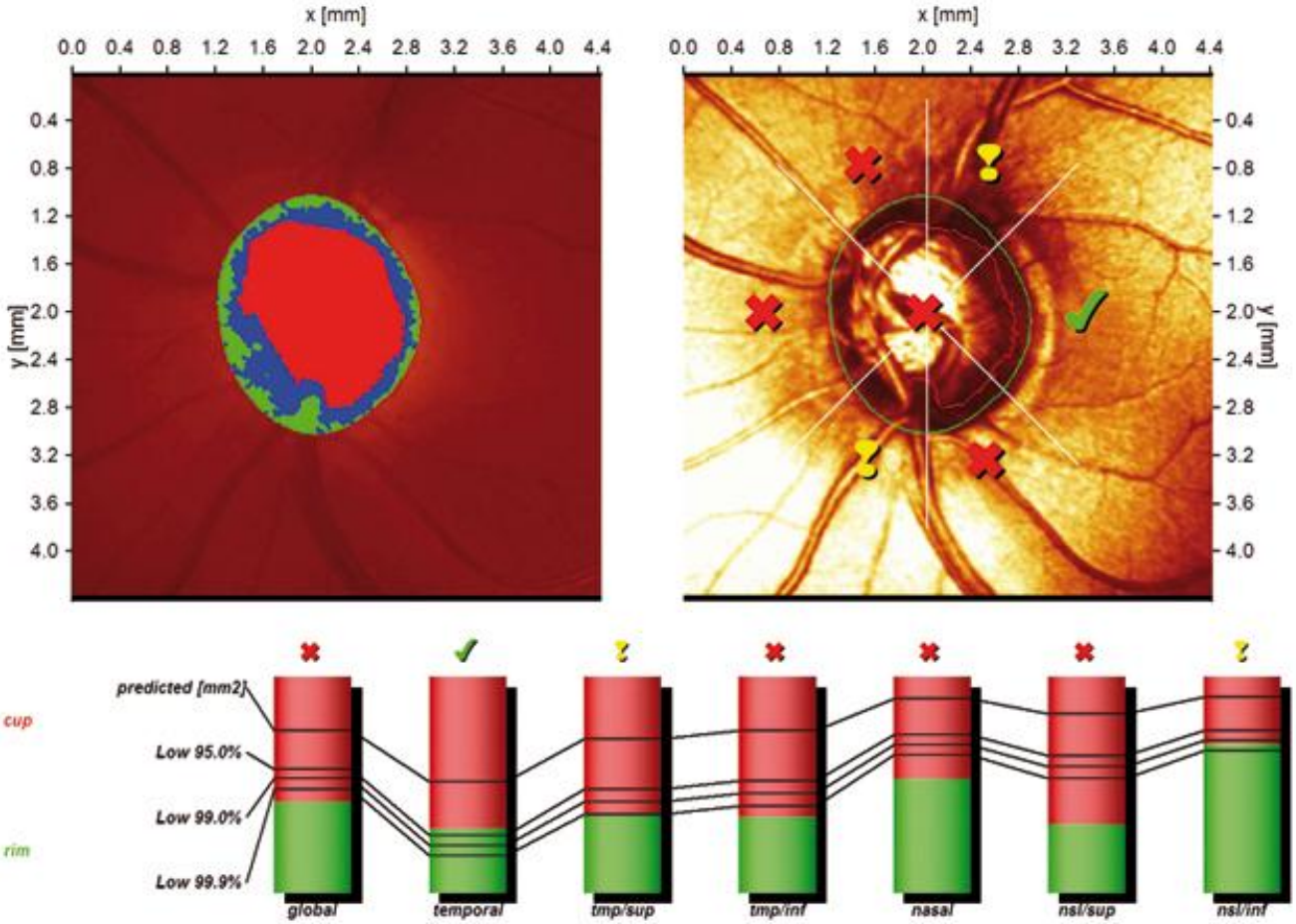


Heidelberg Retina Tomograph
Regression Analysis

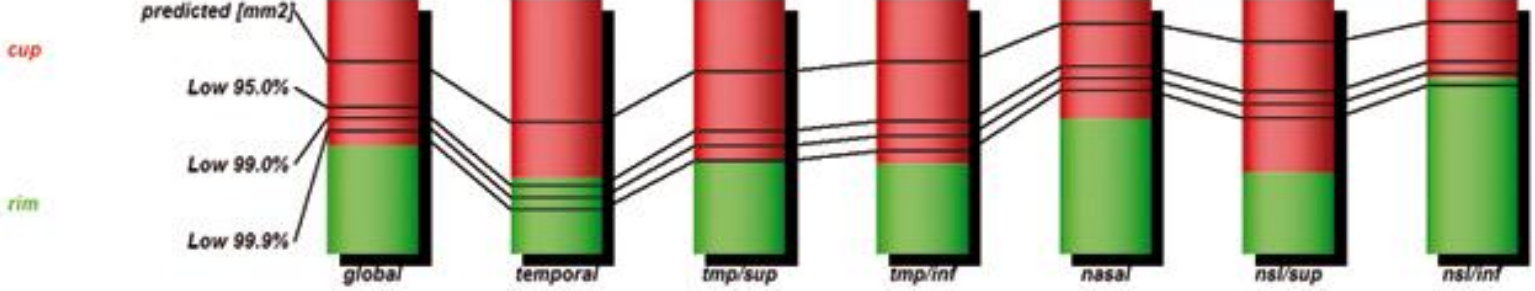
HEIDELBERG ENGINEERING

Patient:	**Glaucoma, Outside**
	Sex: male DOB: 14.Dez.1951 Pat-ID: Caucasian Ethnicity: (Caucasian)
Examination:	**Date:**
Scan:	Focus: -1.00 dpt Depth: 3.50 mm Operator: dcp IOP: ---

OS



Moorfields Regression Classification: *Outside normal limits (*)*



Moorfields Regression Classification: *Outside normal limits (*)*

(*) Moorfields regression classification (Ophthalmology 1998;105:1557-1563). Classification based on statistics. Diagnosis is physician's responsibility.

Rim Area	global	temporal	tmp/sup	tmp/inf	nasal	nsl/sup	nsl/inf
actual [mm2]	1.08	0.17	0.12	0.13	0.31	0.11	0.24
predicted [mm2]	1.92	0.30	0.23	0.27	0.52	0.30	0.31
low 95.0% CI lim. [mm2]	1.47	0.16	0.16	0.18	0.42	0.23	0.26
low 99.0% CI lim. [mm2]	1.35	0.13	0.14	0.16	0.40	0.21	0.24
low 99.9% CI lim. [mm2]	1.22	0.10	0.12	0.14	0.37	0.19	0.23
actual/disc area [%]	42.4	29.9	36.8	35.6	52.9	32.0	69.3
predicted [%]	75.2	51.3	71.0	75.2	89.9	82.9	90.6
low 95.0% CI lim. [%]	57.5	26.8	47.7	51.9	73.2	63.4	74.9
low 99.0% CI lim. [%]	52.8	21.9	42.1	46.1	68.6	58.2	70.6
low 99.9% CI lim. [%]	47.8	17.2	36.3	40.2	63.6	52.7	65.8

Date: 18.Aug.2009 Signature:

Complete ONH Assessment

HRT checks all vital structure of optic nerve head:

CUP

- C/D Ratio
- Shape
- Asymmetry

RIM

- Area & Volume
- Asymmetry

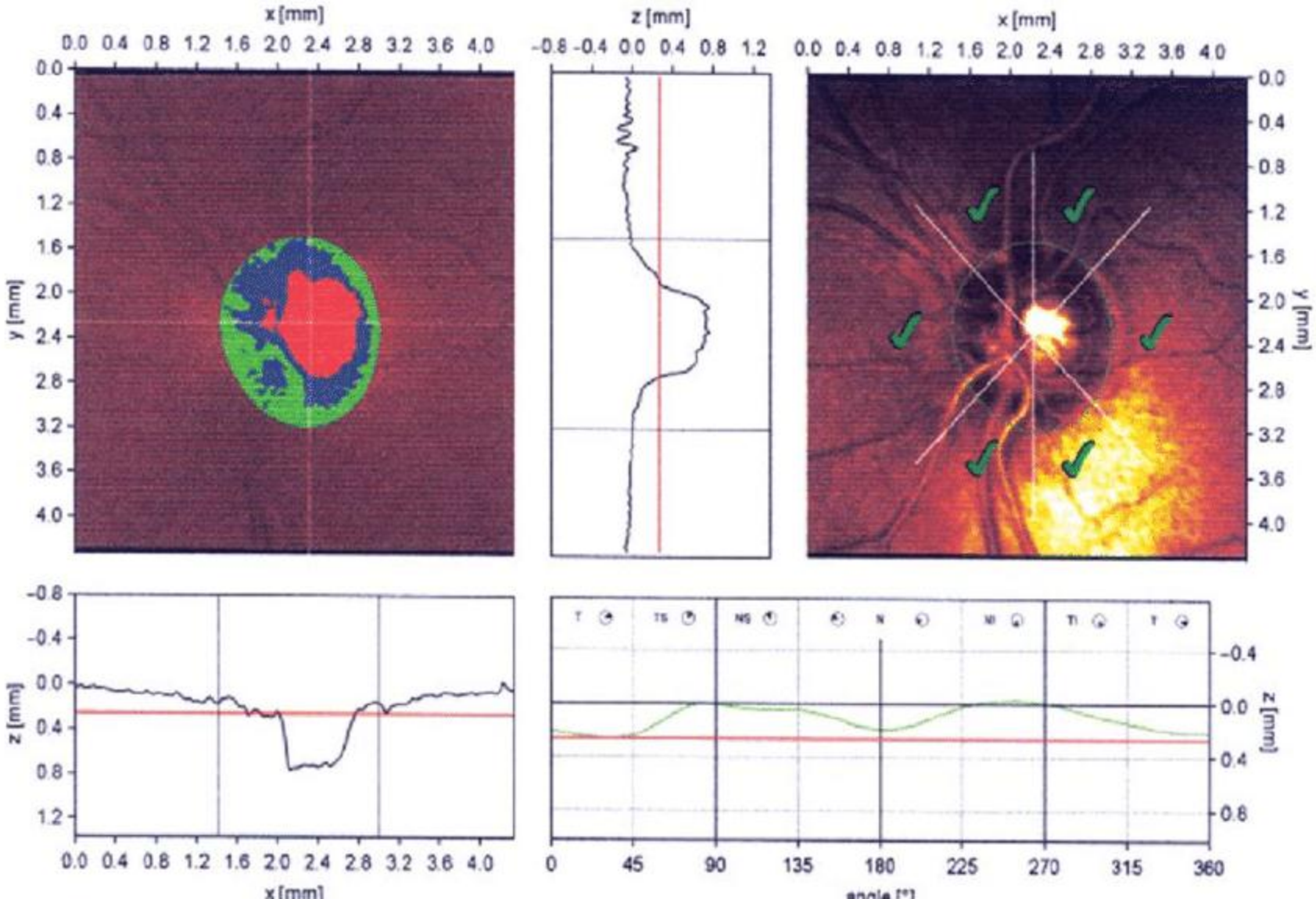
RNFL

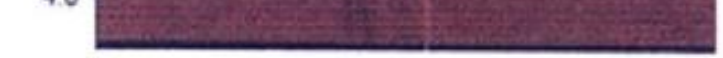
- Height Variation Contour
- Thickness
- Asymmetry

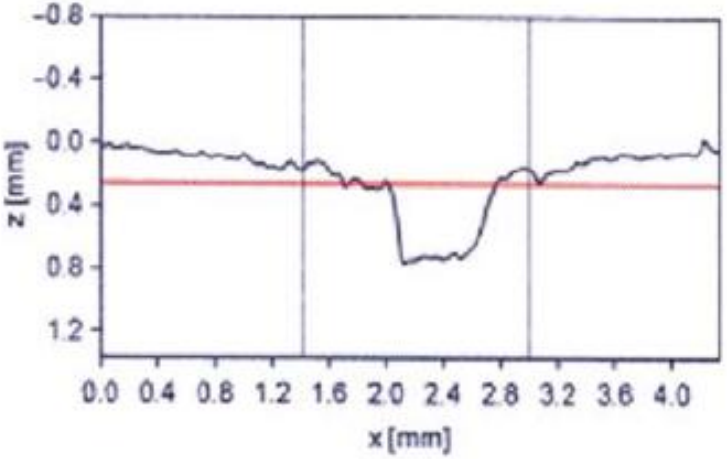
Patient:

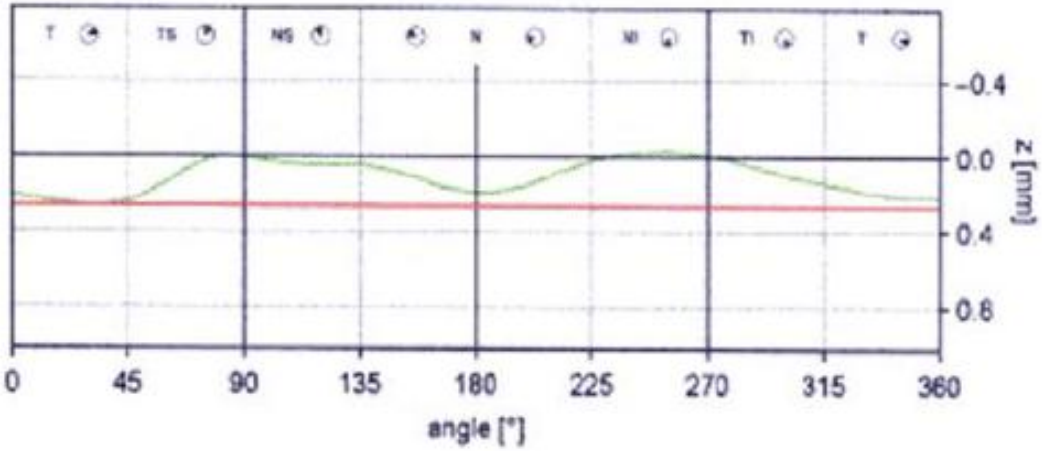
Examination: **Date: 21/Aug/2003**

Scan: Focus: 1.00 dpt Depth: 2.75 mm Operator: Rajesh IOP: ---

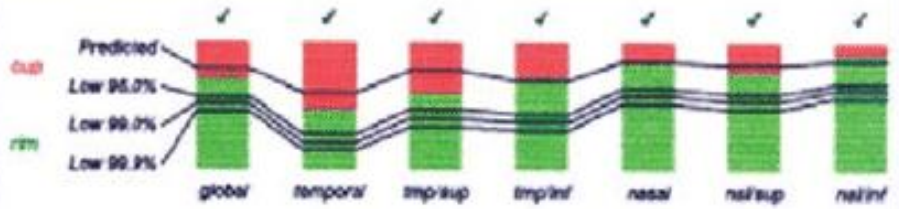








Stereometric analysis ONH		Normal range
Disk area	2.133 mm²	1.69 - 2.82
Cup area	0.598 mm²	0.26 -1.27
Rim area	1.535 mm²	1.20 -1.78
Cup volume	0.156 cmm	-0.01 - 0.49
Rim volume	0.234 cmm	0.24 - 0.49
Cup/disk area ratio	0.280	0.16 - 0.47
Linear cup/disk ratio	0.529	0.36 - 0.80
Mean cup depth	0.211 mm	0.14 - 0.38
Maximum cup depth	0.634 mm	0.46 - 0.90
Cup shape measure	–0.226	-0.27 - -0.09
Height variation contour	0.295 mm	0.30 - 0.47
Mean RNFL thickness	0.155 mm	0.18 - 0.31
RNFL cross-sectional area	0.801 mm²	0.95 - 1.61
Reference height	0.263 mm	
Topography std dev.	12 µm	



Moorfields Classification: Within normal limits (*)

(*) Moorfields regression classification (Ophthalmology 1998;105:1557-1563) Classification based on statistics. Diagnosis is physician's responsibility.

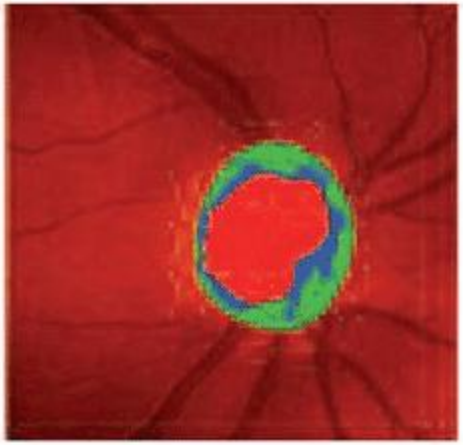
Comments:

Date: 04/Aug/2004 Signature:

Heidelberg Retina Tomograph
OU Report

Patient:
Pat-ID:
DOB: 1930
Gender: female
Examination: Mar/22/2001
Ethnicity:

OD		OS
Quality: Very good (SD 14 µm)		**Quality:** Very good (SD 13 µm)
Focus: 2.00 dpt		**Focus:** 2.00 dpt
Operator: —		**Operator:** —
Disc Size: 2.09 mm² (average)		**Disc Size:** 2.42 mm² (average)



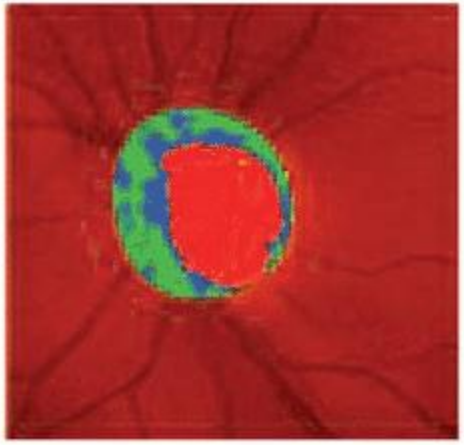
CUP

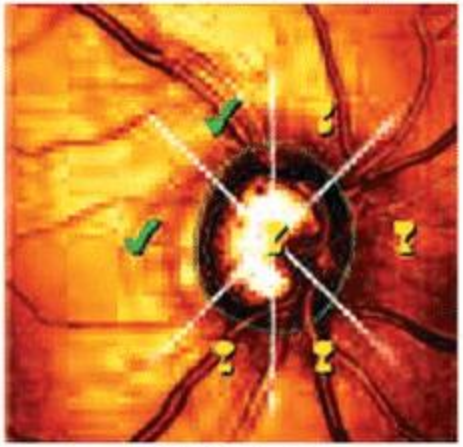
Linear Cup/Disc Ratio [ ]

0.71 ✓	Asymmetry ✓ 0.01	0.70 ✓
p = 0.05	p = 0.41	p = 0.09

Cup Shape Measure [ ]

0.06 ✗	Asymmetry ✗ 0.12	-0.06 ✓
p < 0.001	p < 0.001	p = 0.12





MRA: Borderline

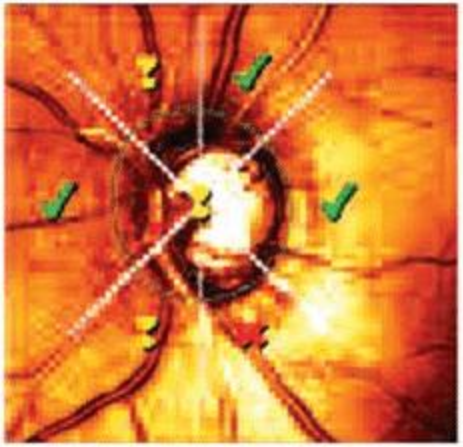
RIM

Rim Area [mm²]

1.05 ✗	Asymmetry ✓ -0.18	1.23 ?
p < 0.001	p = 0.27	p = 0.003

Rim Volume [mm³]

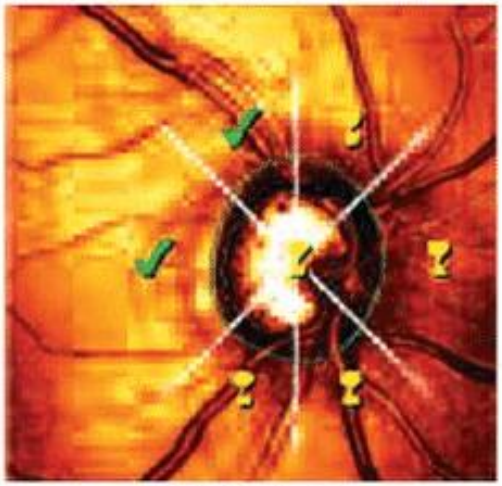
0.22 ✓	Asymmetry ✓ -0.05	0.27 ✓
p = 0.06	p = 0.4	p = 0.1



MRA: Outside normal limits

RNFL

Height Variation Contour [mm]



MRA: Borderline

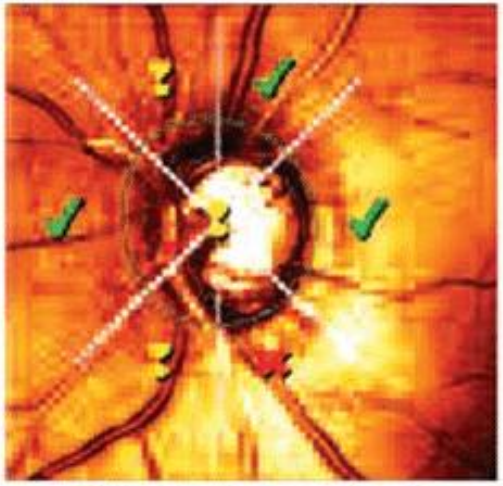
RIM

Rim Area [mm²]

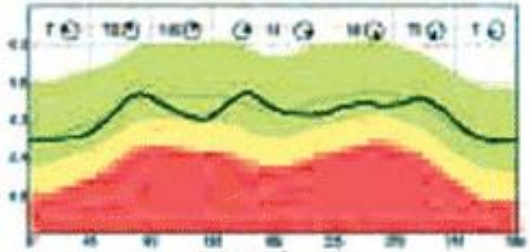
1.05	Asymmetry -0.18	1.23
p < 0.001	p = 0.27	p = 0.003

Rim Volume [mm³]

0.22	Asymmetry -0.05	0.27
p = 0.06	p = 0.4	p = 0.1



MRA: Outside normal limits



RNFL Profile

RNFL

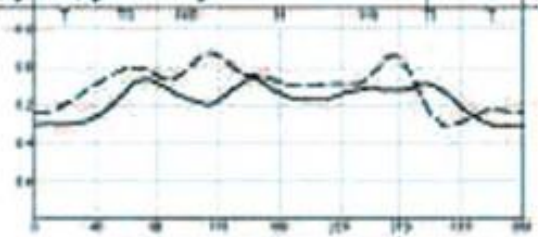
Height Variation Contour [mm]

0.26	Asymmetry -0.13	0.39
p = 0.16	p = 0.05	p > 0.5

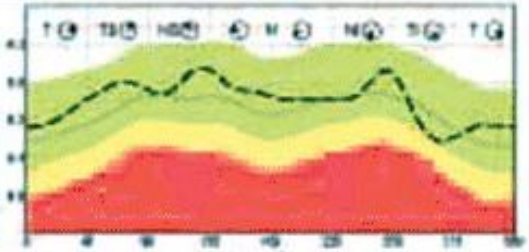
Mean RNFL Thickness [mm]

0.19	Asymmetry 0.00	0.19
p = 0.24	p = 0.4	p = 0.24

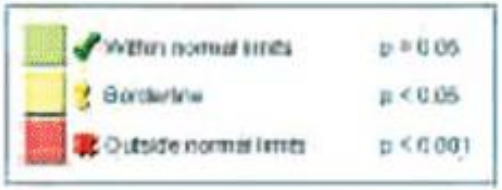
Inter-Eye Asymmetry	46 %

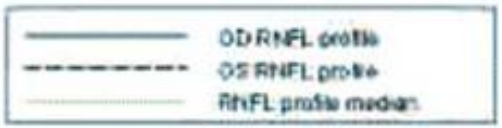


Combined RNFL Profile



RNFL Profile





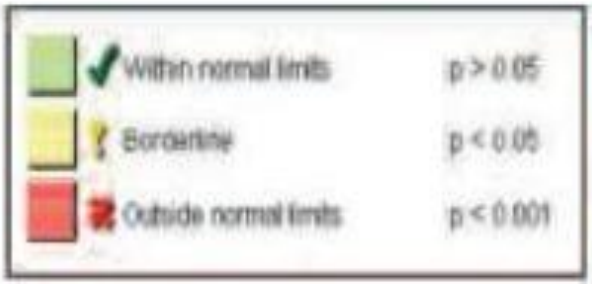
Comments:

Signature:

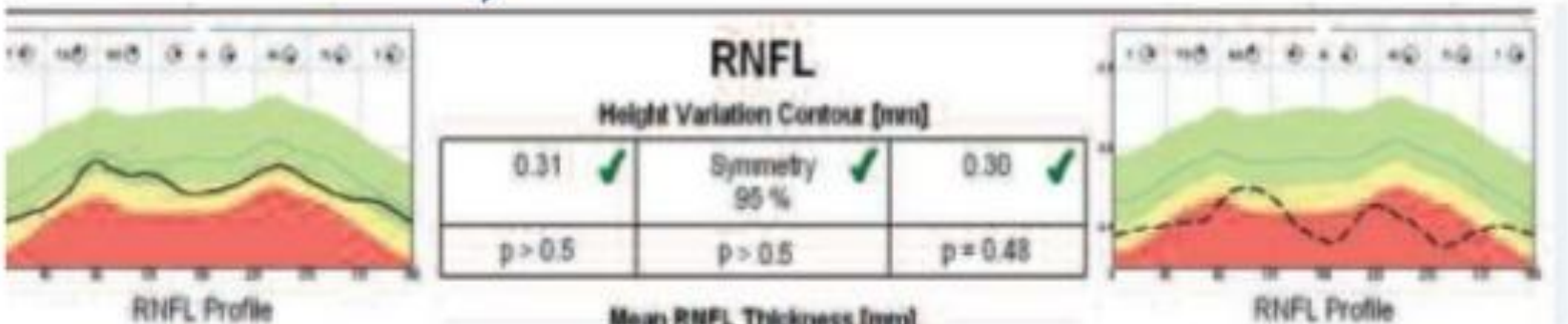
Date: 11/8/2005

Software Version: 3.0.2.370
www.HeidelbergEngineering.com

- Classification symbol also based on the p value
- If the parameter **within the 95% normal range (p>.05), Green√** -- within normal range
- Between **5th &0.1 percentile** of normal distribution **(p<.05 &>0 .001), yellow !** point -- borderline
- p value **< 0.1** percentile of normal distribution**, red *X* --** *outside normal limits*-- means that **< 0.1% (1 out of 1,000)** of all normal from the database have values this low, indicate high probability of abnormality



- Contour height graph presented with 95% normative range superimposed in **green**
- Lightly colored solid line gives average value for specific age , optic disc size & ethnicity
- **Yellow area** represents values between 5th and 0.1 percentile of normal distribution ($p < .05$ and greater than .001) indicating a borderline classification
- **Red area** represents < 0.1 percentile of normal distribution → outside normal limits.



STRENGTH:

- Low level illumination
- Undilated pupil
- Sophisticated analysis software for glaucoma detection and progress.

LIMITATIONS:

- Relies on user defined contour line for reference plane.
- Data outside normal range are not reliable.
- Stereometric measurements influenced by changes in IOP.

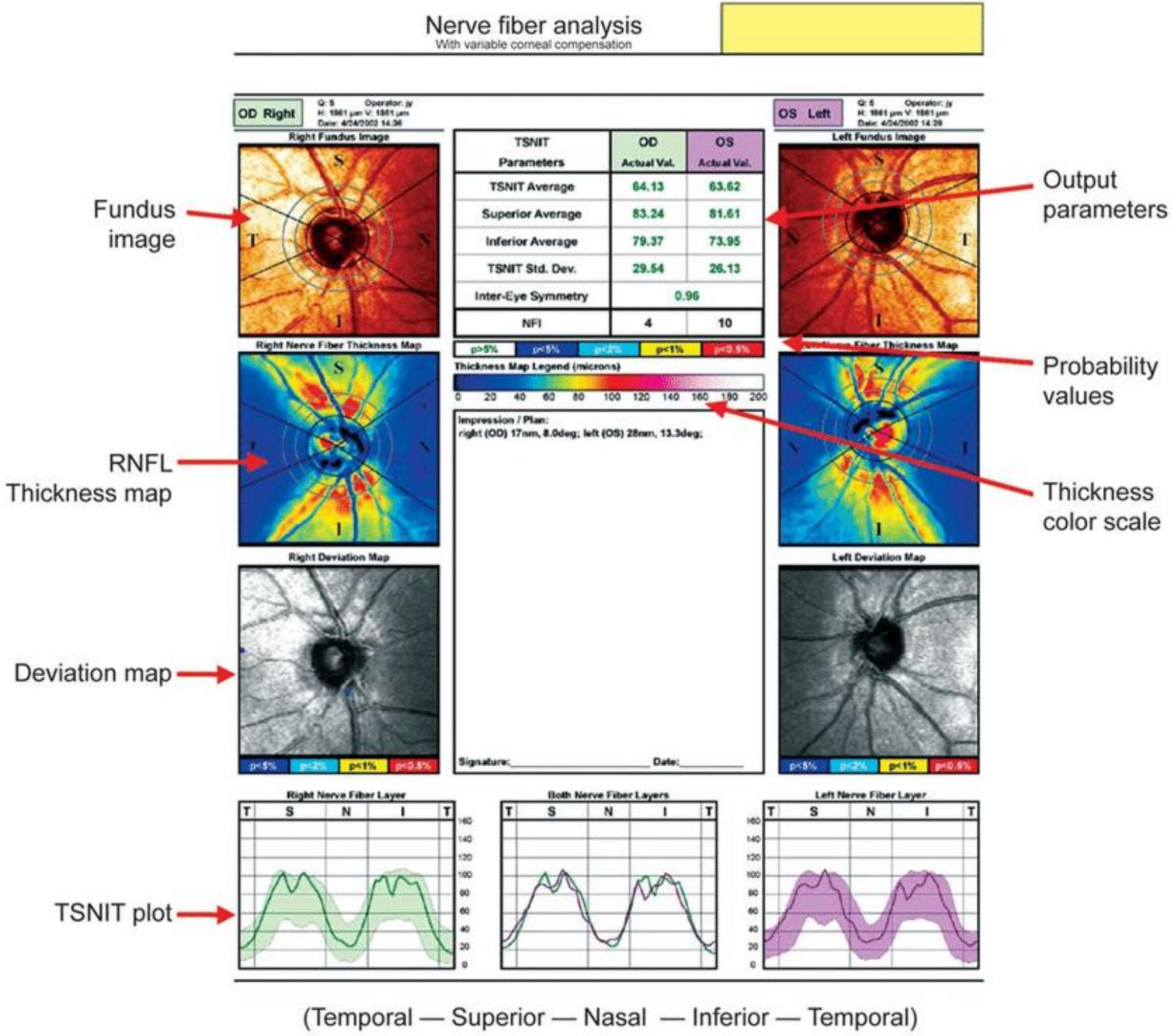
SCANNING LASER POLARIMETRY -Gdx

Scanning Laser Polarimetry

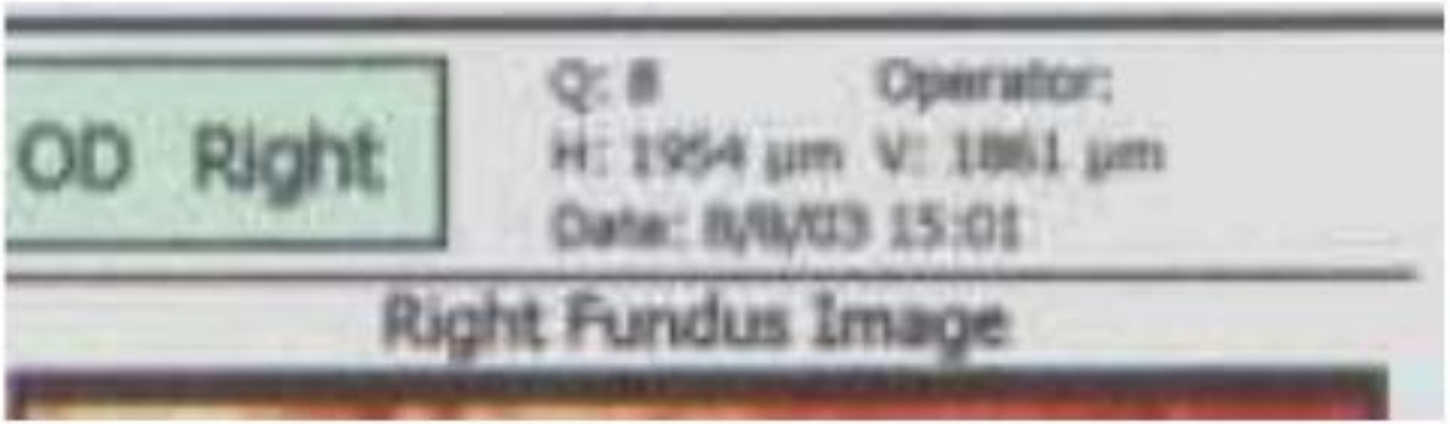
- Glaucoma is characterized by loss of retinal ganglion cells and their axons i.e. retinal nerve fiber layer (RNFL).
- Several studies have shown that changes in optic nerve head (ONH) and retinal nerve fiber layer (RNFL) precede the visual field loss by several years.
- Thus, RNFL examination helps in early diagnosis of glaucoma.

Principle

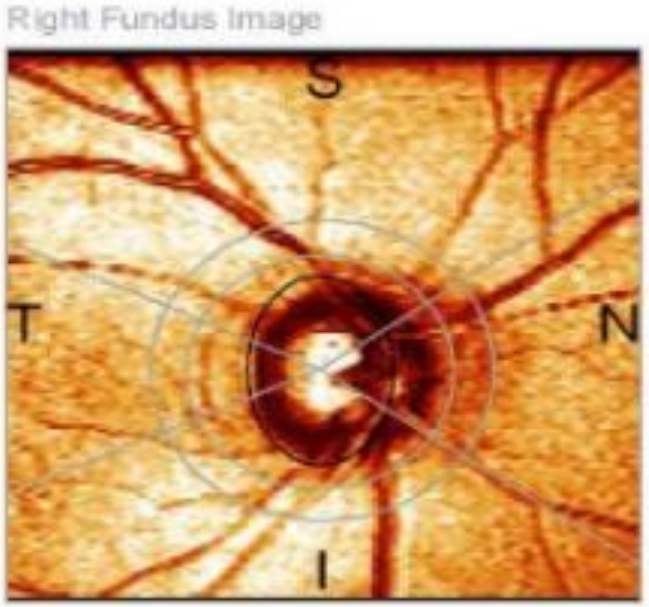
- Scanning laser polarimetry (SLP) is designed to quantitatively assess the thickness of the peripapillary RNFL.
- It is based on the measurement of a physical property called retardation of an illuminating laser beam passing through the birefringent RNFL.
- Birefringence in the nerve fiber layer arises from the parallel arrangement of microtubules within the axons of this layer.


Nerve fiber analysis
With variable corneal compensation
OD Right
OS Left
Right Fundus Image
Left Fundus Image
TSNIT Parameters
OD Actual Val.
OS Actual Val.
TSNIT Average 64.13 63.62
Superior Average 83.24 81.61
Inferior Average 79.37 73.95
TSNIT Std. Dev. 29.54 26.13
Inter-Eye Symmetry 0.96
NFI 4 10
p>5% p<5% p<2% p<1% p<0.5%
Thickness Map Legend (microns)
0 20 40 60 80 100 120 140 160 180 200
Impression / Plan:
right (OD) 17nm, 8.0deg; left (OS) 28nm, 13.3deg;
Signature:_____ Date:_____
Right Nerve Fiber Thickness Map
Left Nerve Fiber Thickness Map
Right Deviation Map
Left Deviation Map
Right Nerve Fiber Layer
Both Nerve Fiber Layers
Left Nerve Fiber Layer
T S N I T
Fundus image
RNFL Thickness map
Deviation map
TSNIT plot
Output parameters
Probability values
Thickness color scale
(Temporal — Superior — Nasal — Inferior — Temporal)

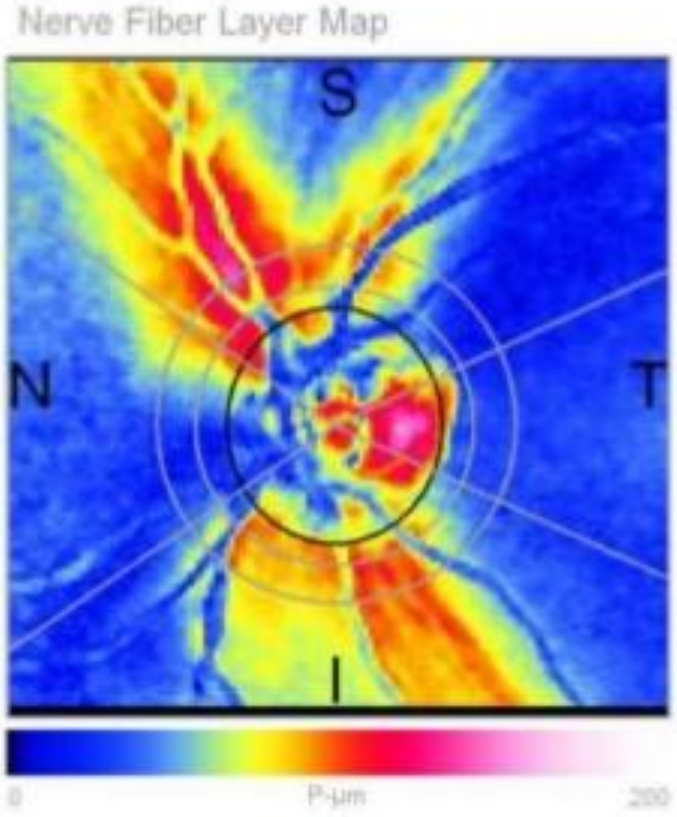
- Patient's identification data
- Image quality score : Scores of 7 or higher are considered to be of good quality, while scores less than 7 should be interpreted with caution.



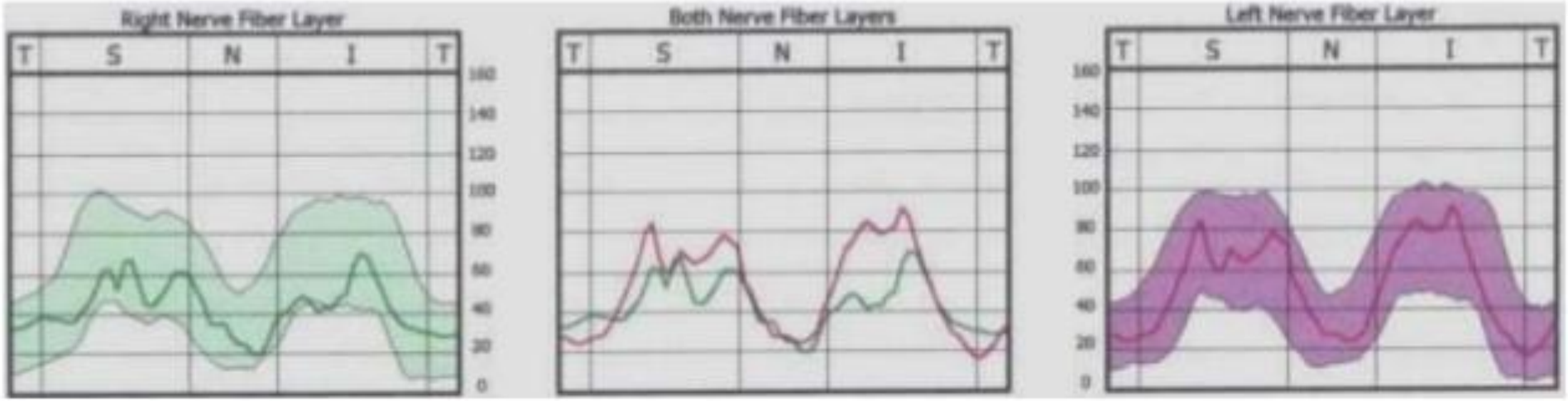
Fundus Image



- The Fundus Image is a reflectance image depicting a 20° x 20° image of the posterior pole.
- The GDx utilizes more than 16,000 data points from the scan area to produce and display the Fundus Image showing the optic nerve head.
- This image allows the initial quality evaluation of the scan to determine if it is adequate for further analysis and is used for centering the ONH ellipse

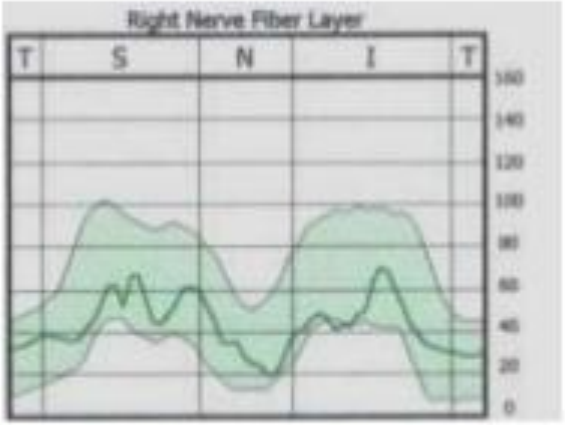


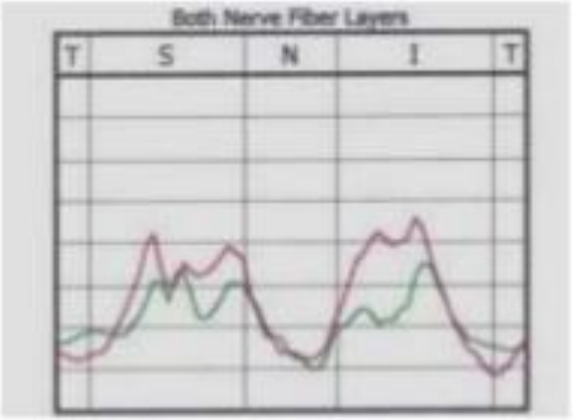
- A typical normal pattern is characterized by bright yellows and reds (thicker) in the superior and inferior sectors, and greens and blues (thinner) in the nasal and temporal sectors.

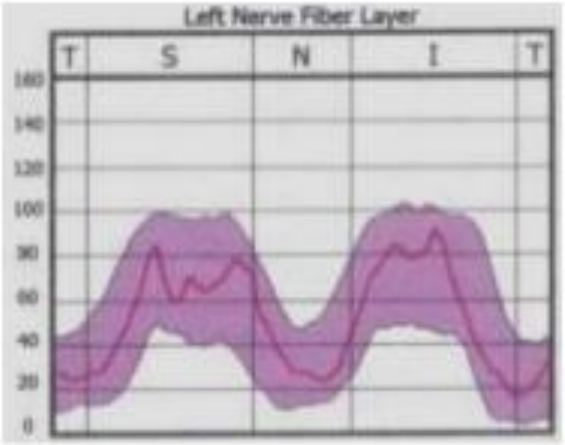


- Symmetry Analysis report, the TSNIT (Temporal-Superior-Nasal-Inferior-Temporal) nerve fiber layer graph displays the normal range (shaded area) and patient's values of RNFL developed from the measurement data obtained along the Calculation Circle.

- The green plot displays the right eye (OD), and the purple plot displays the left eye (OS).
- The left side of the graph starts the plot from the Calculation Circle, beginning at the temporal side of the retina.
- As the map progresses to the right it plots the RNFL values obtained by tracing around the Calculation Circle, passing through the Temporal, Superior, Nasal, Inferior, and then back to the Temporal positions.





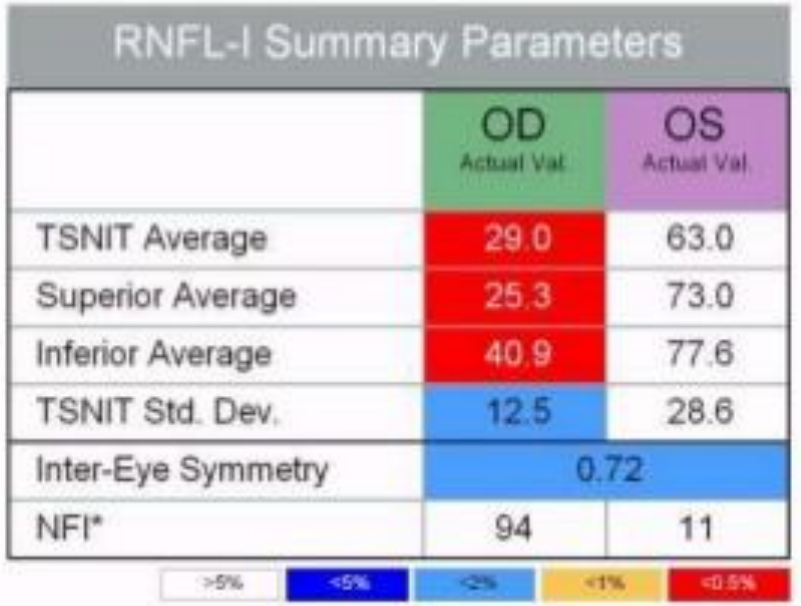


Parameters Table

- It presents parameters computed from the Calculation Circle and they a compared to values

  from the normative databas

- Values are color- coded to indicate deviation from normal, as in the Deviation Map.



RNFL-I Summary Parameters		
	OD Actual Val.	OS Actual Val.
TSNIT Average	29.0	63.0
Superior Average	25.3	73.0
Inferior Average	40.9	77.6
TSNIT Std. Dev.	12.5	28.6
Inter-Eye Symmetry	0.72	
NFI*	94	11

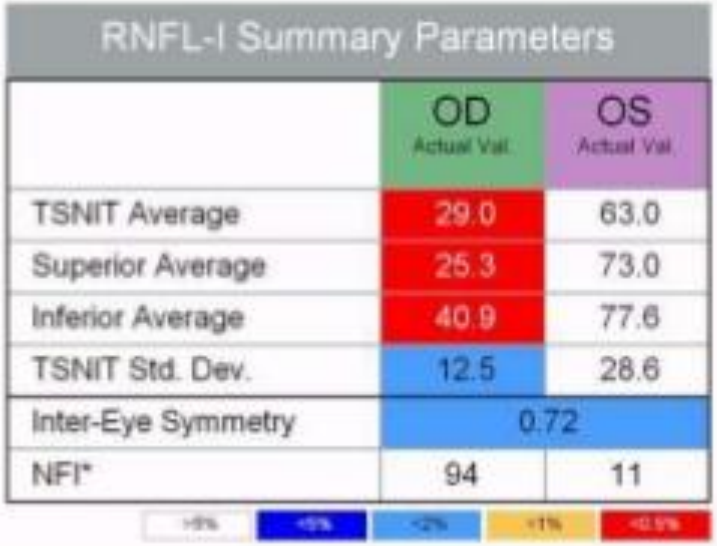
- TSNIT Average :This parameter evaluates the average RNFL (µm) in the Calculation Circle.
  (Normal 46 -68 µm)

- Superior Average: This is the average of all pixels (µm) in the superior 120 degrees of the Calculation Circle. (Normal 55 - 85 µm)

- Inferior Average : This is the average of all pixels (µm) in the inferior 120 degrees of the Calculation Circle.

  (Normal 40 - 75 µm)

- TSNIT Std. Dev. (Standard Deviation) : This number represents the standard deviation of the values contained in the Calculation Circle. The higher the number, the greater the modulation of the double-hump pattern.



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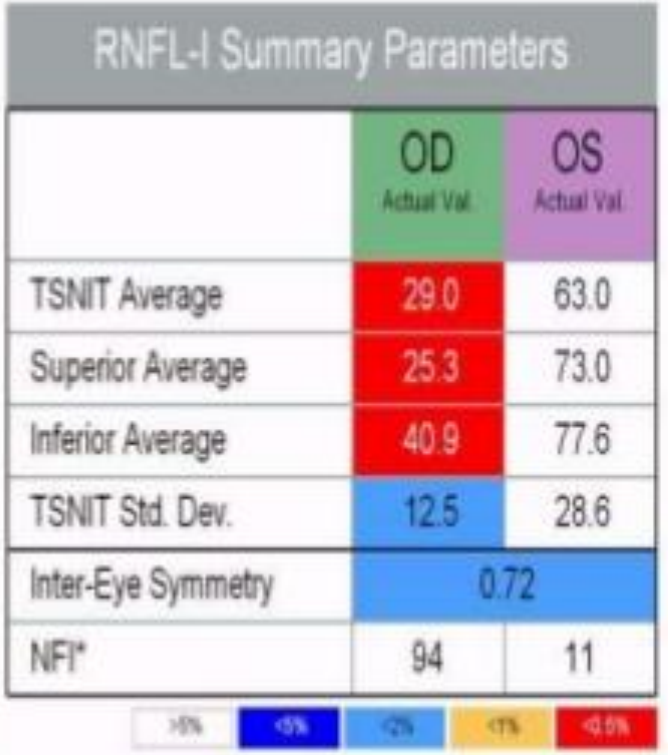
NFI*	94	11

Inter-Eye Symmetry

- This is the correlation of corresponding points in the TSNIT data for right and left eyes.
- The closer the ratio is to 1.0, the more symmetric the nerve fiber layer.
- If only one eye is evaluated, this value is not shown.

- The Nerve Fiber Indicator (NFI) for GDx is an algorithm that analyzes the entire RNFL profile.
- The NFI is an indicates the likelihood that the polarimetric retinal nerve fiber layer map is abnormal.
- A higher number is more likely to be related to abnormality, but is not definitive NFI (Nerve Fiber Indicator)



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TSNIT Std. Dev.	12.5	28.6
Inter-Eye Symmetry	0.72	
NFI*	94	11

>5% <5% <2% <1% <0.5%

Advantages

- Easy to operate
- Does not require pupillary dilation
- Comparison with age matched normative database
- Good reproducibility
- Does not require a reference plane.

Limitations

- Affected by anterior and posterior segment pathologies.
- Does not measure actual RNFL thickness
- Limited use in moderate/advanced glaucoma.
- Difficult in nystagmus, very small pupil and media opacities.
- Requires wider database for Indian population.
- Young patients database not available.
- Backward compatibility not present.

IMAGING TECHNOLOGIES

1. Scanning laser polarimetry- GDx.
2. Confocal scanning laser ophthalmoscopy- Heidelberg Retina Tomograph(HRT)
3. Optical coherence tomography

Normative Stereometric Parameters

PARAMETER	NORMAL	EARLY	MODERATE	ADVANCED
Disc Area (mm2)	2.257 ± 0.563	2.345 ± 0.569	2.310 ± 0.554	2.261 ± 0.461
Cup Area (mm2)	0.768 ± 0.505	0.953 ± 0.594	1.051 ± 0.647	1.445 ± 0.562
Rim Area (mm2)	1.489 ± 0.291	1.3 93 ±0.340	1.260 ± 0.415	0.817 ± 0.334
Cup Volume (mm3)	0.240 ± 0.245	0.294 ± 0.270	0.334 ± 0.318	0.543 ± 0.425
Rim Volume (mm3)	0.362 ± 0.124	0.323 ± 0.156	0.262 ± 0.139	0.128 ± 0.096
Cup/Disc Area Ratio	0.314 ± 0.152	0.380 ± 0.179	0.430 ± 0.203	0.621 ± 0.189

PARAMETER	NORMAL	EARLY	MODERATE	ADVANCED
Mean Cup Depth (mm)	0.262 ± 0.118	0.279 ± 0.115	0.289 ± 0.130	0.366 ± 0.182
Maximum Cup Depth (mm)	0.679 ± 0.223	0.680 ± 0.210	0.674 ± 0.249	0.720 ± 0.276
Cup Shape Measure	-0.181 ± 0.092	-0.147 ± 0.098	-0.122 ± 0.095	-0.036 ± 0.096
Height Variation Contour (mm)	0.384 ± 0.087	0.364 ± 0.100	0.330 ± 0.108	0.256 ± 0.090
Mean RNFL Thickness (mm)	0.384 ± 0.063	0.217 ± 0.076	0.182 ± 0.086	0.130 ± 0.061
RNFL Cross-Sectional Area (mm2)	1.282 ± 0.328	1.155 ± 0.396	0.957 ± 0.440	0.679 ± 0.302

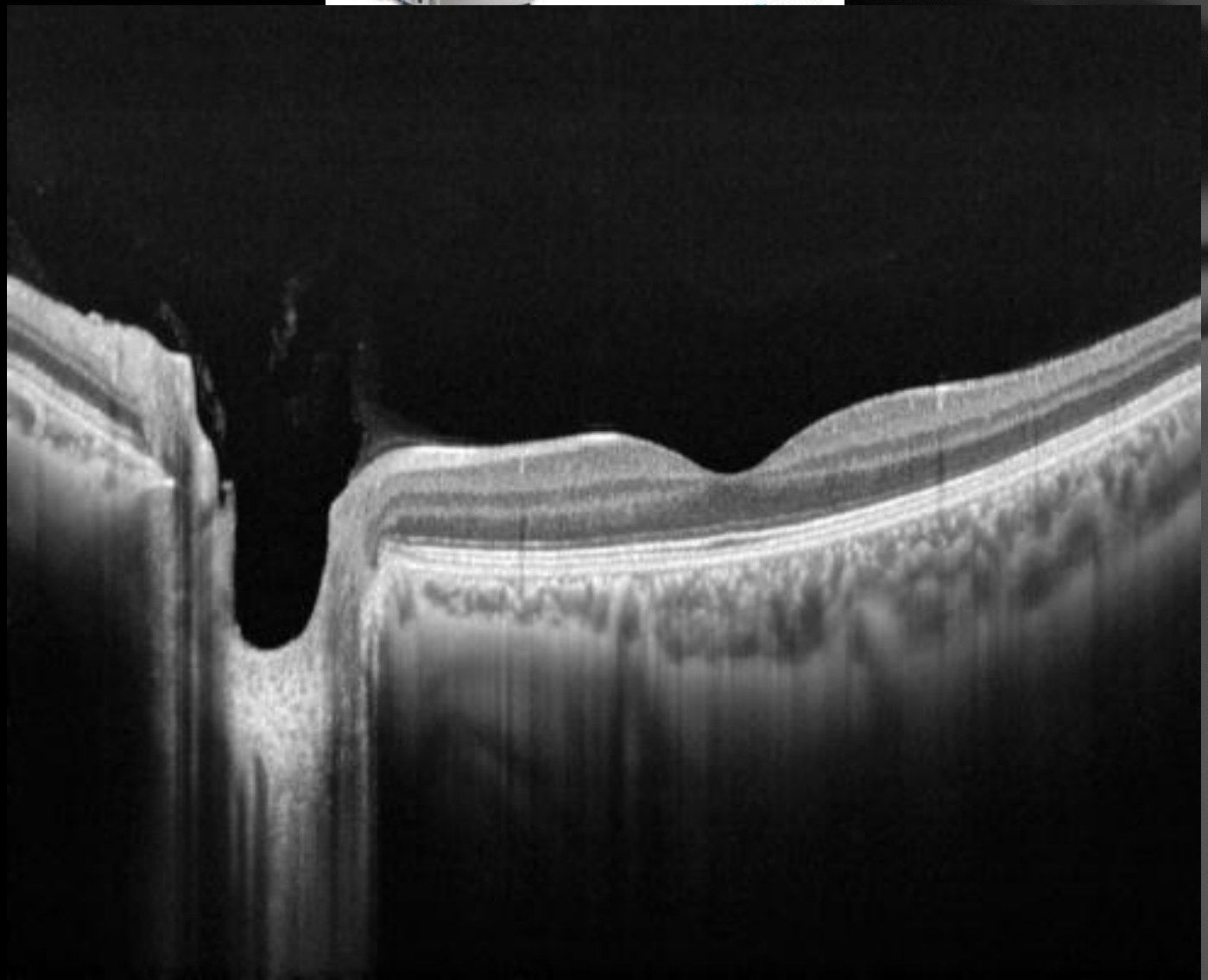
DIAGNOSTIC ACCURACY

	GDX	HRT	OCT
SPECIFICITY	72%to78%	86%	> 90%
SENSTIVITY	56%to 92%	84%	67% to 84%

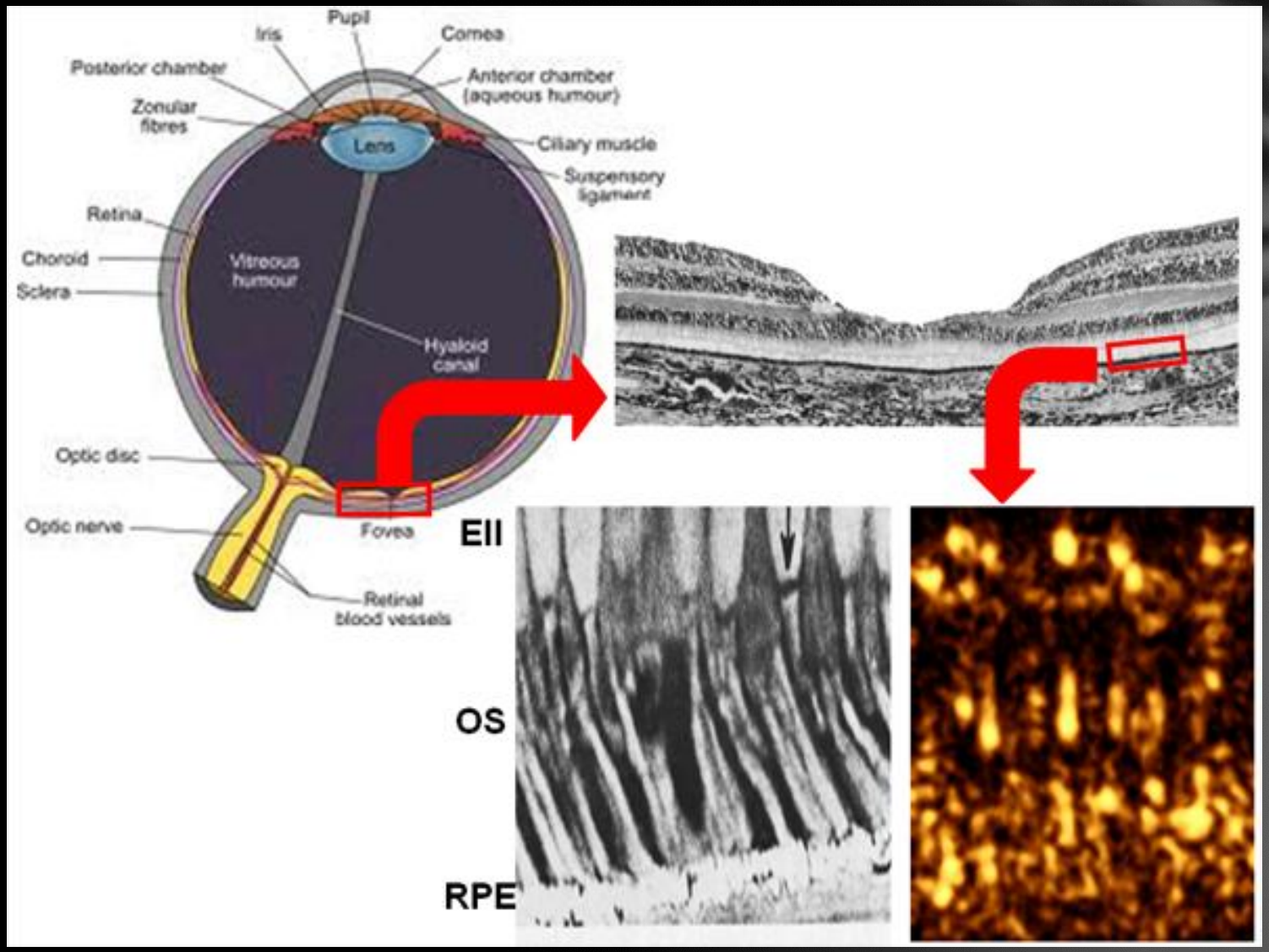
FUTURE DEVELOPMENTS IN GLAUCOMA IMAGING

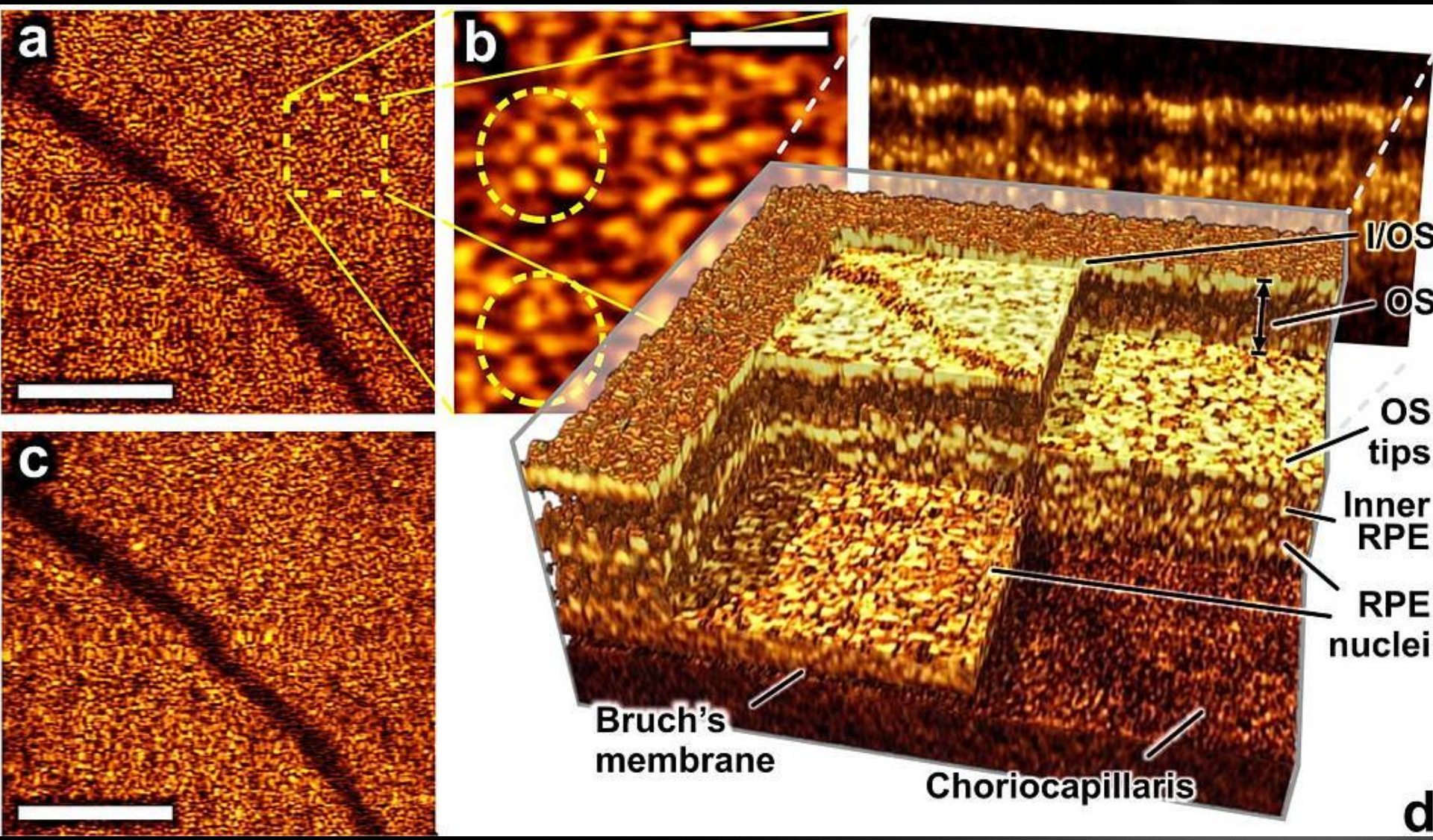
- SWEPT –SOURCE OCT
- LONGER WAVELENGTH OCT
- ADAPTIVE OPTIC OCT
- POLARIZATION SENSITIVE OCT
- OCT ANGIOGRAPHY: ANGIOVUE

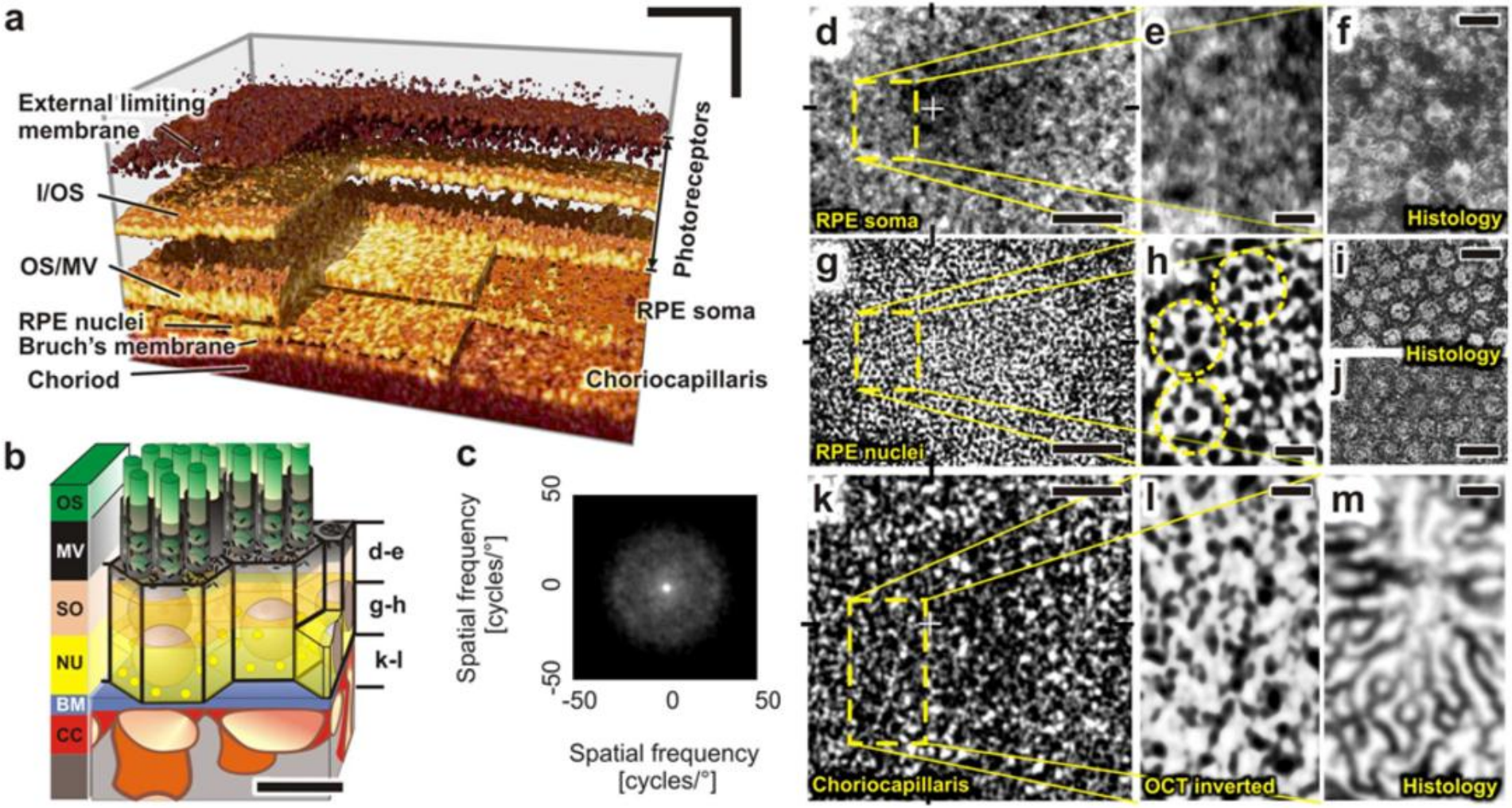

Swept Source Optical
Coherence Tomography
DRI OCT Triton series

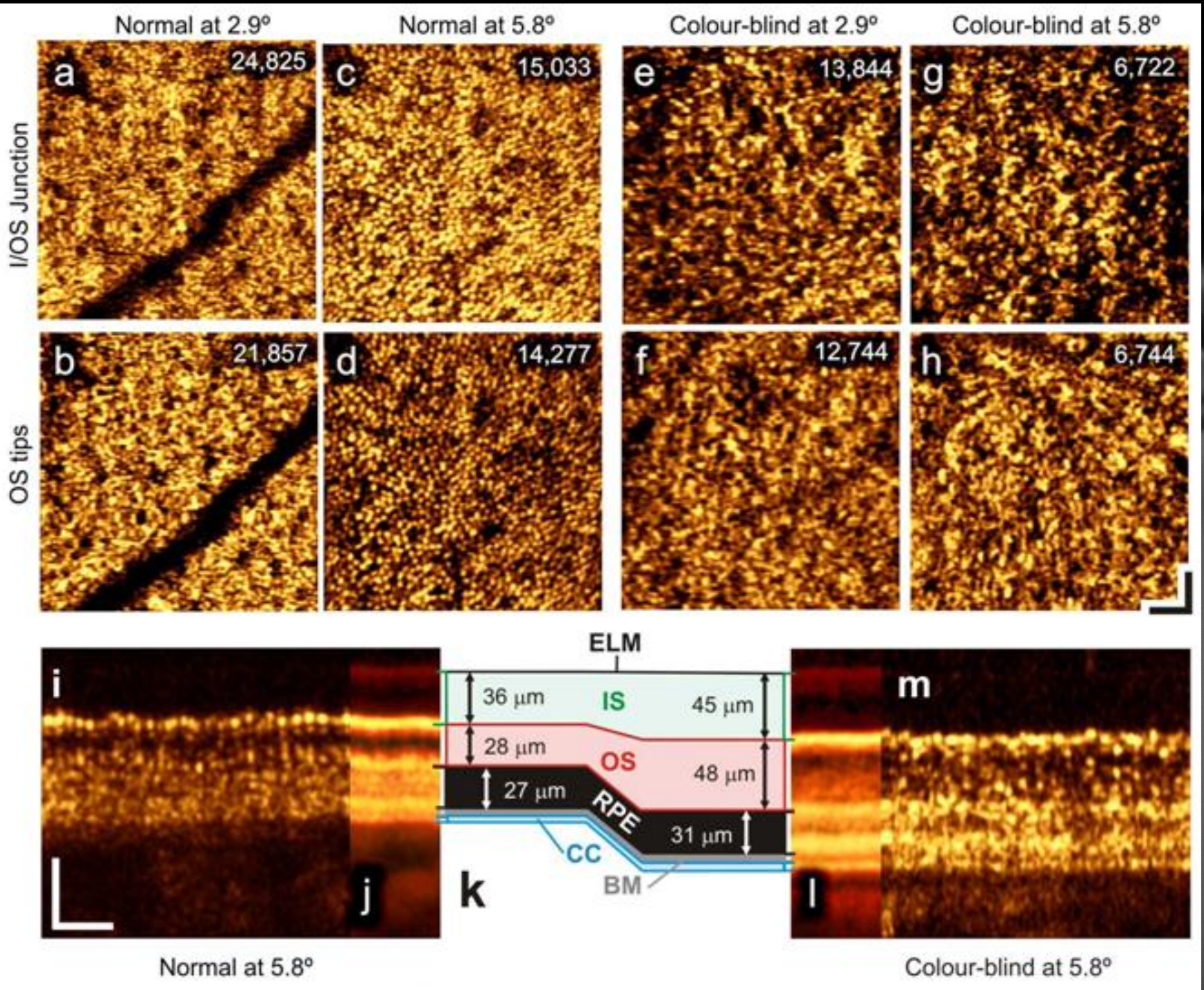


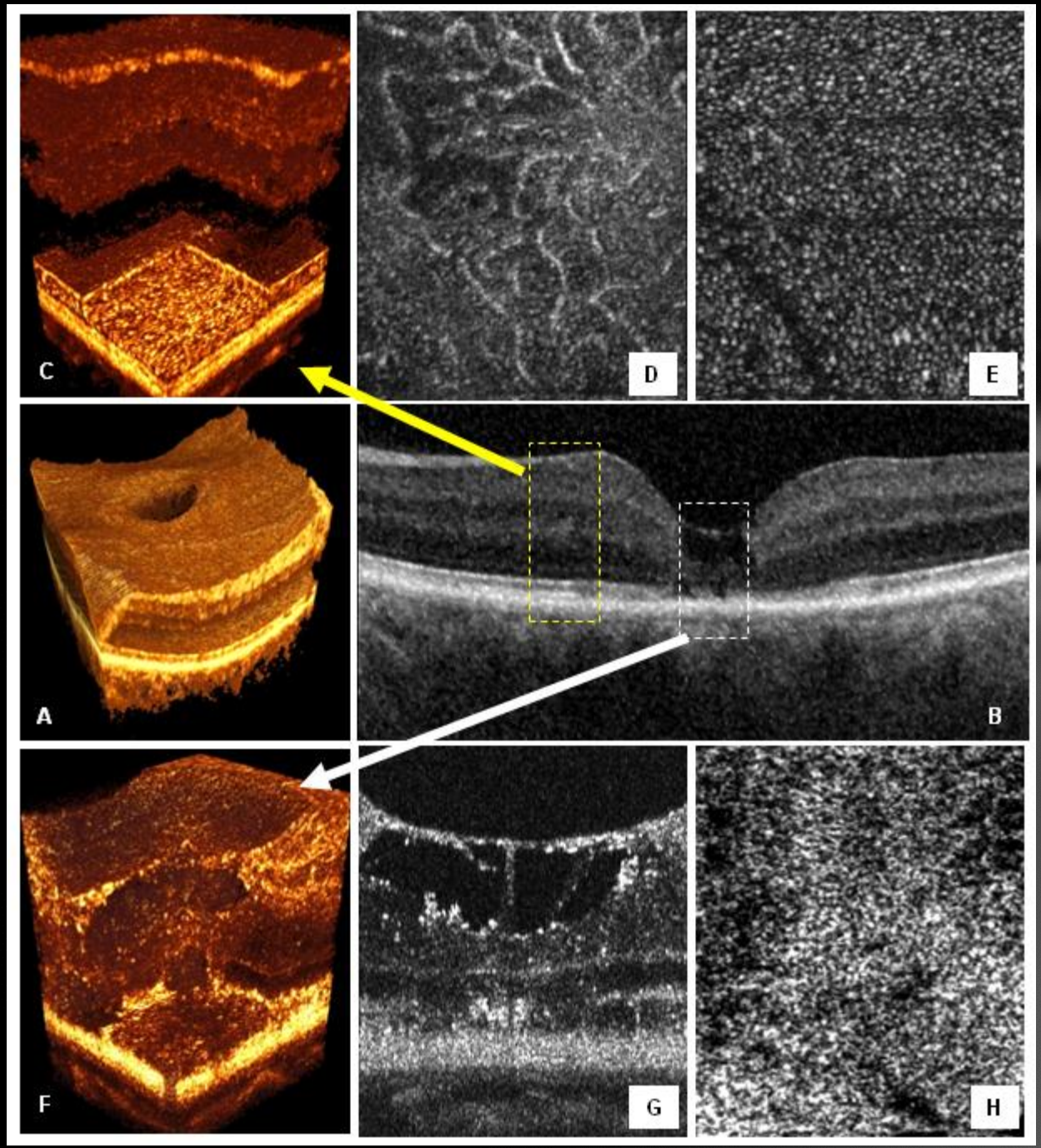
Adaptive optic OCT




a
b
c
I/OS
OS
OS tips
Inner RPE
RPE nuclei
Bruch's membrane
Choriocapillaris
d


a
External limiting membrane
I/OS
OS/MV
RPE nuclei
Bruch's membrane
Choriod
Photoreceptors
RPE soma
Choriocapillaris
b
OS
MV
SO
NU
BM
CC
d-e
g-h
k-l
c
Spatial frequency [cycles/°]
50
0
-50
-50
0
50
Spatial frequency [cycles/°]
d
e
f
RPE soma
Histology
g
h
i
j
RPE nuclei
Histology
k
l
m
Choriocapillaris
OCT inverted
Histology

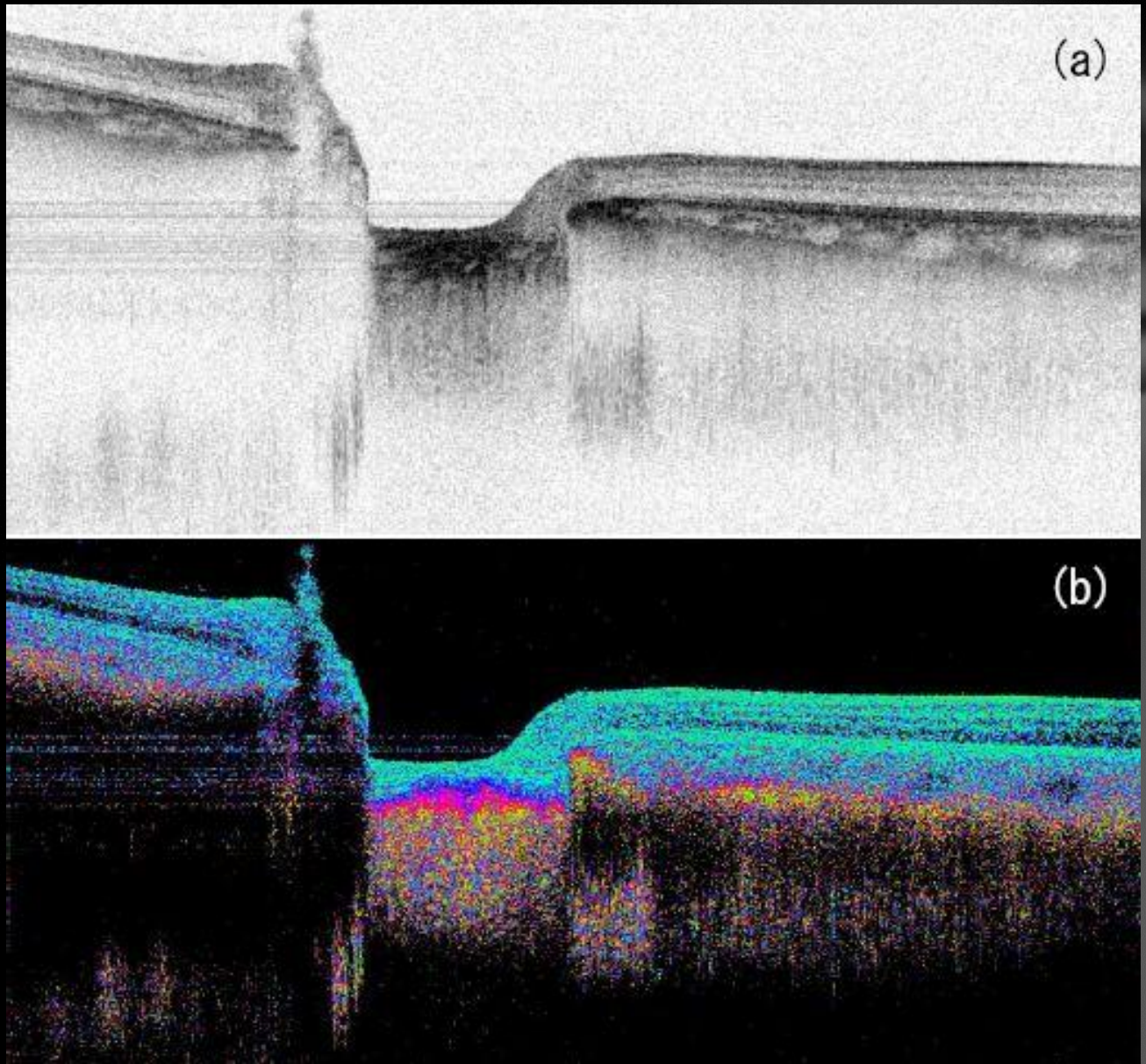

Normal at 2.9°
Normal at 5.8°
Colour-blind at 2.9°
Colour-blind at 5.8°
I/OS Junction
OS tips
a
24,825
c
15,033
e
13,844
g
6,722
b
21,857
d
14,277
f
12,744
h
6,744
ELM
i
36 µm
IS
45 µm
28 µm
OS
48 µm
27 µm
RPE
31 µm
CC
BM
j
k
l
m
Normal at 5.8°
Colour-blind at 5.8°


C
D
E
A
B
F
G
H

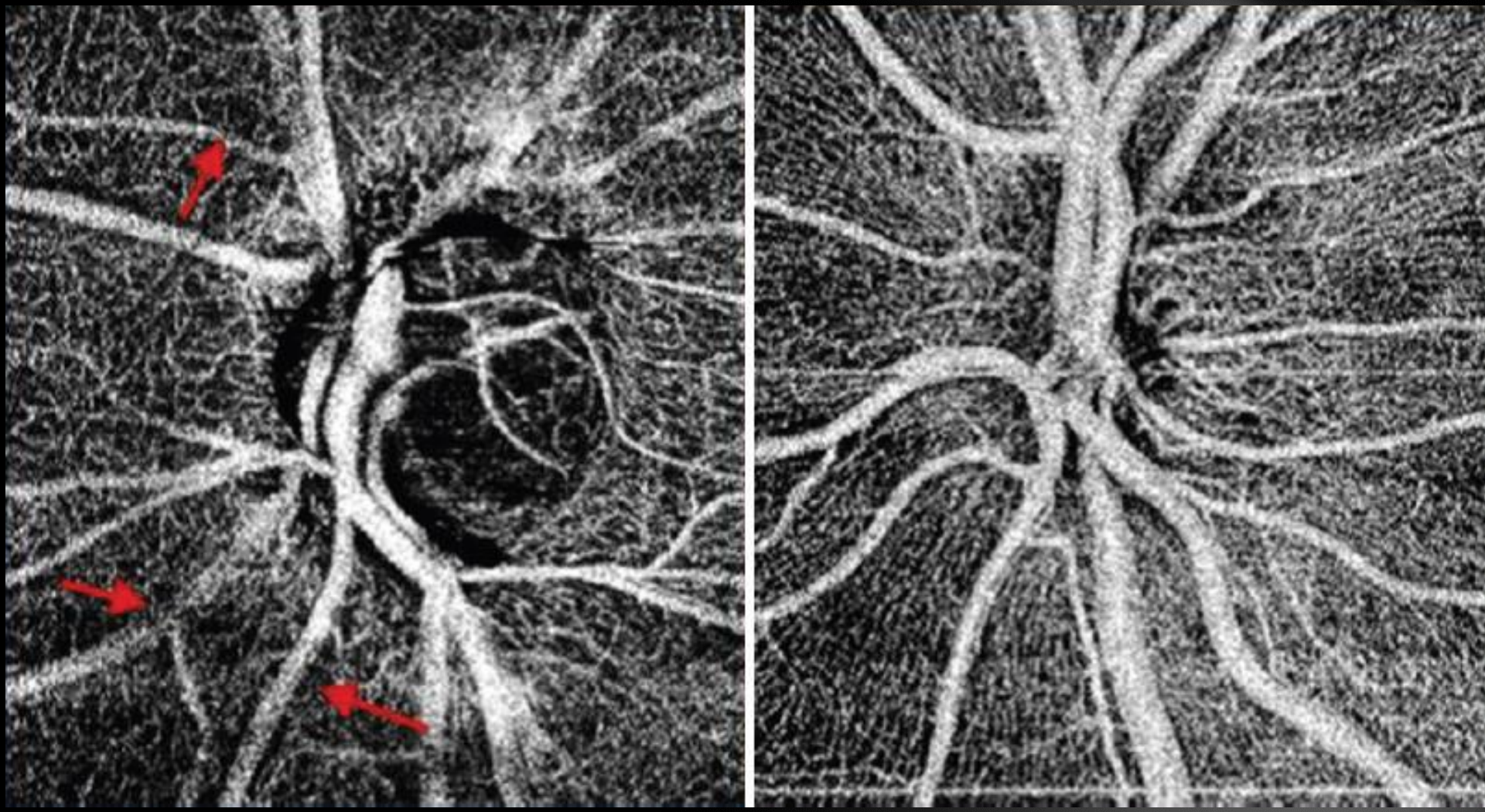
Telesto Series Polarization-Sensitive SD-OCT Imaging System

Deep, Polarization-Sensitive Imaging

Polarization sensitive OCT




AngioVue
IMAGING SYSTEM

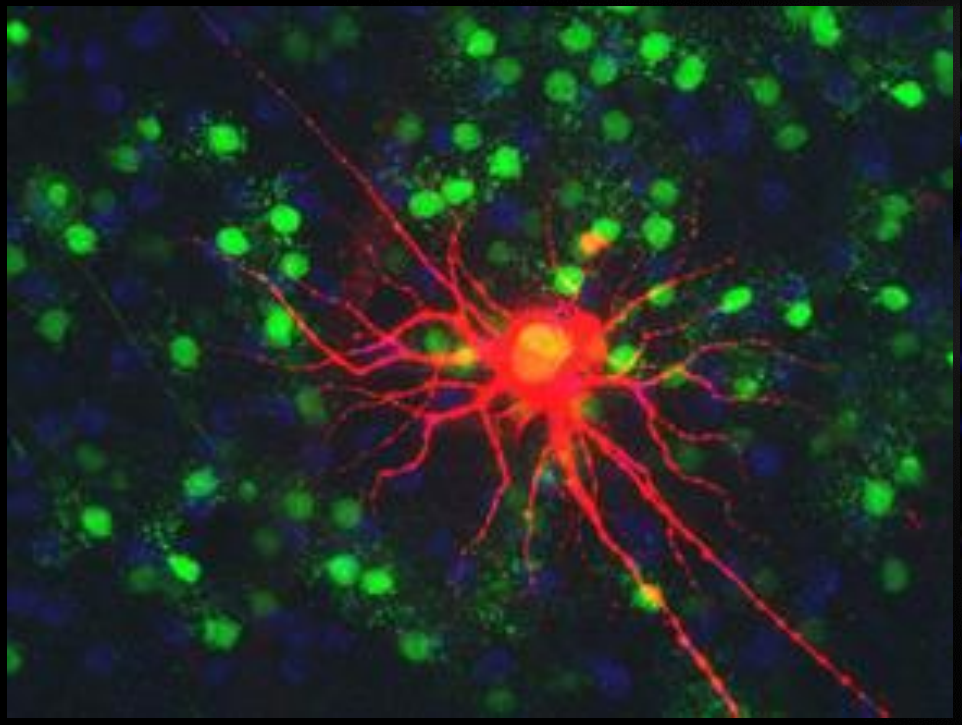


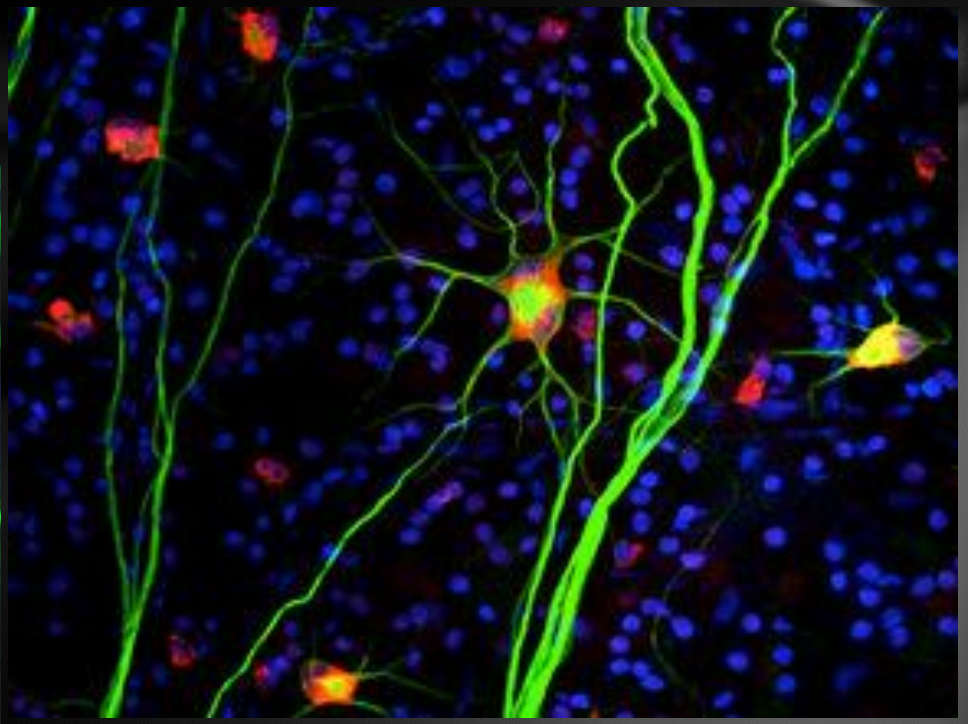

Patient
View
Acquisition
Add Data
Administration
Help
Logout
0019
Name BRVO with Ischemia
DOB
Thumbnail
Single
Multi
OU
Compare
Report
Angiography
Date
Procedure
13/01/2016
All
Superficial
Enhance
Reset
ILM
2.6
IPL/INL
15.6
Deep
Enhance
Reset
IPL/INL
15.6
IPL/INL
70.2
Outer retina
Enhance
Reset
IPL/INL
70.2
BM
0.0
Choroc apillaris
Enhance
Reset
BM
0.0
BM
33.4
Overlay
Line
Overlay
OD(R)
13/01/2016
OD(R)
Line
13/01/2016
OD(R)
Angio Center
13/01/2016
OD(R)
Angio Disc
13/01/2016
OD(R)
Angio Disc
13/01/2016

Researches

The high resolution AOSLO images make it possible to see retinal ganglion cells directly and to visualize the transport of mitochondria within the cells. It is hypothesized that changes in the shape or motion of the mitochondria will predict glaucoma and/or glaucoma progression. The visible light OCT images provide information on the thicknesses of specific layers in the retina, which may change early in glaucoma before vision loss occurs.

Ganglion cell






thank you
danke
謝謝
ngiyabonga
teşekkür ederim
gracias
спасибо
dank je
bedankt
dziękuję
obrigado
sukriya
kop khun krap
go raibh maith agat
terima kasih
merci
dakujem
grazie
arigato
mochchakkeram