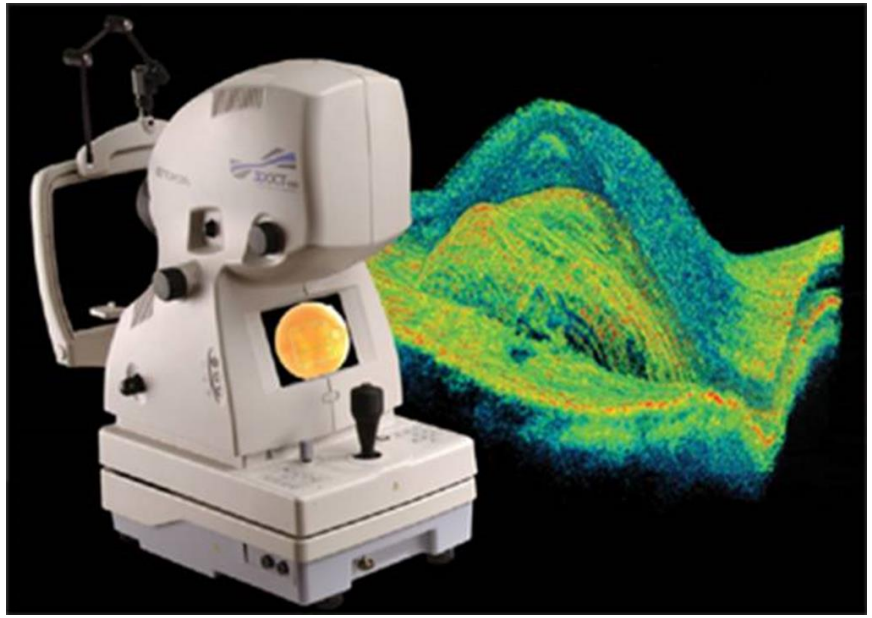
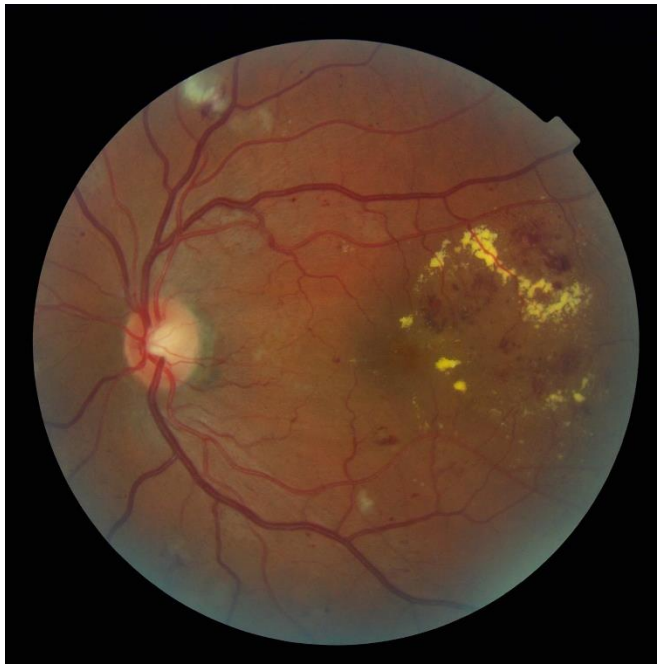
Optical Coherence Tomography in Diabetic Retinopathy

Mrs Samantha Mann
Consultant Ophthalmologist
Clinical Lead of SEL-DESP





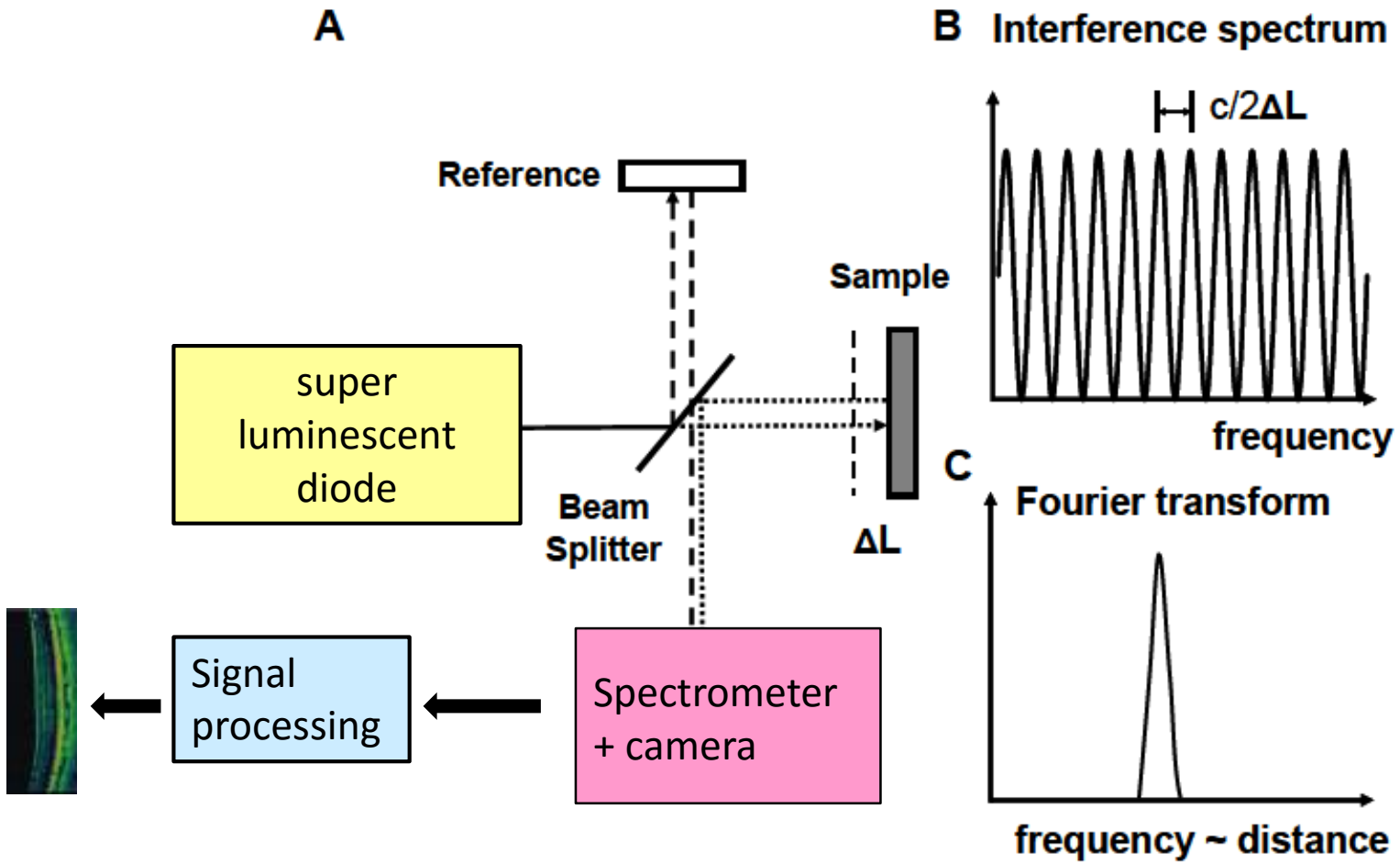
Content

- OCT imaging
- Retinal layers
- OCT features in Diabetes
- Some NON DR features seen in diabetes patients
- OCT grading in Diabetes
- Quiz

Introduction

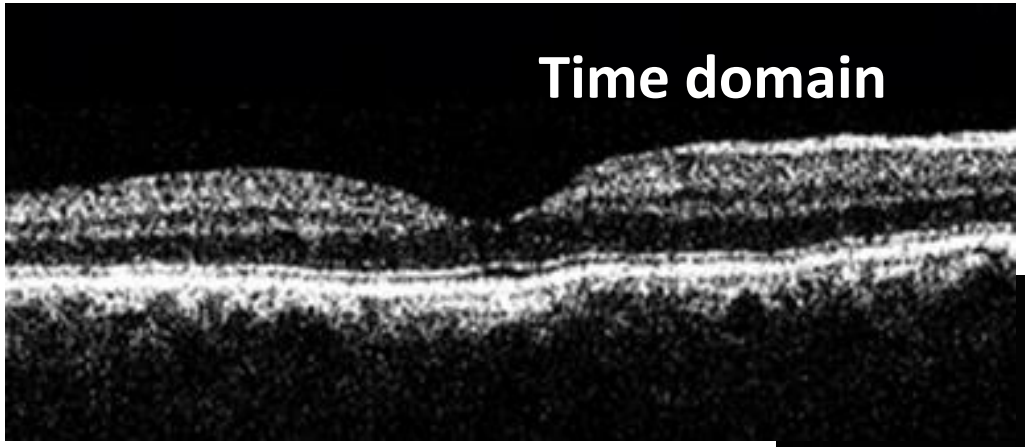
- Optical Coherence Tomography (OCT) was first introduced by Huang and colleagues in 1991 and became commercially available in 1995.
- Non-contact imaging technique that employs low-coherence interferometry (light waves analogous to ultrasound waves) .
- Tissue is “segmented” into layers based upon reflectance. Algorithm can assign “thickness” values to each layer
- Cross-sectional images are constructed from a series of laterally adjacent depth-scans obtained while scanning the probe beam across the eye

Schematic of Spectral/Fourier Domain OCT

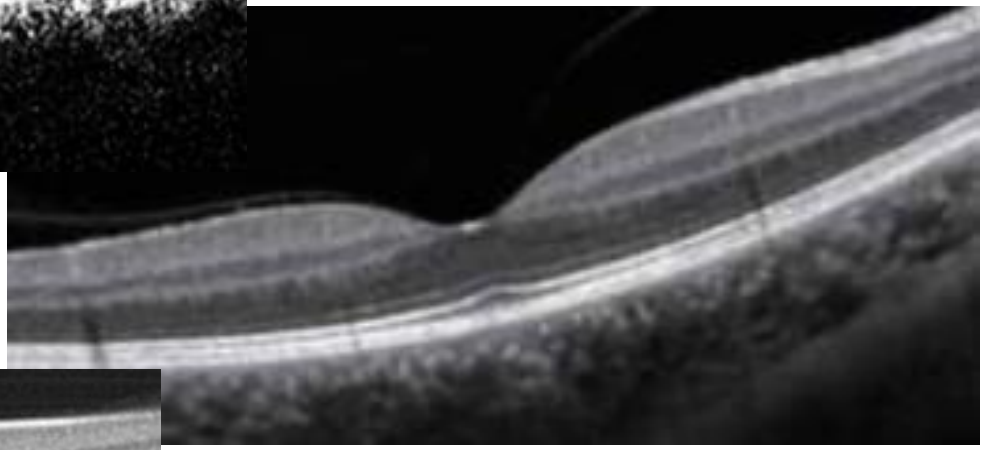


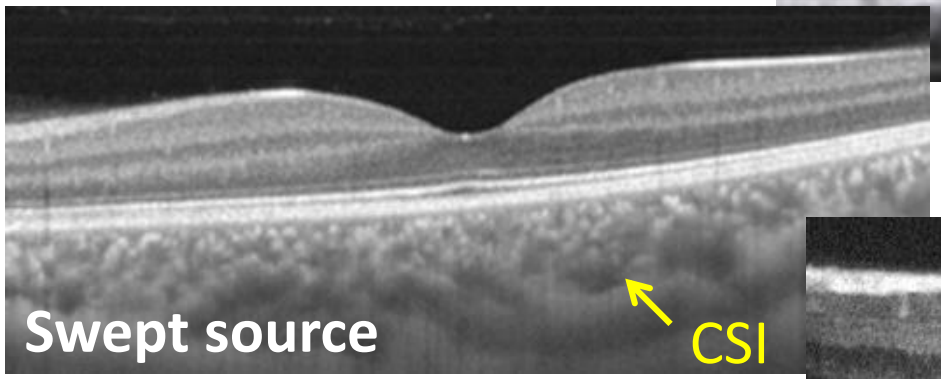
Developments in OCT

	1996	2002	2006	2010
Type of OCT		Time domain	Fourier domain	Swept source
			Spatially encoded frequency domain (SEFD-OCT)	Time encoded frequency domain (TEFD-OCT)
A scans/sec	100	400	26,000	100,000
Resolution	16μm	10 μm	5 μm	3 μm
			spectrometer based system	frequency swept laser based system

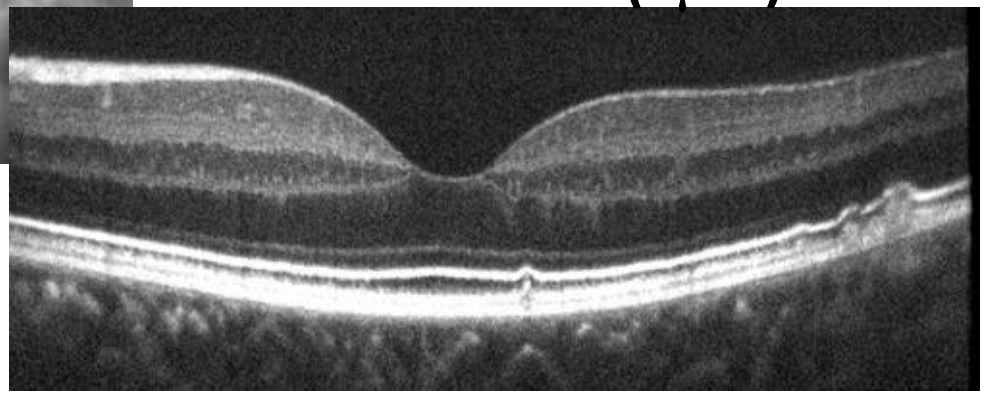


Fourier domain

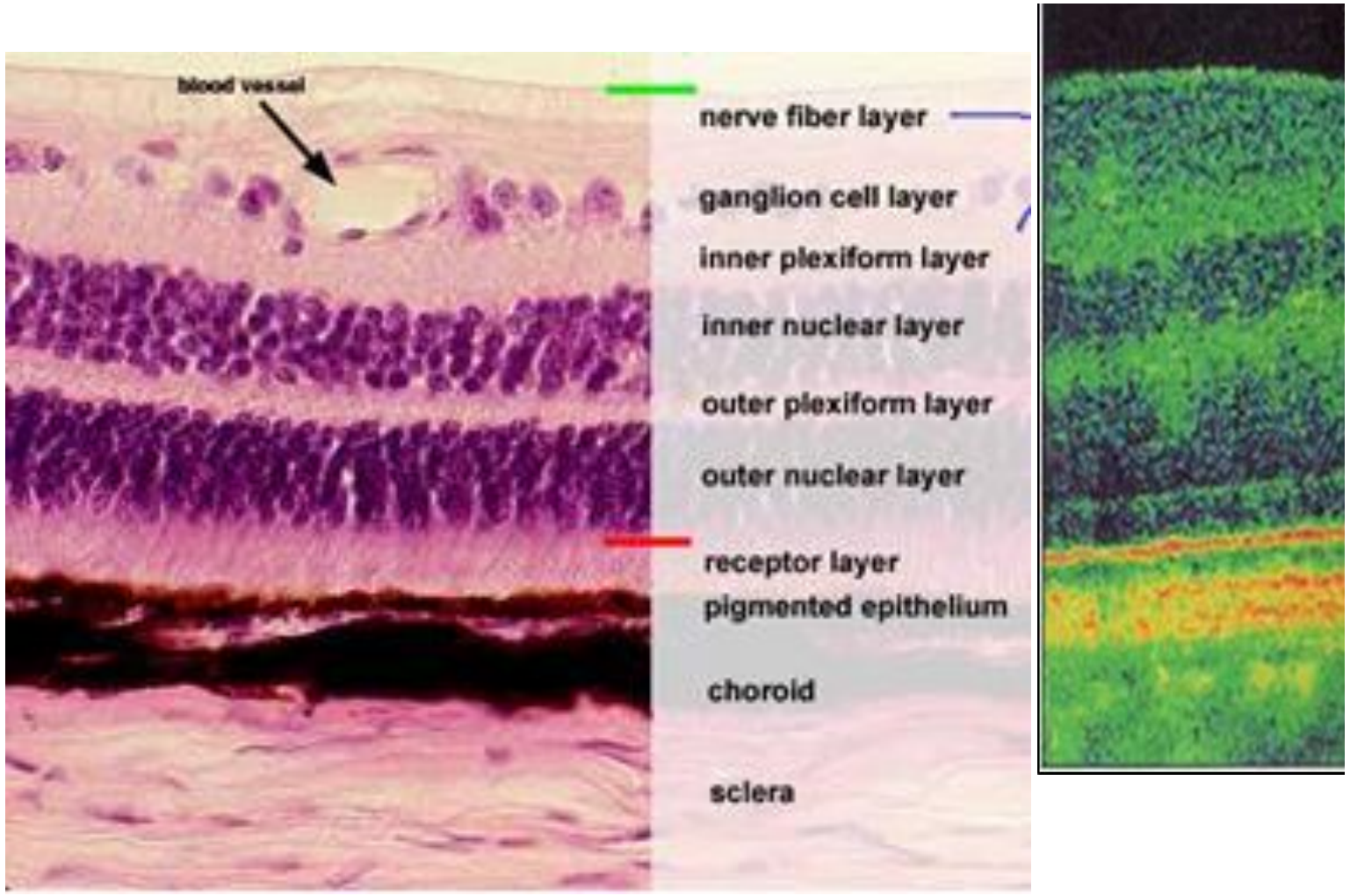




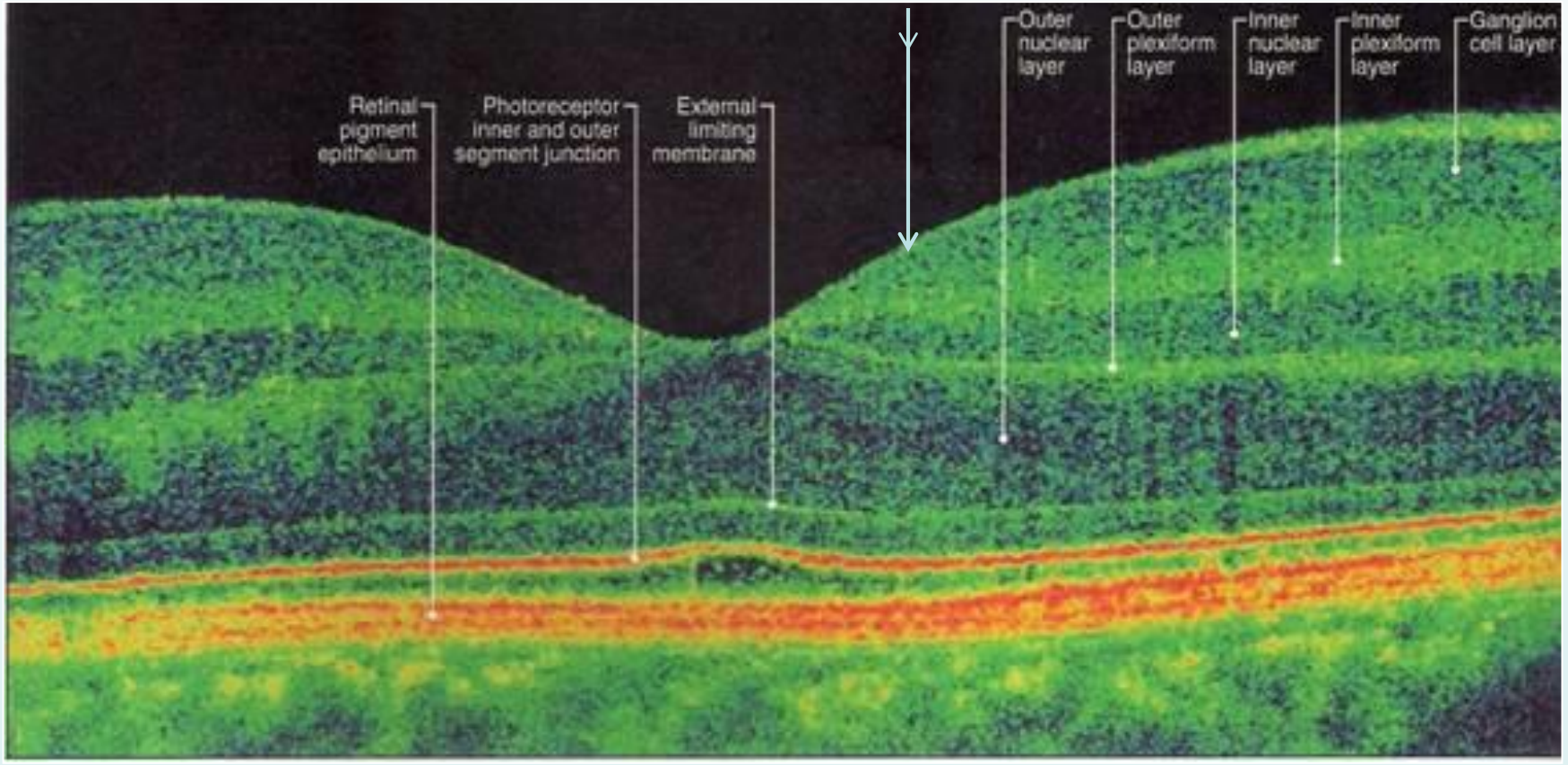
UH-SD (3µm)



Retinal Structure / OCT layers



Normal Retinal OCT/ false colour



Staurenghi G et al. Ophthalmology 2014;121:1572-1578

AMERICAN ACADEMY OF OPHTHALMOLOGY
The Eye M.D. Association

Proposed Lexicon for Anatomic Landmarks in Normal Posterior Segment Spectral-Domain Optical Coherence Tomography

The IN•OCT Consensus

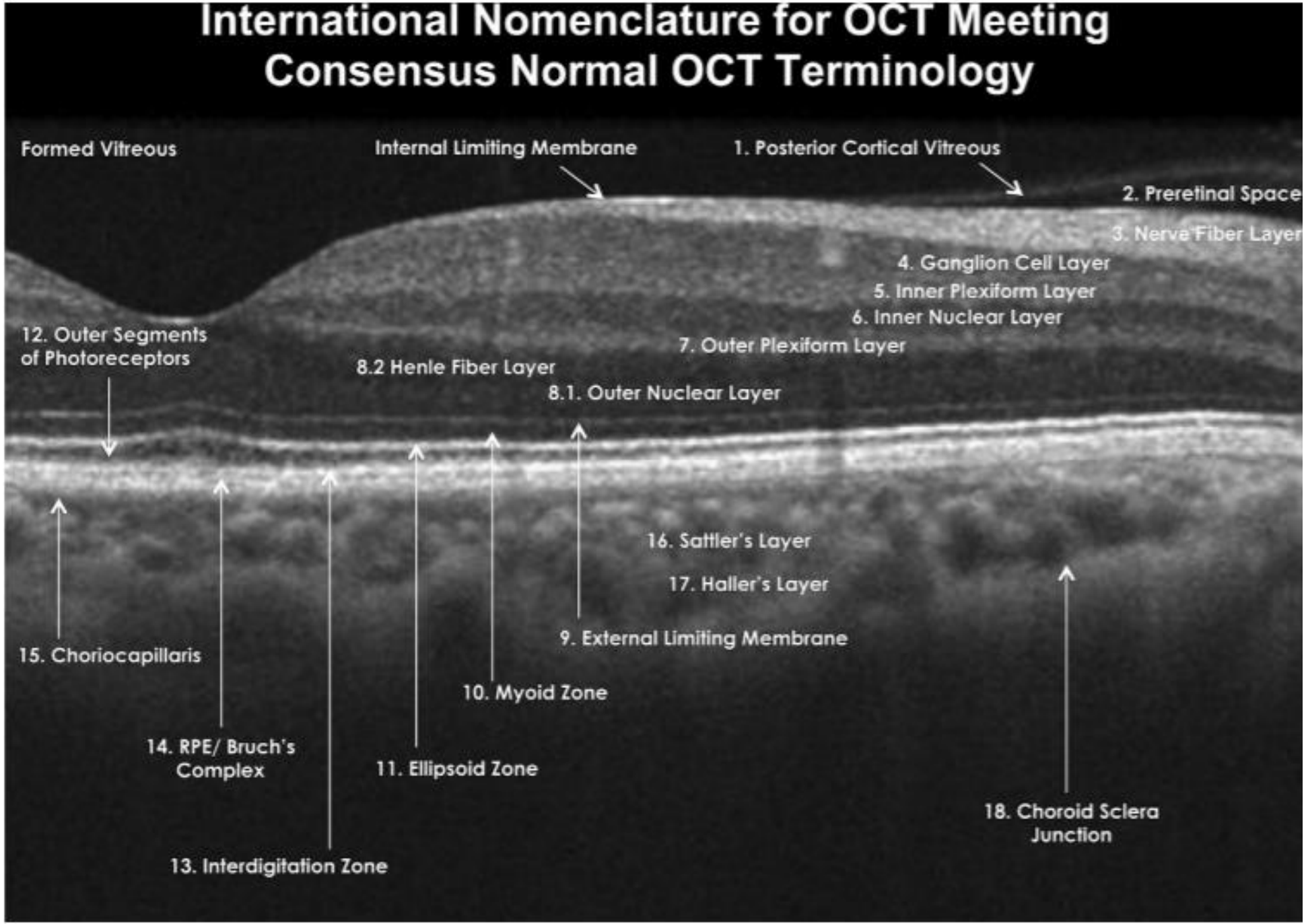
*Giovanni Staurenghi, MD,[1] Srinivas Sadda, MD,[2] Usha Chakravarthy, FRCOphth, PhD,[3] Richard F. Spaide, MD,[4] for the International Nomenclature for Optical Coherence Tomography (IN•OCT) Panel**

Purpose: To develop a consensus nomenclature for the classification of retinal and choroidal layers and bands visible on spectral-domain optical coherence tomography (SD-OCT) images of a normal eye.

Design: An international panel with expertise in retinal imaging (International Nomenclature for Optical Coherence Tomography [IN•OCT] Panel) was assembled to define a consensus for OCT imaging terminology.

Participants: A panel of retina specialists.

Methods: A set of 3 B-scan images from a normal eye was circulated to the panel before the meeting for

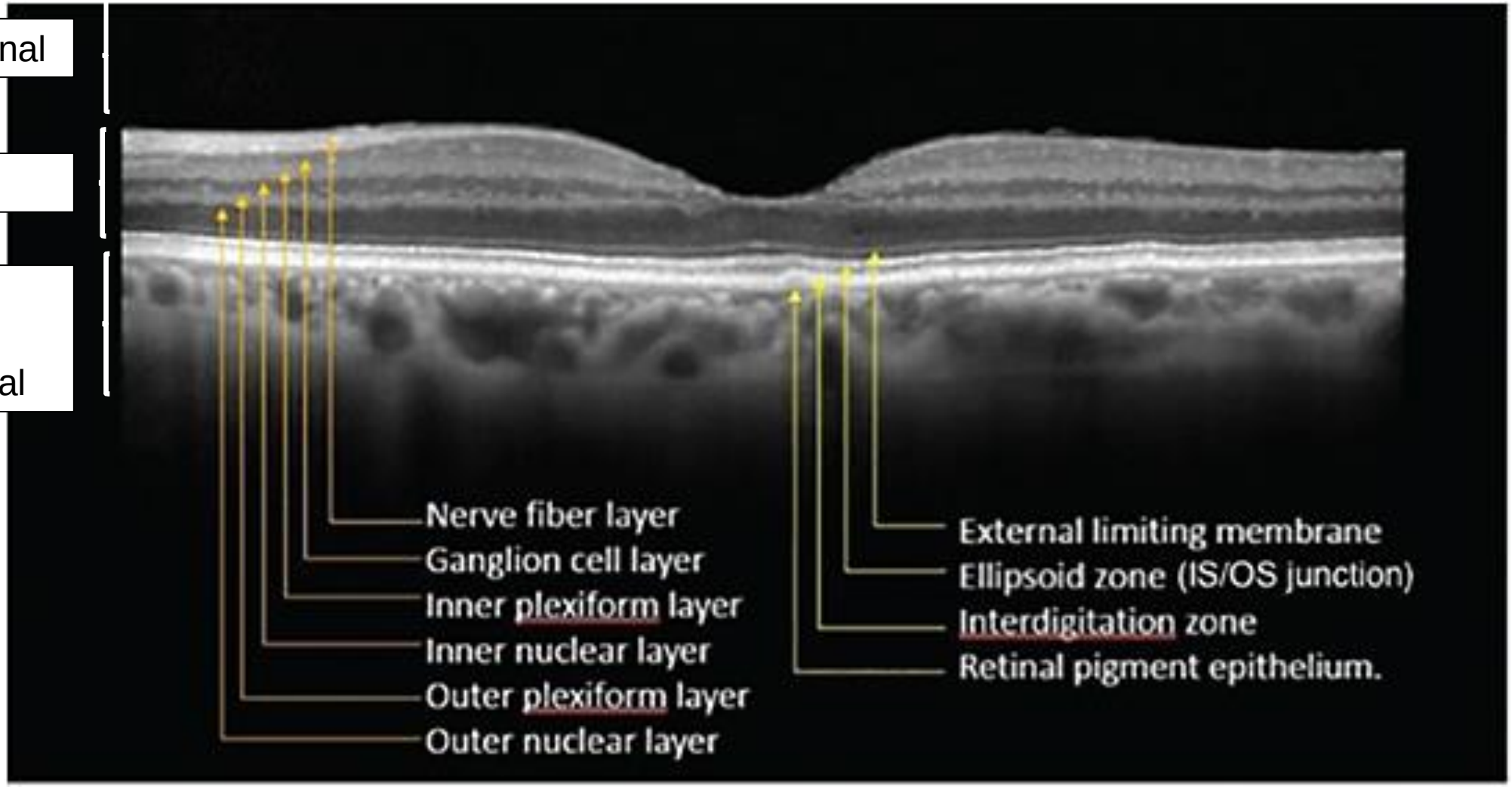

International Nomenclature for OCT Meeting
Consensus Normal OCT Terminology
Formed Vitreous
Internal Limiting Membrane
1. Posterior Cortical Vitreous
2. Preretinal Space
3. Nerve Fiber Layer
4. Ganglion Cell Layer
5. Inner Plexiform Layer
6. Inner Nuclear Layer
7. Outer Plexiform Layer
8.2 Henle Fiber Layer
8.1. Outer Nuclear Layer
12. Outer Segments of Photoreceptors
16. Sattler's Layer
17. Haller's Layer
9. External Limiting Membrane
15. Choriocapillaris
10. Myoid Zone
14. RPE/ Bruch's Complex
11. Ellipsoid Zone
13. Interdigitation Zone
18. Choroid Sclera Junction

Retinal Layers

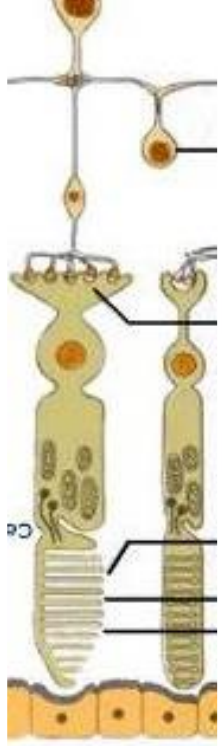
Pre-retinal

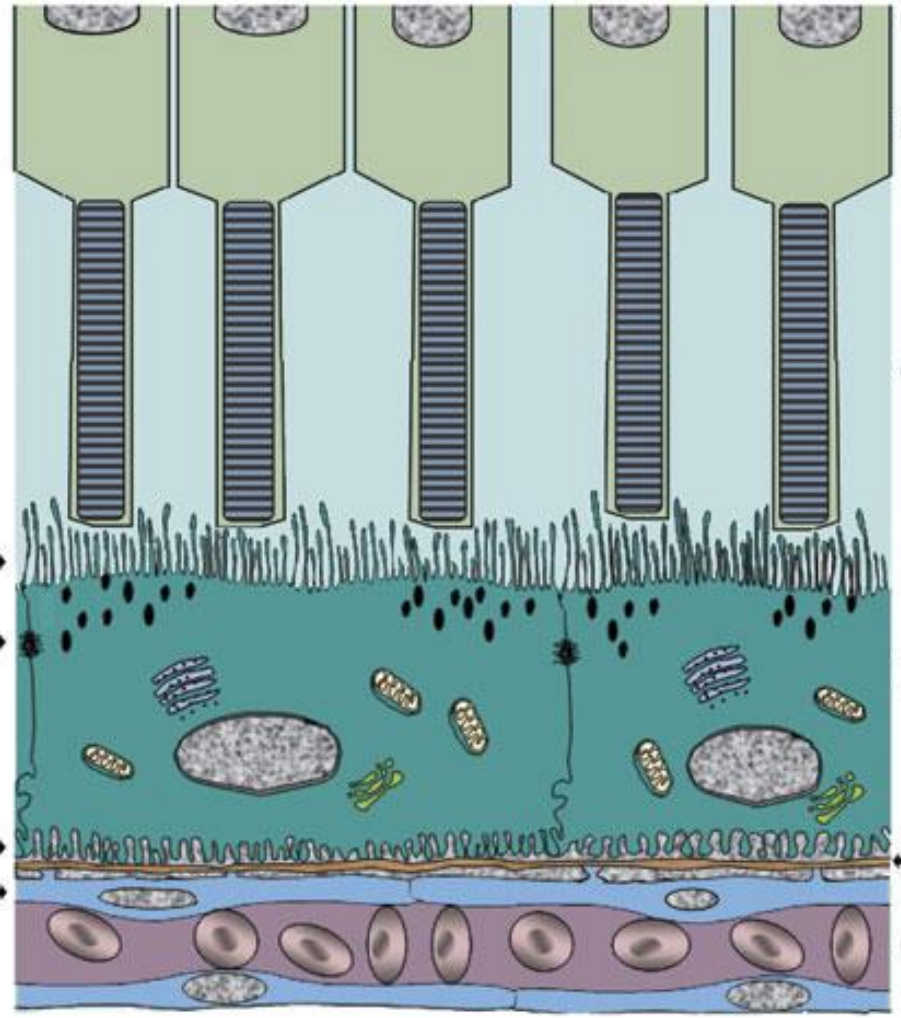
Retinal

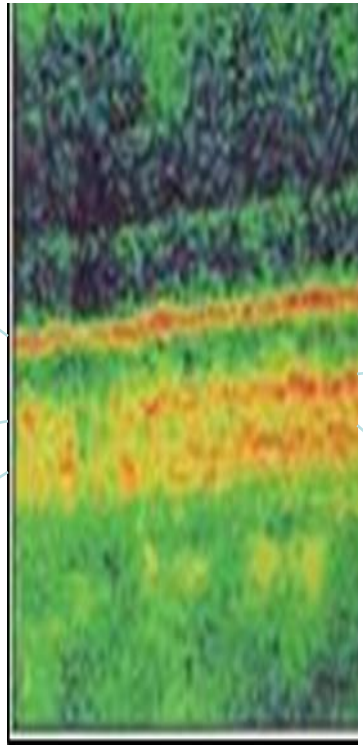
Sub-retinal/ choroidal



‘Trilaminar band’







IS/OS junction

Interdigitation zone

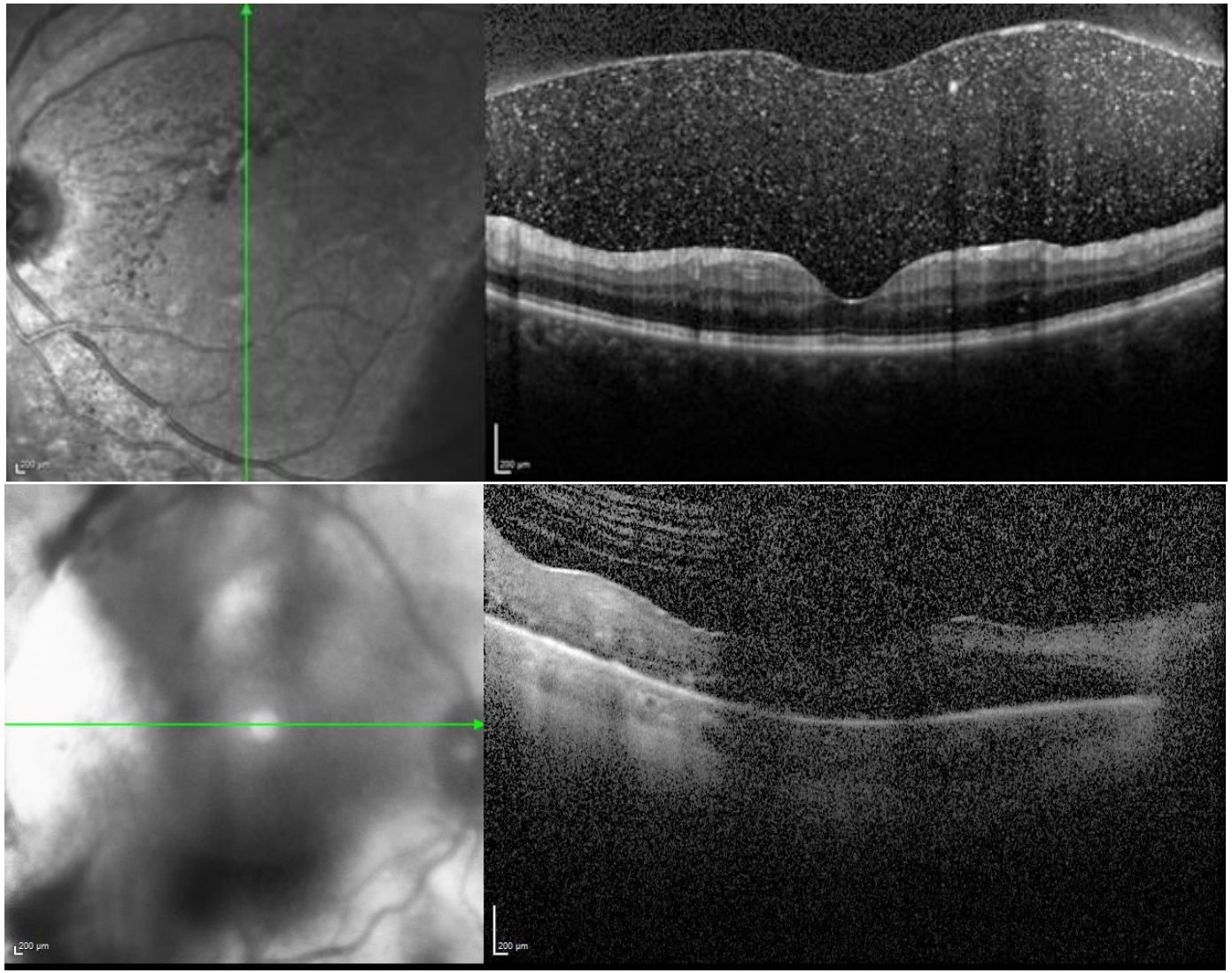
RPE

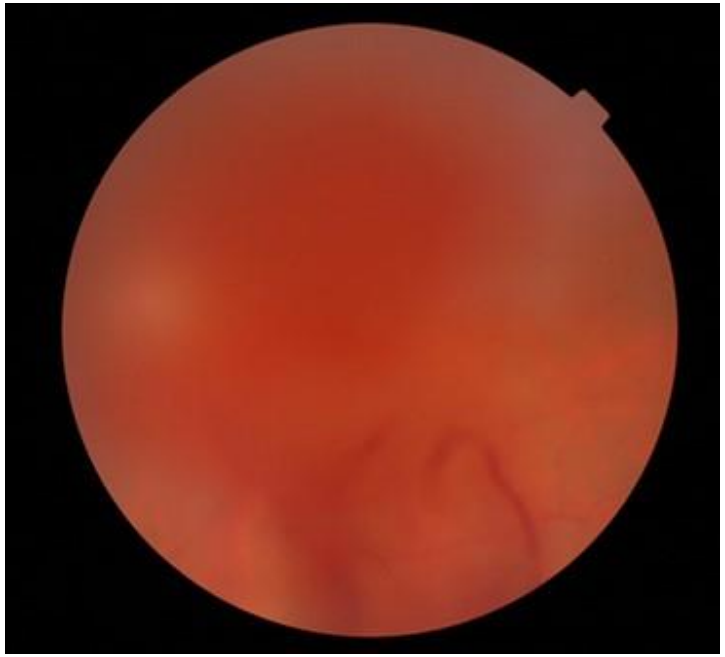
Relative OCT Signal "Reflectivity"

SIGNAL	STRUCTURES
High (white)	RPE, IS/OS junction, exudate, ERM
Moderately High	NFL, Scar Tissue, CNV, blood, vitreo-retinal interface
Moderate (grey)	Retina, Choroid, Vitreous bands
Moderately Low	Vitreous debris, Posterior hyaloid, Outer retina, noise
Low (black)	Vitreous, Silicone oil, Cysts, "Shadowing" behind blood vessels and behind exudates

	Diabetes feature	Non DR patholoy
Vitreous/ vitreoretinal interface	**Vitreous haemorrhage**	Vitreous haemorrhage (secondary to PVD/retinal tear)
	Vitreo-macular traction	Vitreo-macular traction/ Epi-retinal membrane
Posterior hyaloid	**Pre-retinal haemorrhage**	Valsalva haemorrhage
	NVD/NVE	
Retinal	**Microaneurysms/ exudates**	Lamellar hole/ macular hole/ Retinal Vein Occlusion
	Cotton wool spot (NFL)	CRAO
	Intra-retinal cysts/ DMO	Cystoid macular oedema secondary to RVO/post op
Sub-Retinal	**Subretinal fluid**	Central serous retinopathy/ AMD
sub RPE/ Choroidal/ Bruchs		PED, CNV, wet AMD, polypoidal, drusen, Geographic atrophy

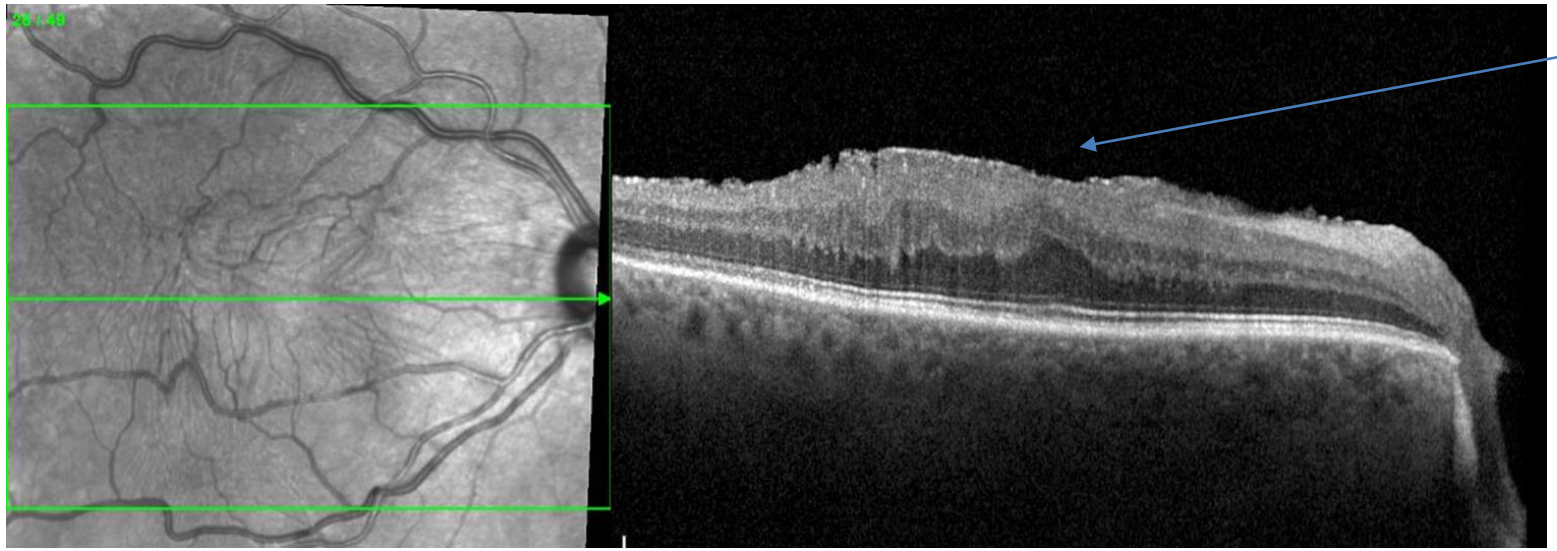
Vitreous Haemorrhage



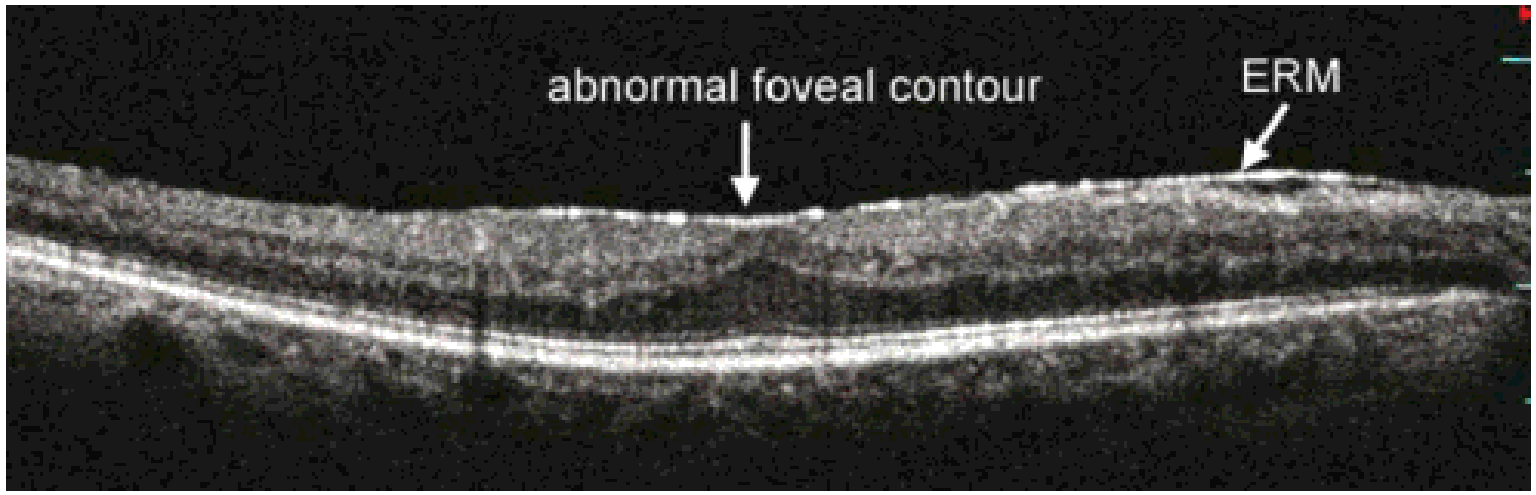


Often no signal or minimal signal with vitreous haemorrhage

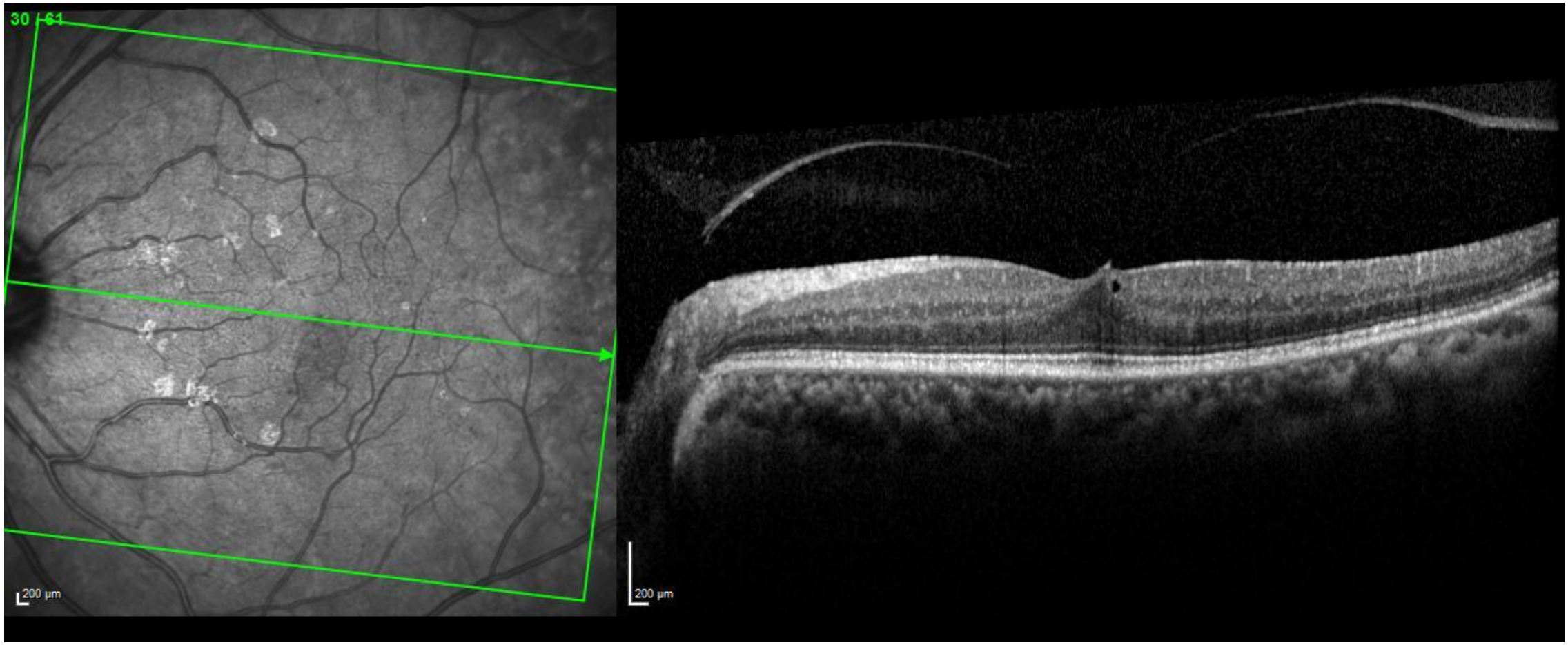
Epiretinal Membrane (non DR)



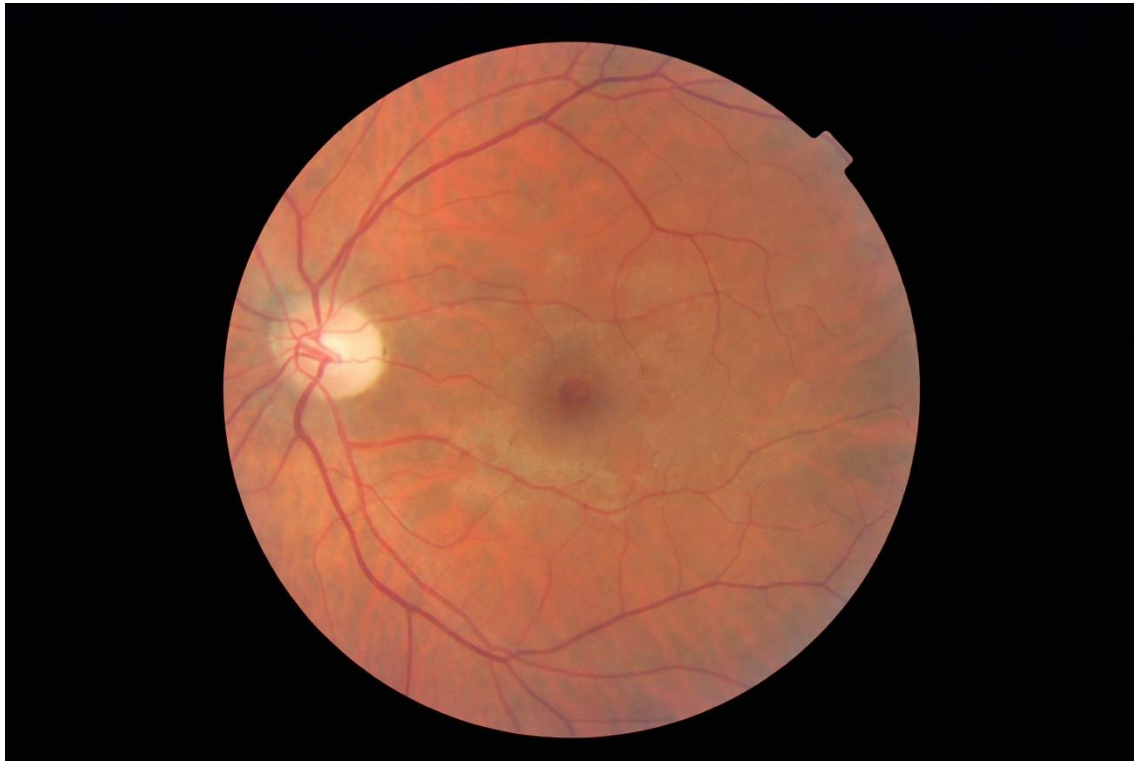
traction

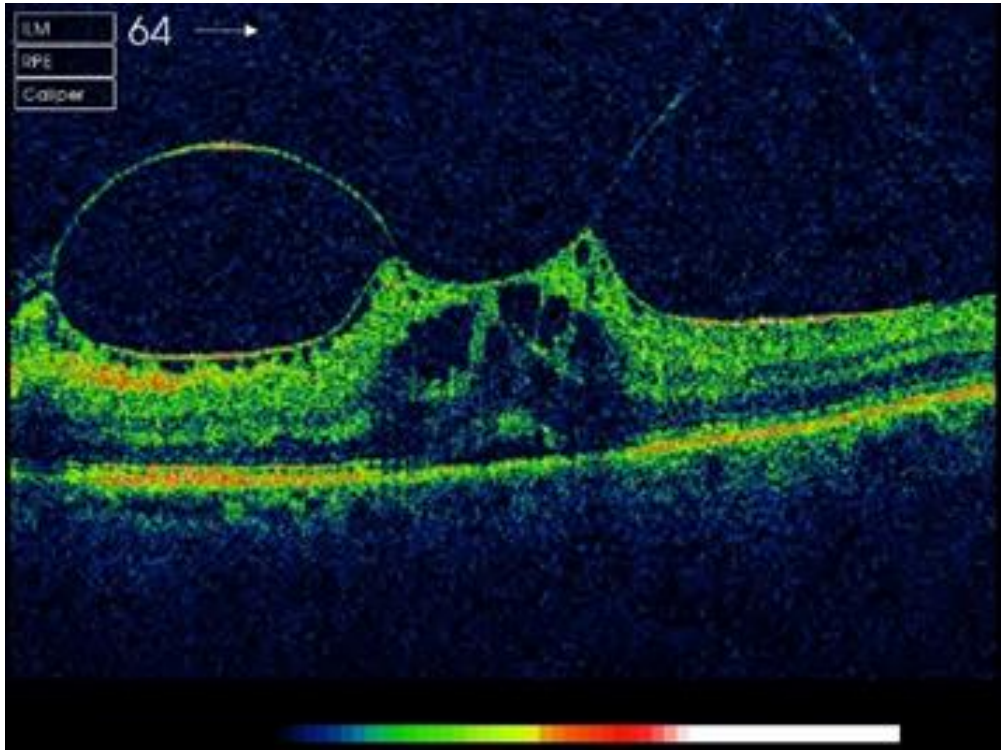


Vitreo-Macular Traction (non DR)

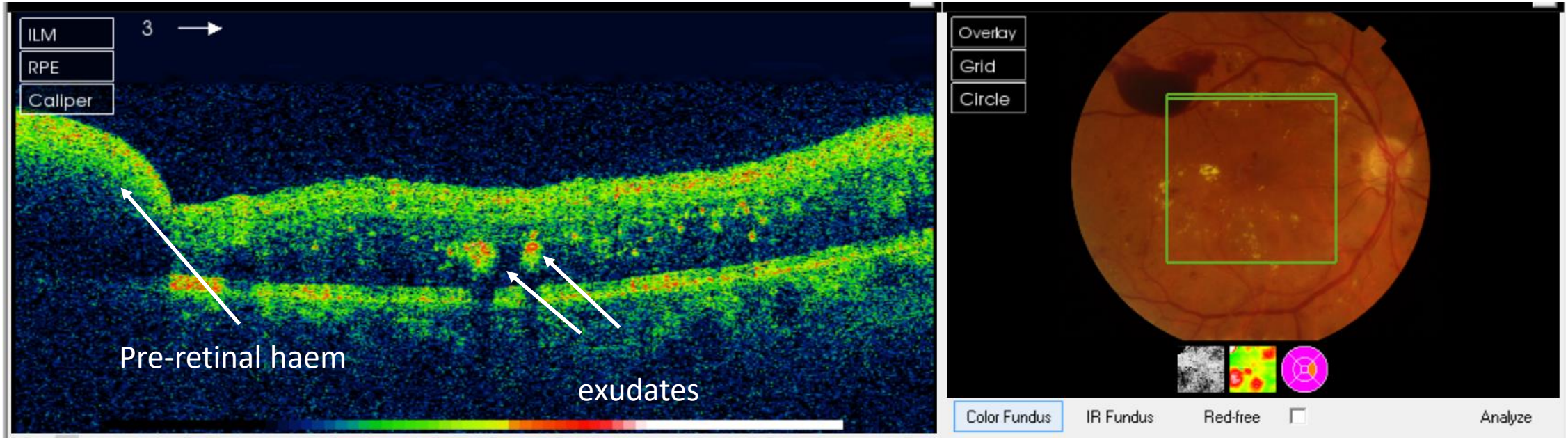


Vitreo-Macular Traction- requires VR referral

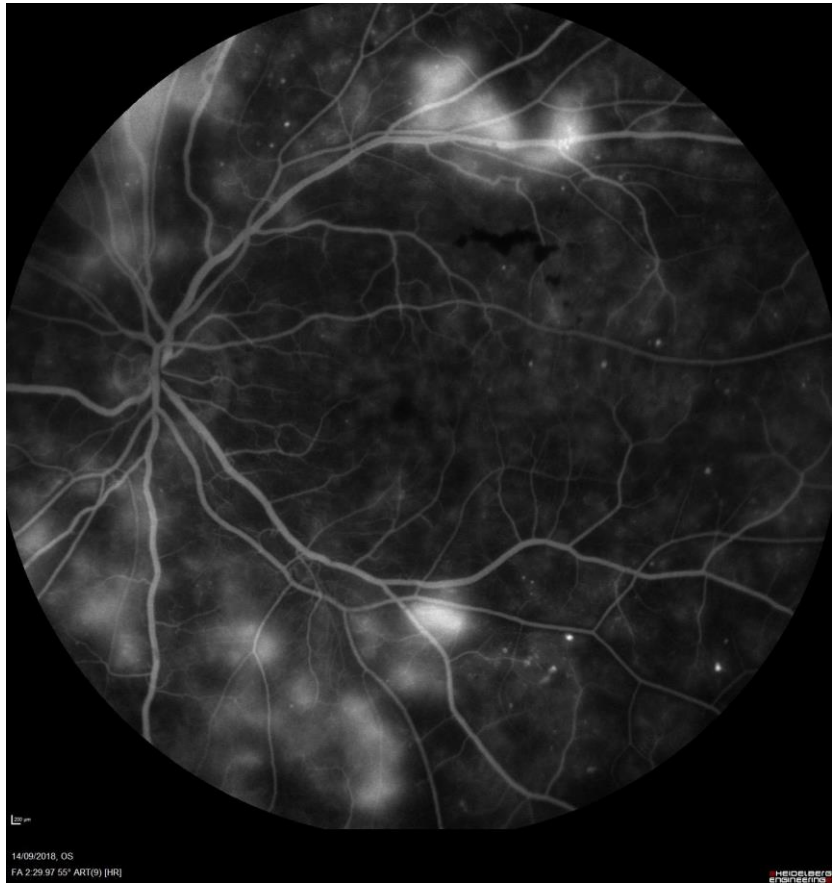


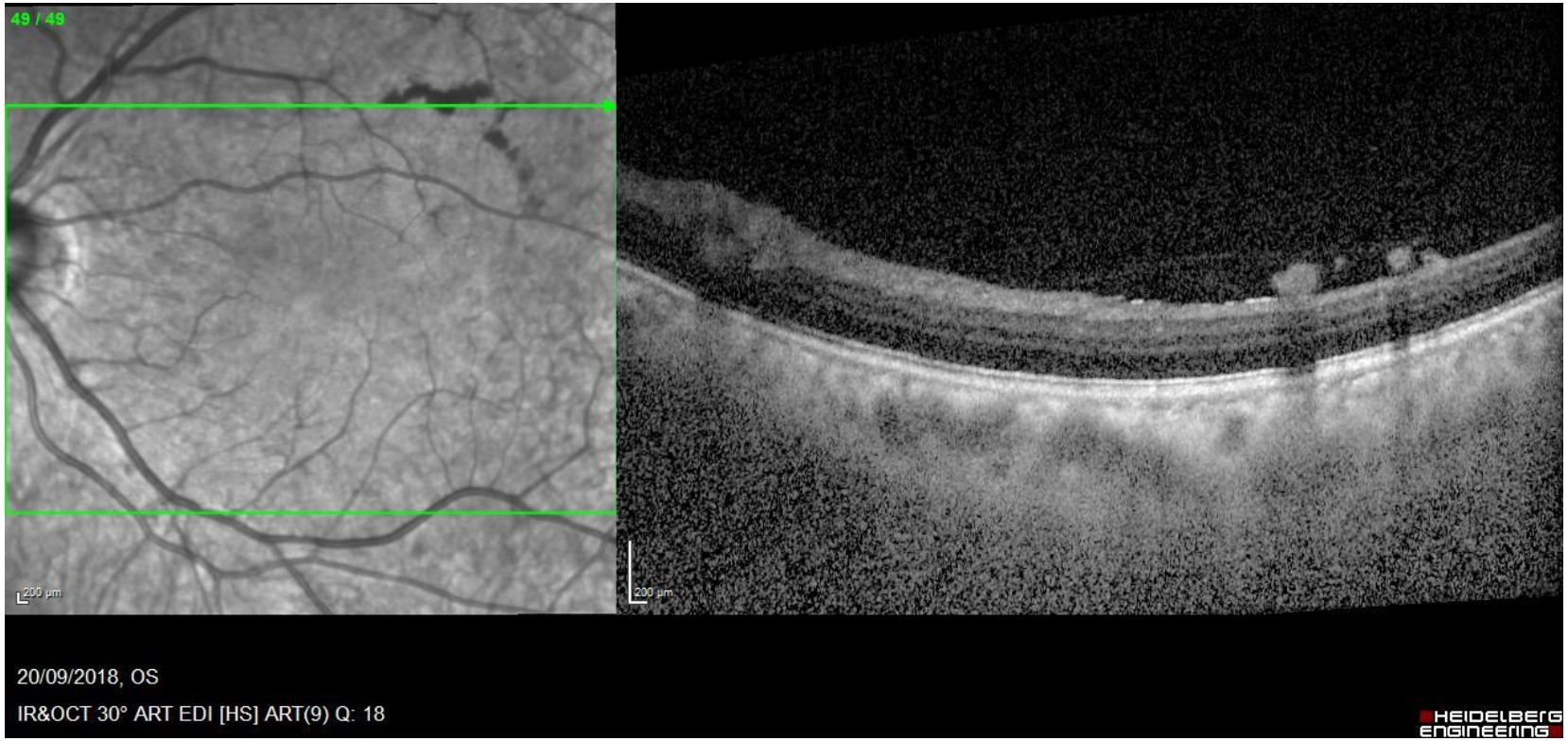


Pre-retinal Haemorrhage

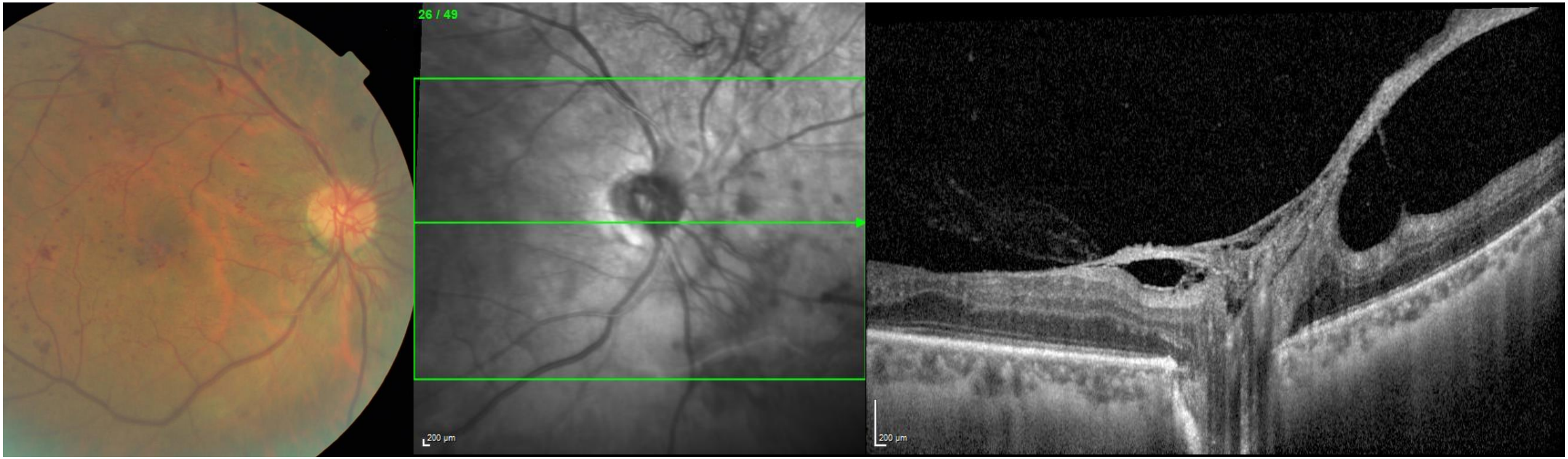


New Vessels Elsewhere

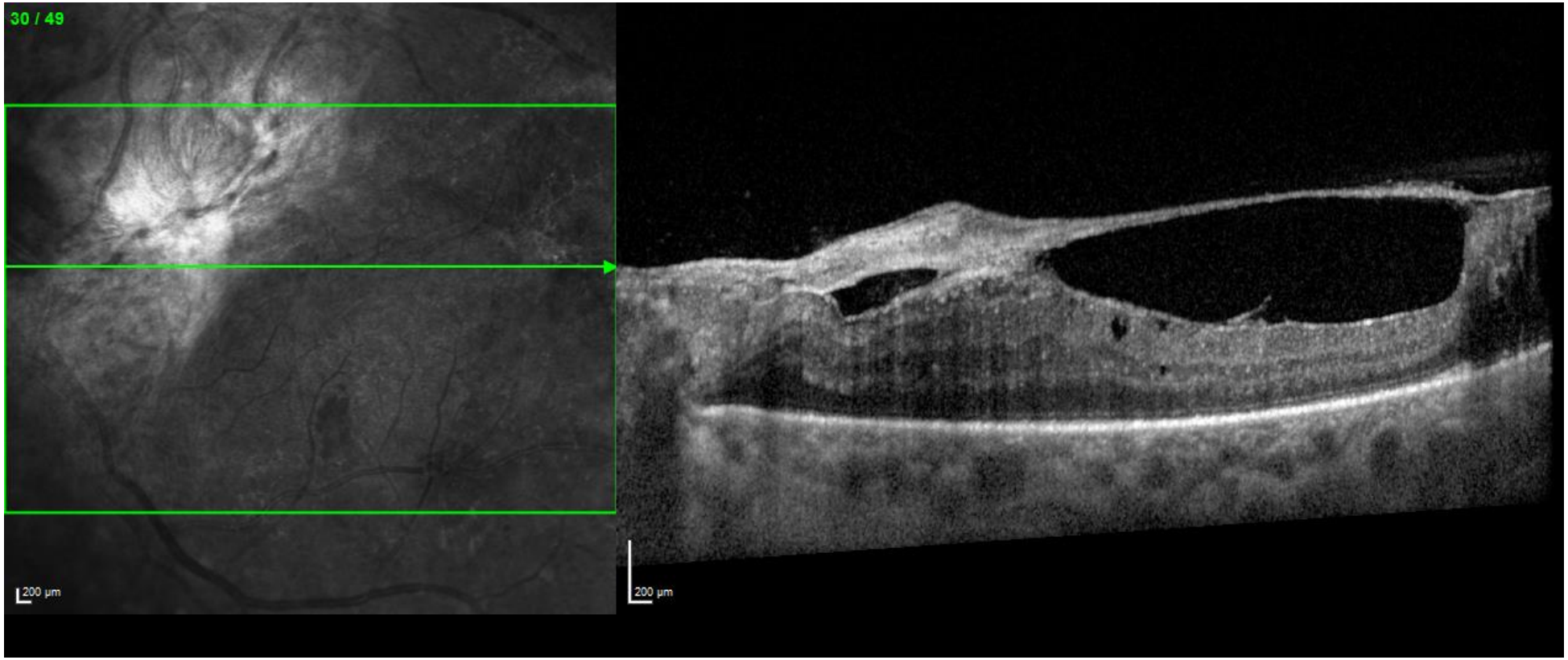




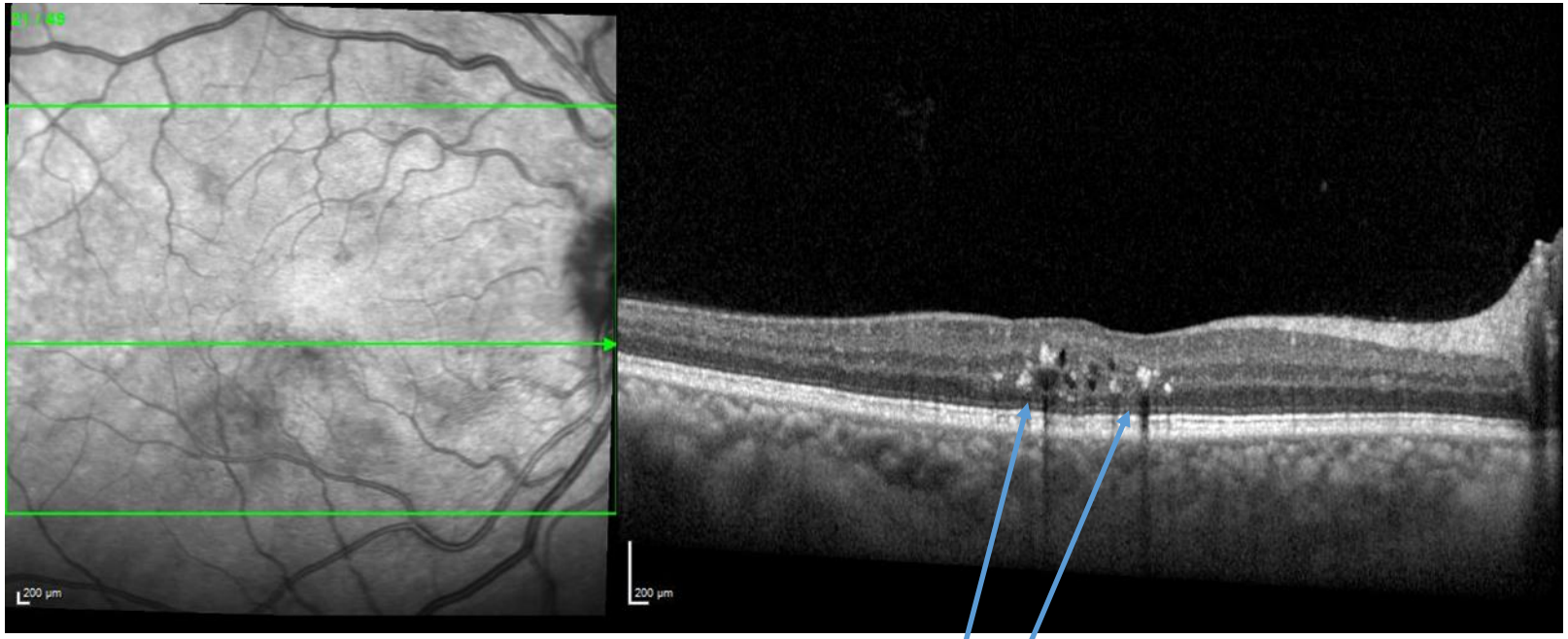
New Vessels at Disc



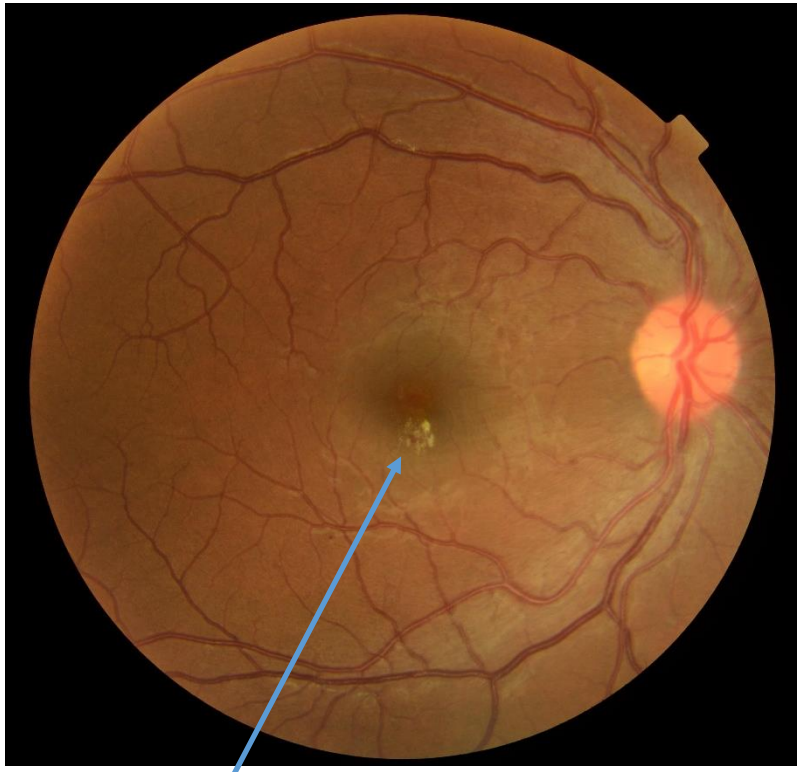
Traction retinal detachment- requires VR referral



Exudates/ microaneurysms

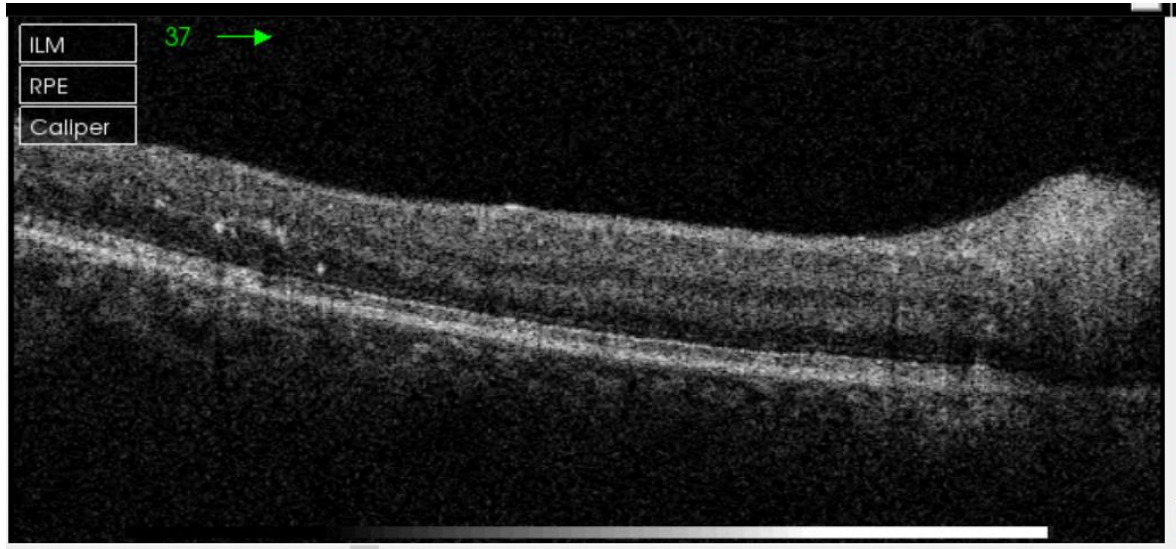


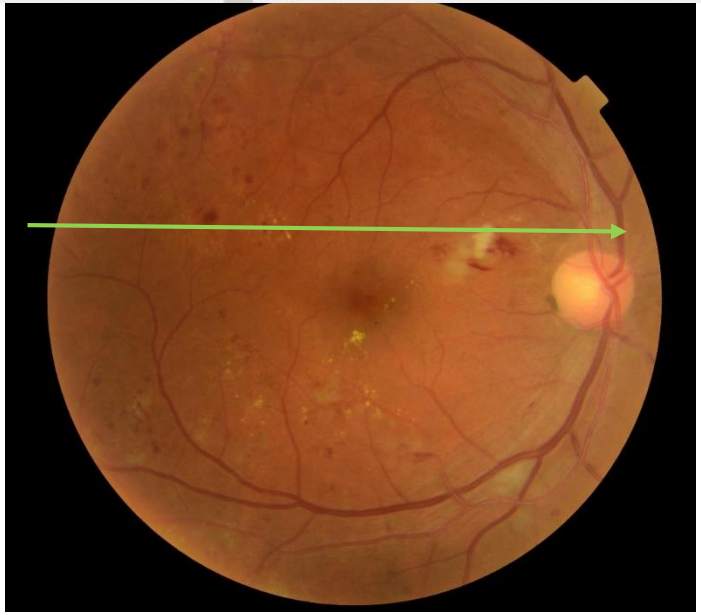
Exudates

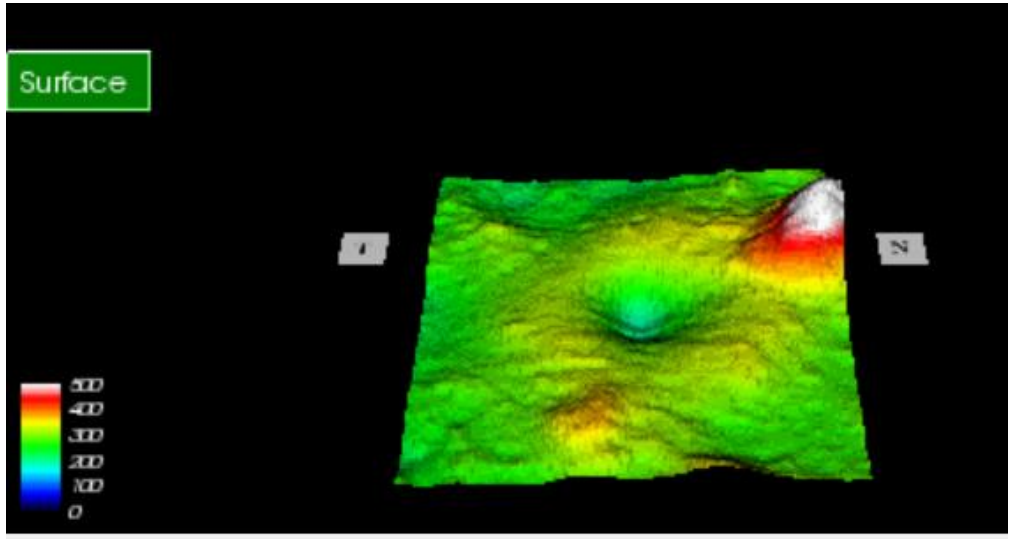


Exudates

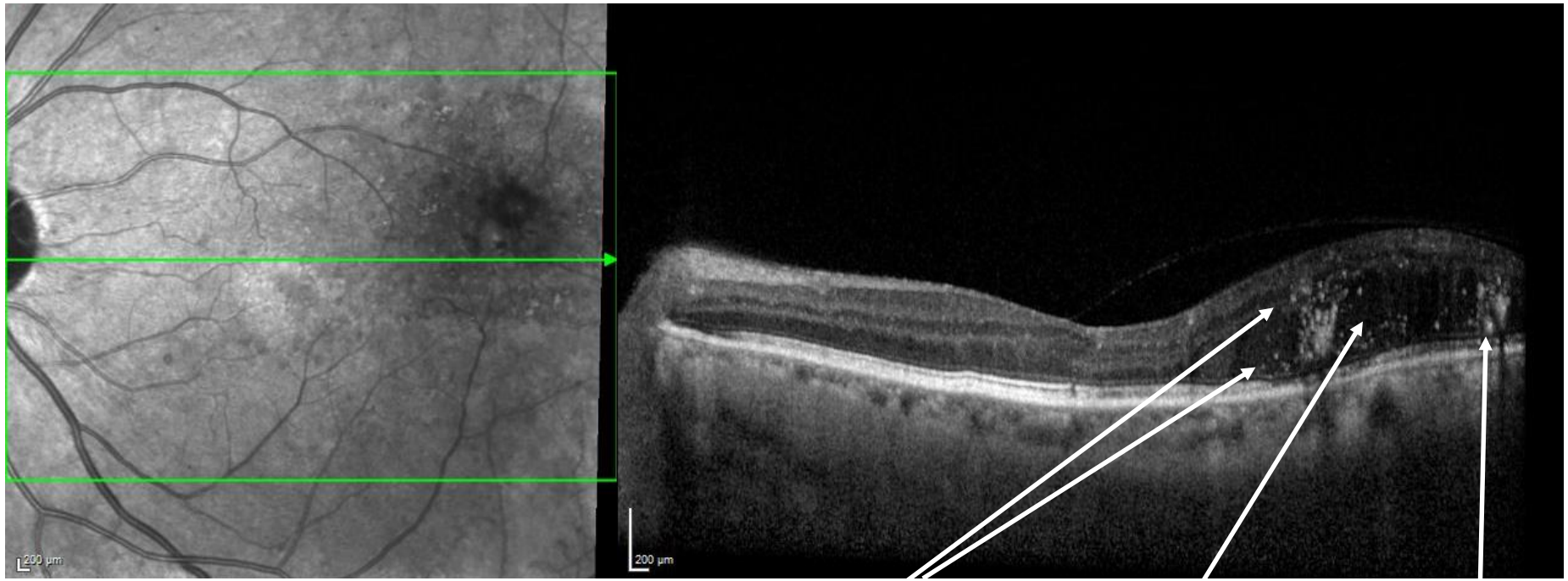
Cotton Wool Spots







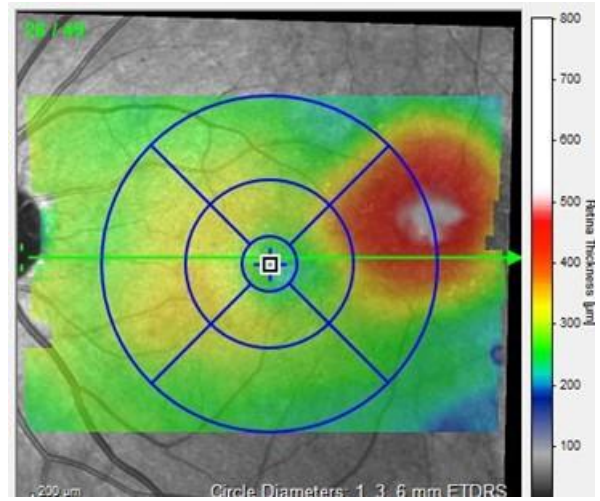
Diabetic Macular Odema (DMO)

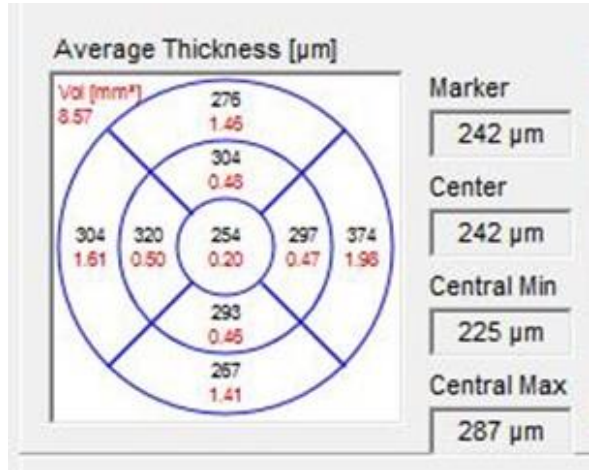


Hyper-reflective dots

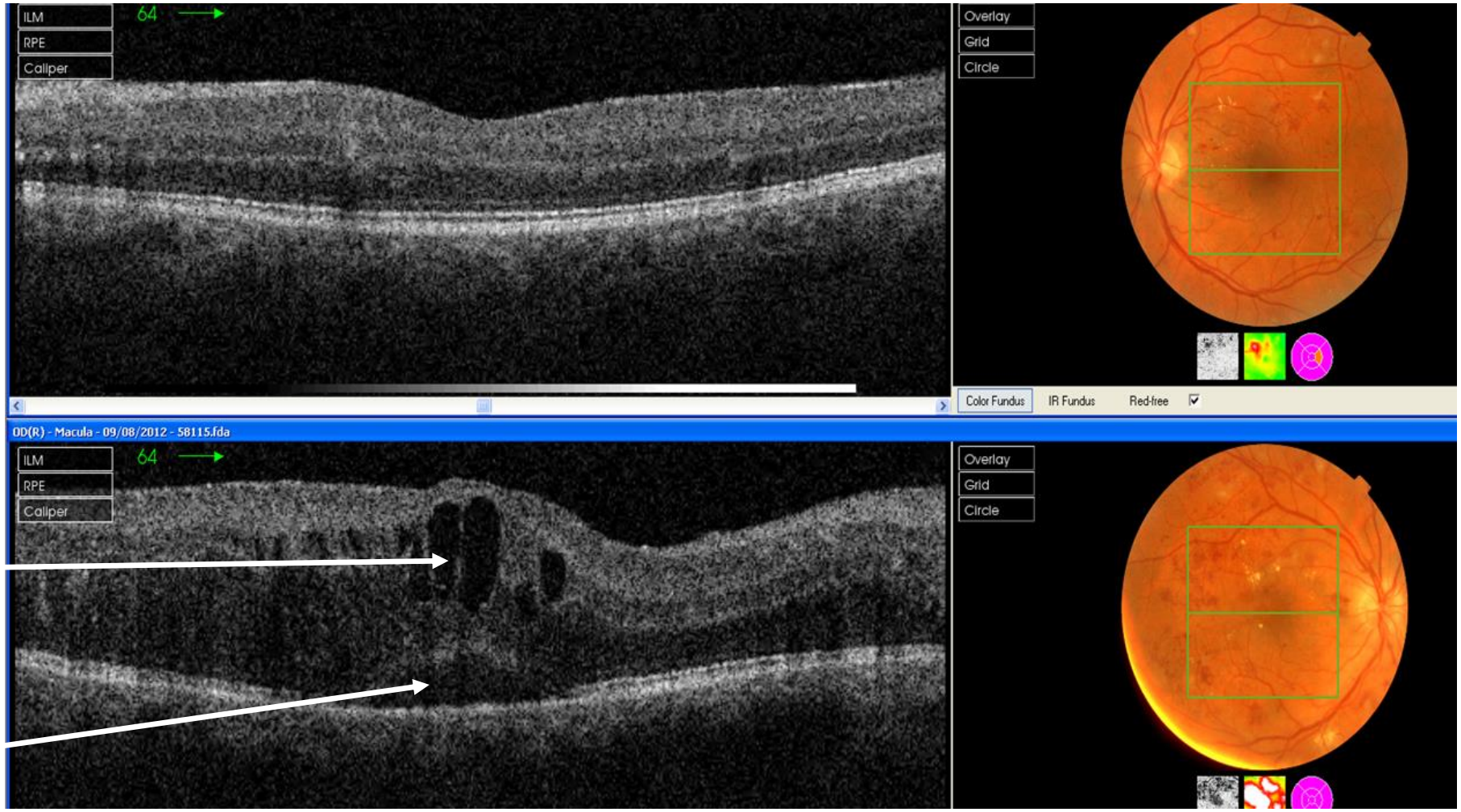
Intra-retinal cysts

Exudates





Diabetic Macular Odema (DMO)



Intra-retinal cysts

Sub-retinal fluid

DRIL

JAMA Ophthalmol. 2014 Nov;132(11):1309-16. doi: 10.1001/jamaophthalmol.2014.2350.

Disorganization of the retinal inner layers as a predictor of visual acuity in eyes with center-involved diabetic macular edema.

Sun JK[1], Lin MM[2], Lammer J[3], Prager S[4], Sarangi R[5], Silva PS[1], Aiello LP[1].

Author information

Abstract

IMPORTANCE: Biomarkers that predict future visual acuity (VA) in eyes with baseline diabetic macular edema (DME) would substantively improve risk assessment, management decisions, and selection of eyes for clinical studies targeting DME.

OBJECTIVE: To determine whether baseline or early change in the novel spectral domain-optical coherence tomography (SD-OCT) parameter disorganization of the retinal inner layers (DRIL) is predictive of VA in eyes with center-involved DME.

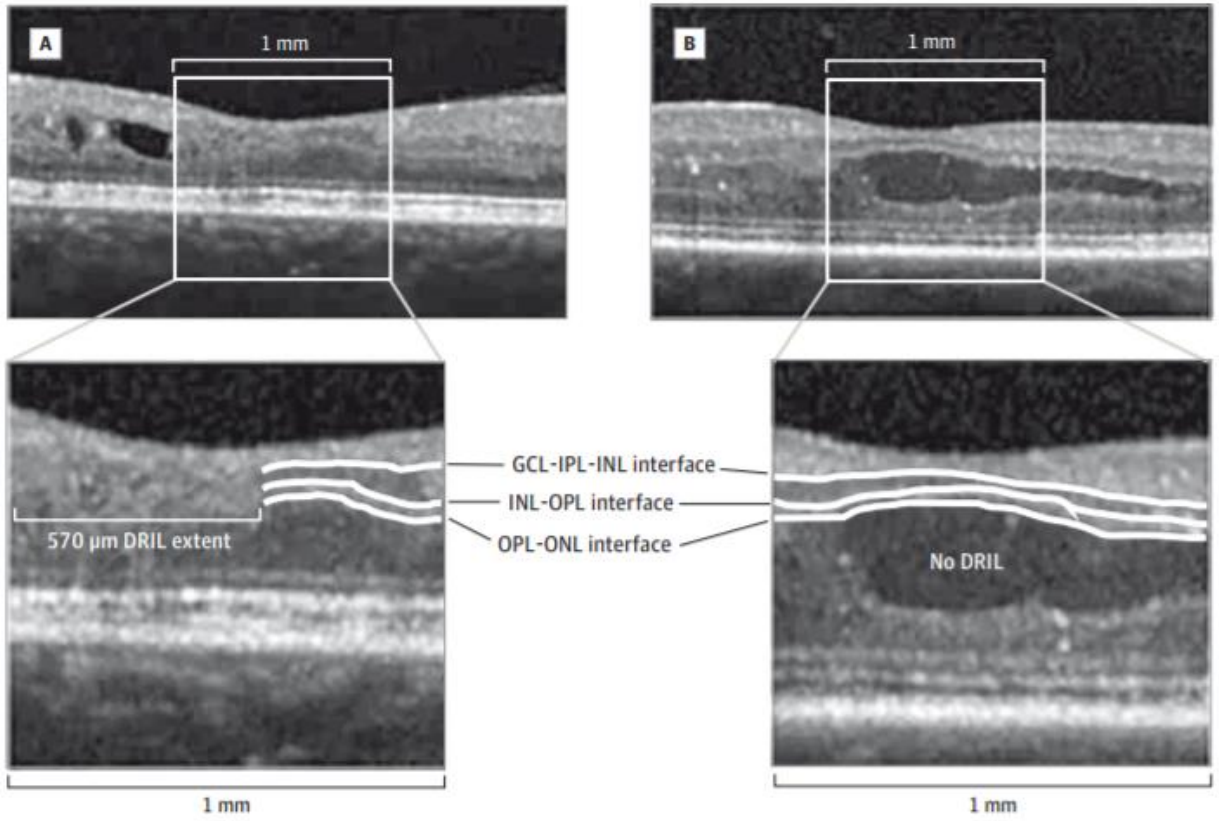
DESIGN, SETTING, AND PARTICIPANTS: At a tertiary care referral center for diabetic eye disease, a retrospective, longitudinal cohort study obtained demographics, VA, and SD-OCT images from baseline, 4-month, and 8-month visits in 96 participants (120 eyes) with diabetes mellitus and baseline center-involved DME (SD-OCT central subfield thickness, ≥ 320 μm for men and ≥ 305 μm for women). Exclusion criteria included substantial media opacity, cataract surgery within 6 months, and nondiabetic retinal pathology affecting VA. On SD-OCT, the 1-mm-wide retinal area centered on the fovea was evaluated by masked graders for DRIL extent, cysts, hyperreflective foci, microaneurysms, cone outer segment tip visibility, and external limiting membrane or photoreceptor disruption and reflectivity.

MAIN OUTCOMES AND MEASURES: Visual acuity and SD-OCT-derived retinal morphology.

RESULTS: Greater DRIL extent at baseline correlated with worse baseline VA (point estimate, 0.04; 95% CI, 0.02-0.05 per 100 μm; P < .001). An increase in DRIL during 4 months was associated with VA worsening at 8 months (point estimate, 0.03; 95% CI, 0.02-0.05 per 100 μm; P < .001). A multivariate model that included a 4-month change in VA, DRIL, and external limiting membrane disruption was predictive of an 8-month VA change (r = 0.80). Each approximately 300-μm DRIL increase during 4 months predicted a 1-line, 8-month VA

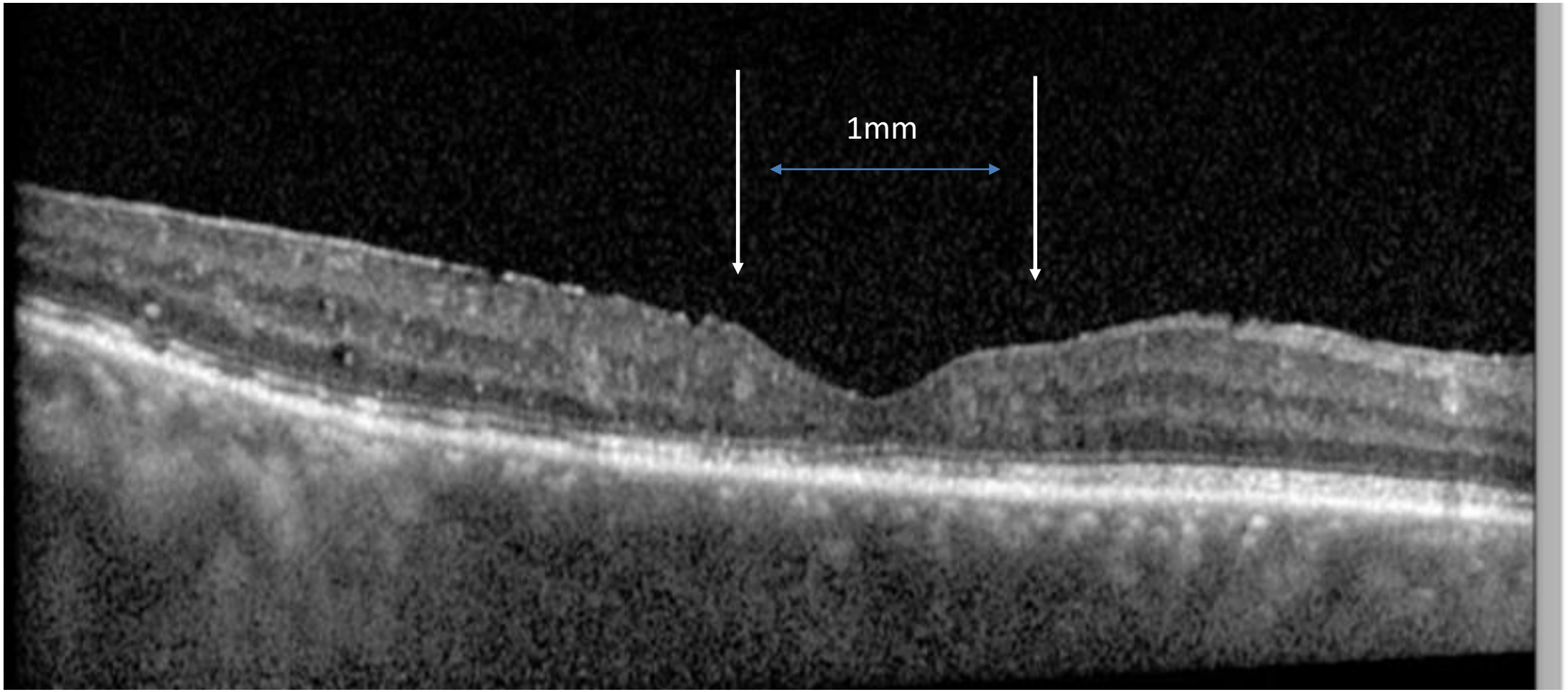
DRIL associated with worsening VA

Figure 1. Representative Images of the Presence or Absence of Disorganization of the Retinal Inner Layers (DRIL)

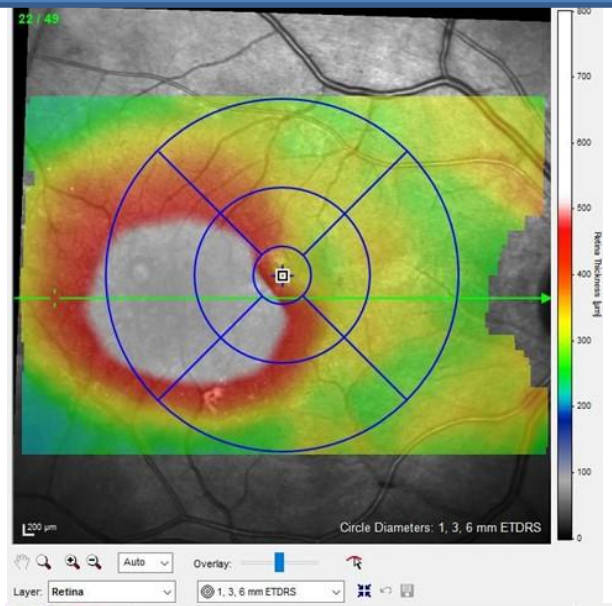


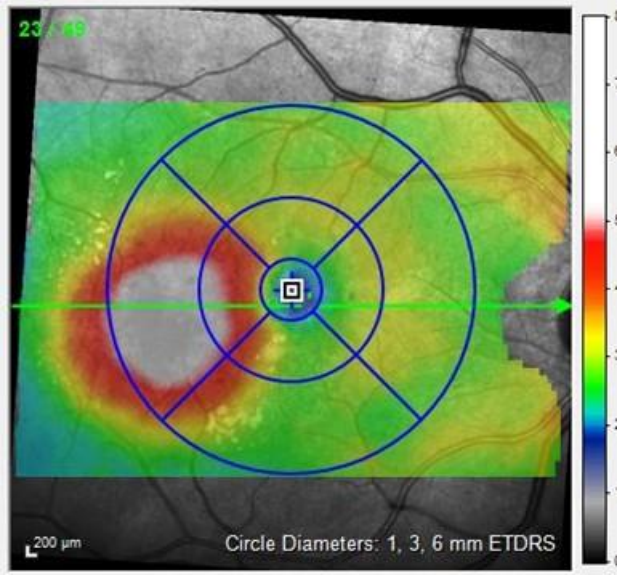
A, DRIL is present, and retinal layer boundaries can only be partially identified at the right-hand edge of the 1-mm box. B, DRIL is absent, and all retinal layer boundaries can be identified throughout the 1-mm box. The presence or absence of DRIL is independent of other pathology, such as intraretinal cystic changes. Insets are magnifications of the central 1-mm-wide area to show segmentation of the inner retinal layers, with white lines demarcating interfaces between ganglion cell–inner plexiform complex (GCL-IPL), inner nuclear layer (INL), outer plexiform layer (OPL), and outer nuclear layer (ONL).

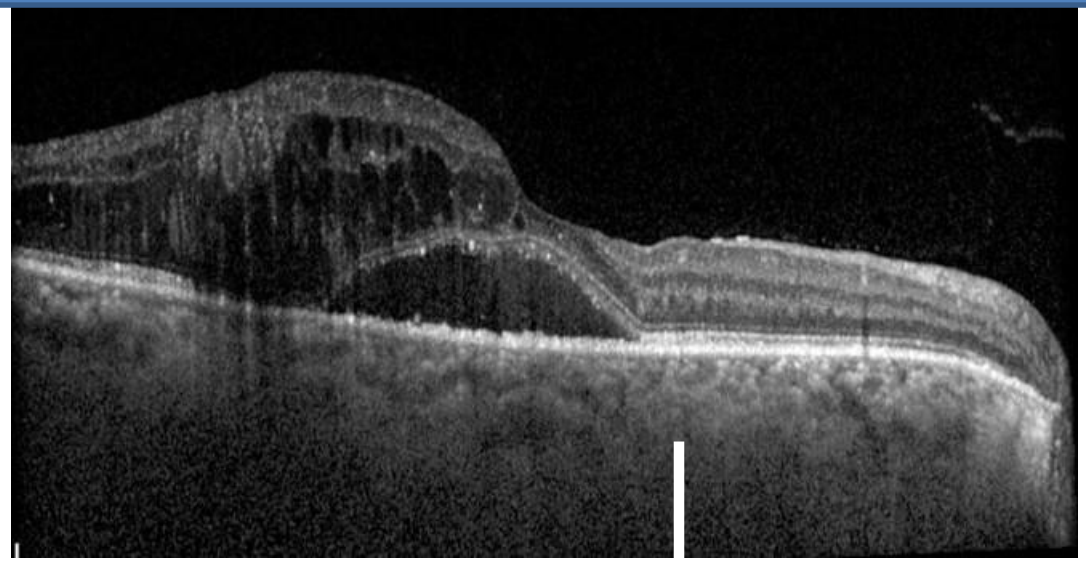
“Disorganisation of the Retinal Inner Layers”

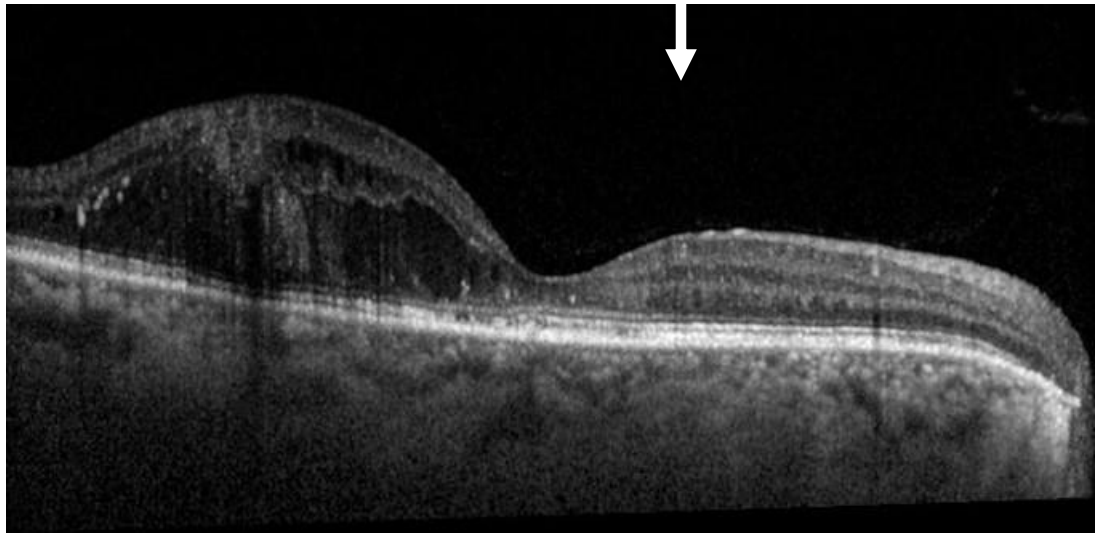


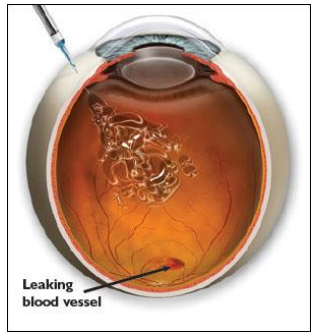
Centre-involving Clinically Significant Diabetic Macular Oedema





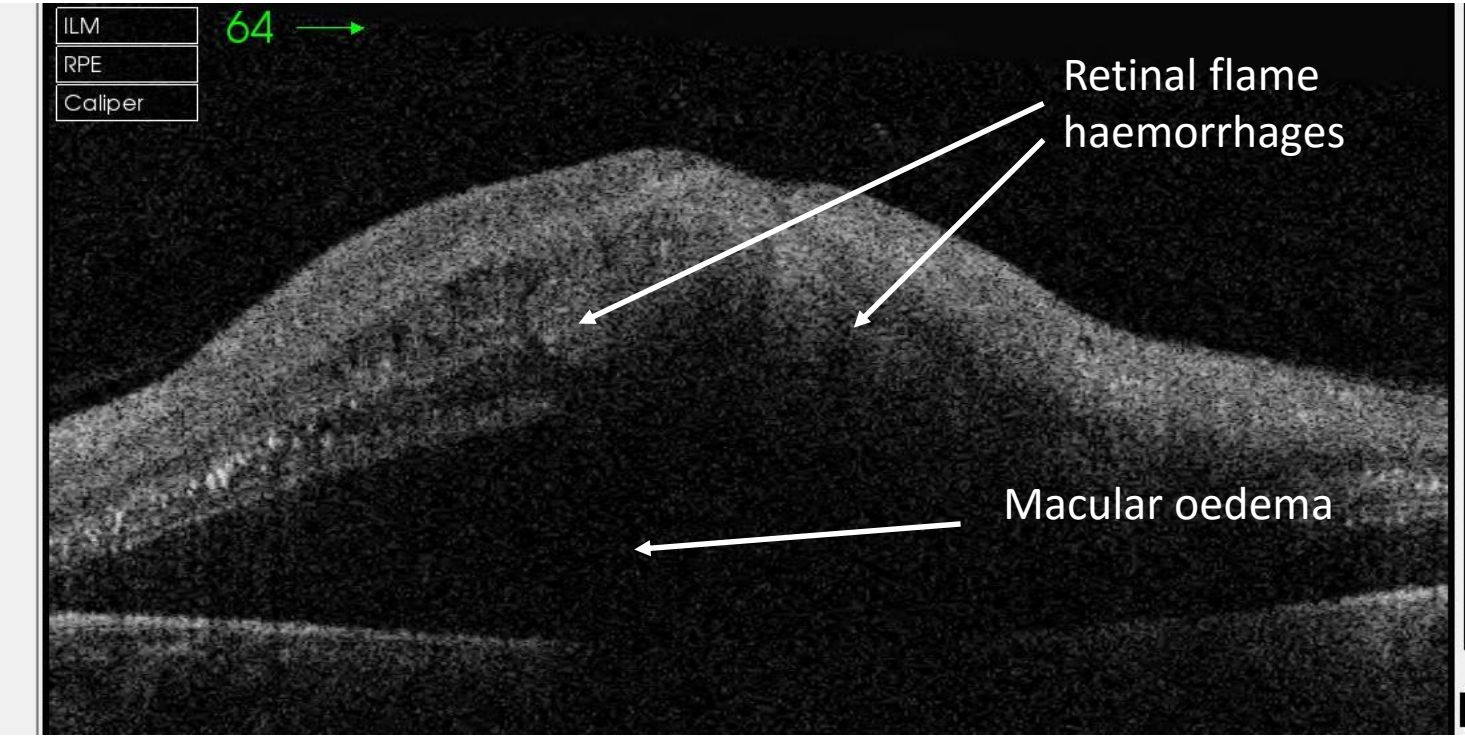


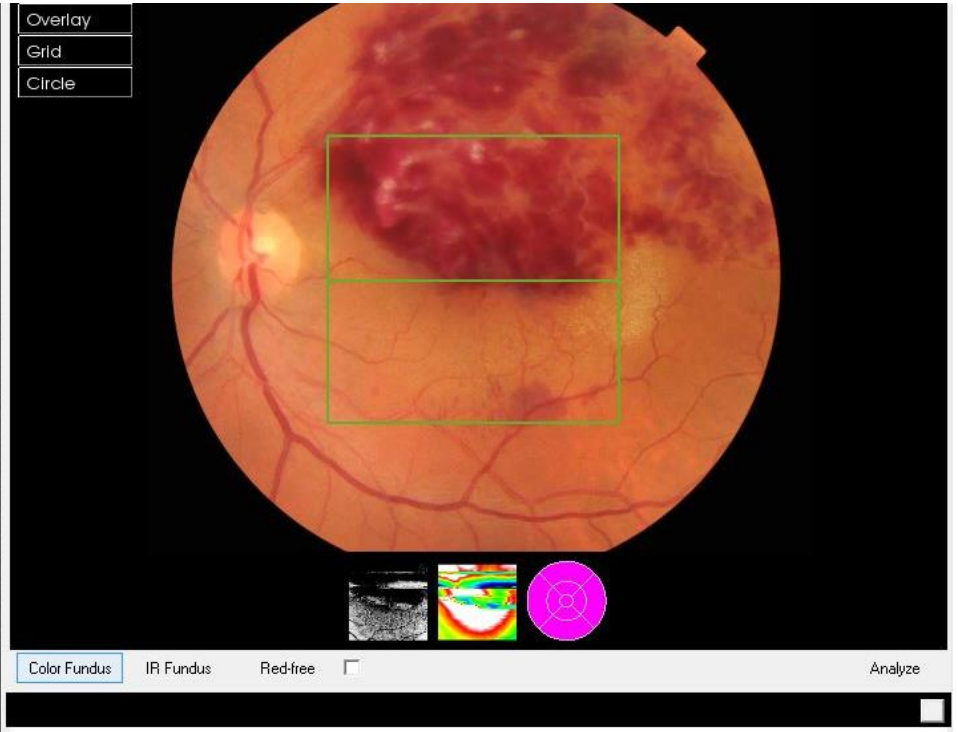




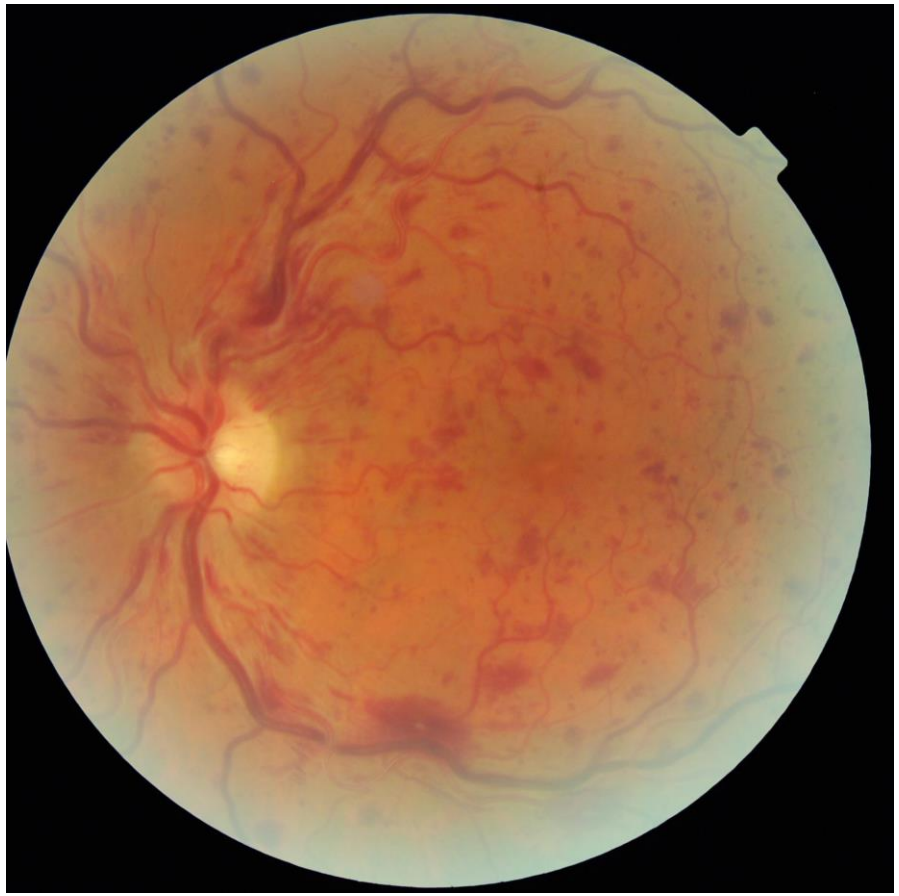
Retinal thickening Improved Post 4 anti-VEGF injections

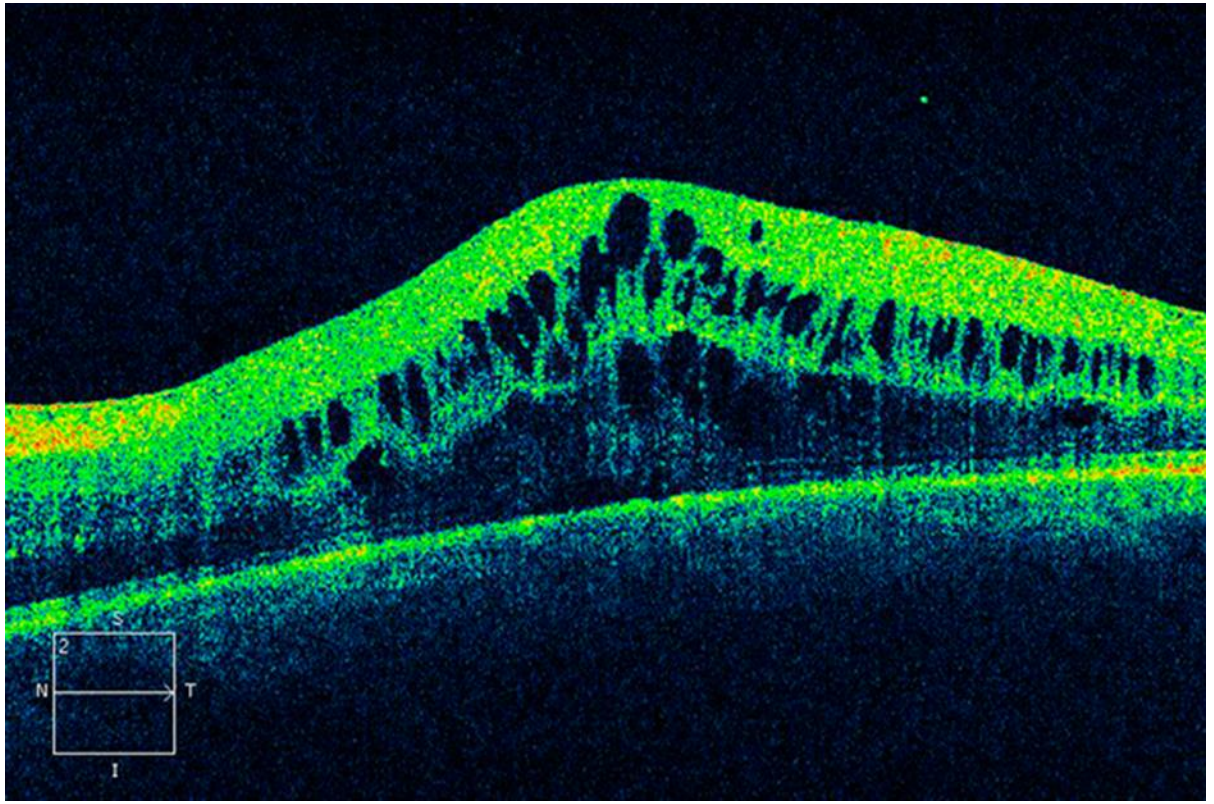
Branch Retinal Vein Occlusion- non DR





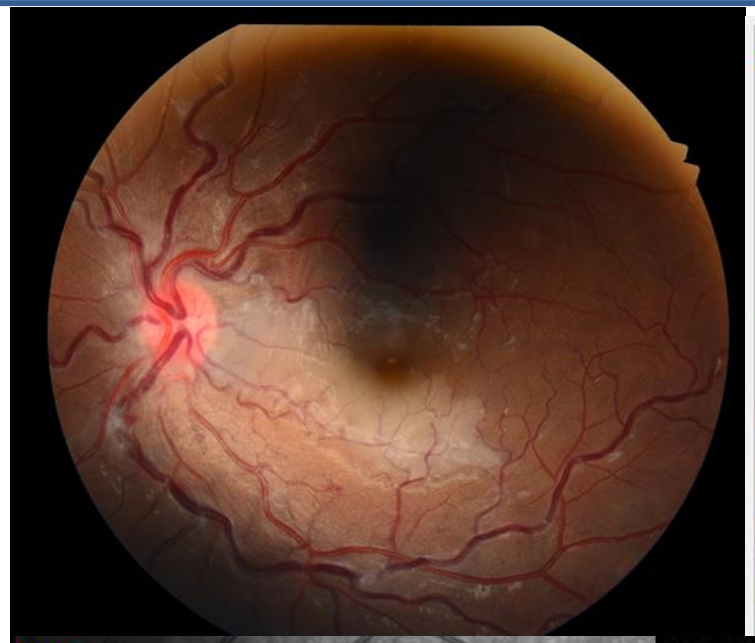
Central Retinal Vein Occlusion- non DR

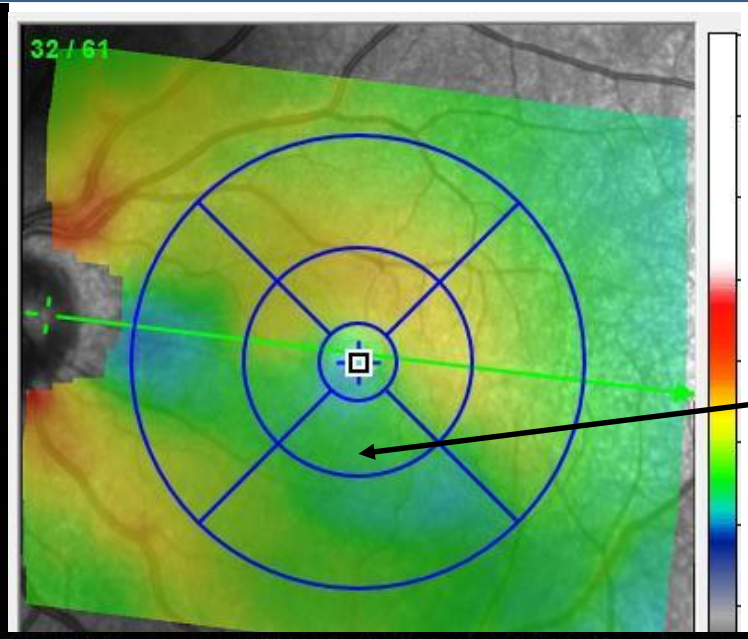




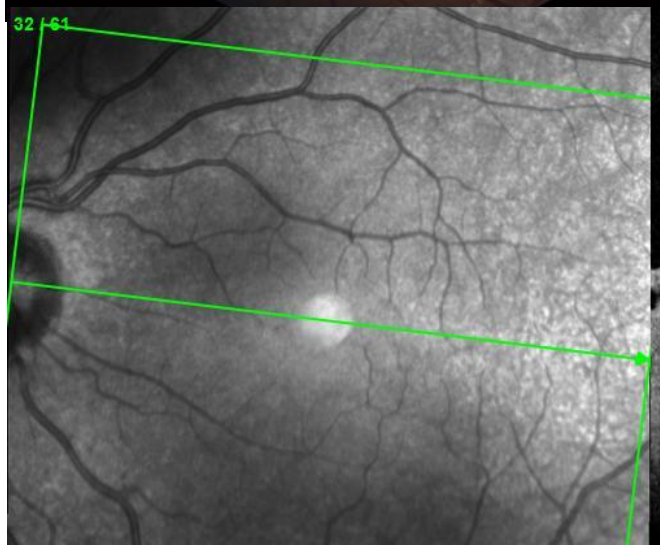
Cystoid macular oedema

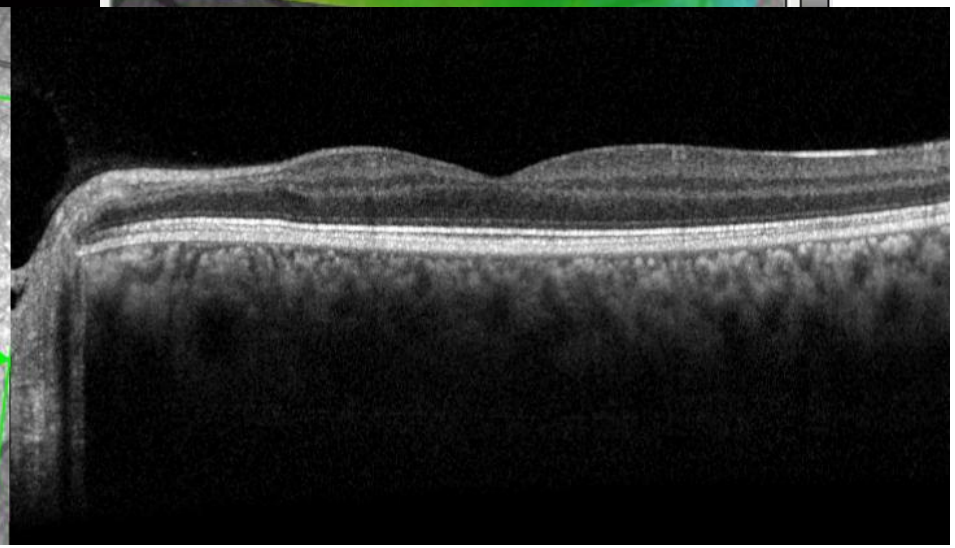
Branch Retinal artery Occlusion- non DR



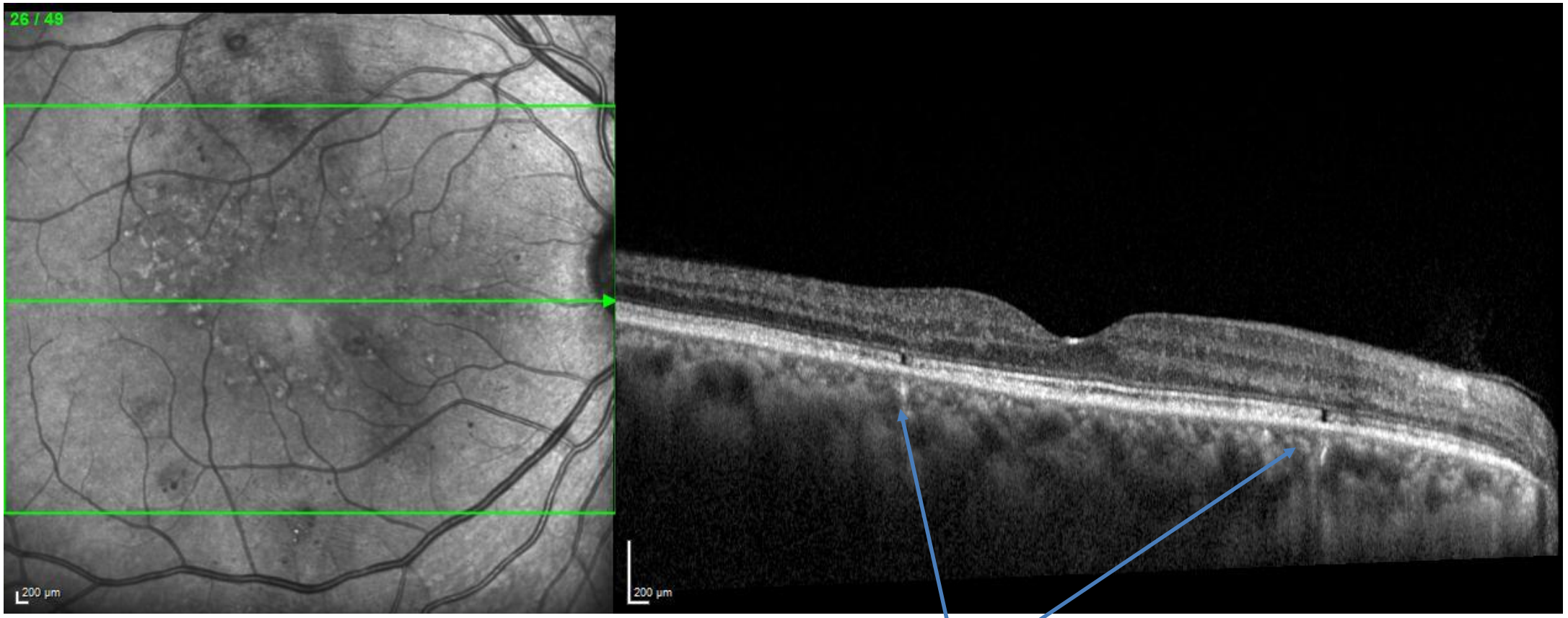


Retinal thinning



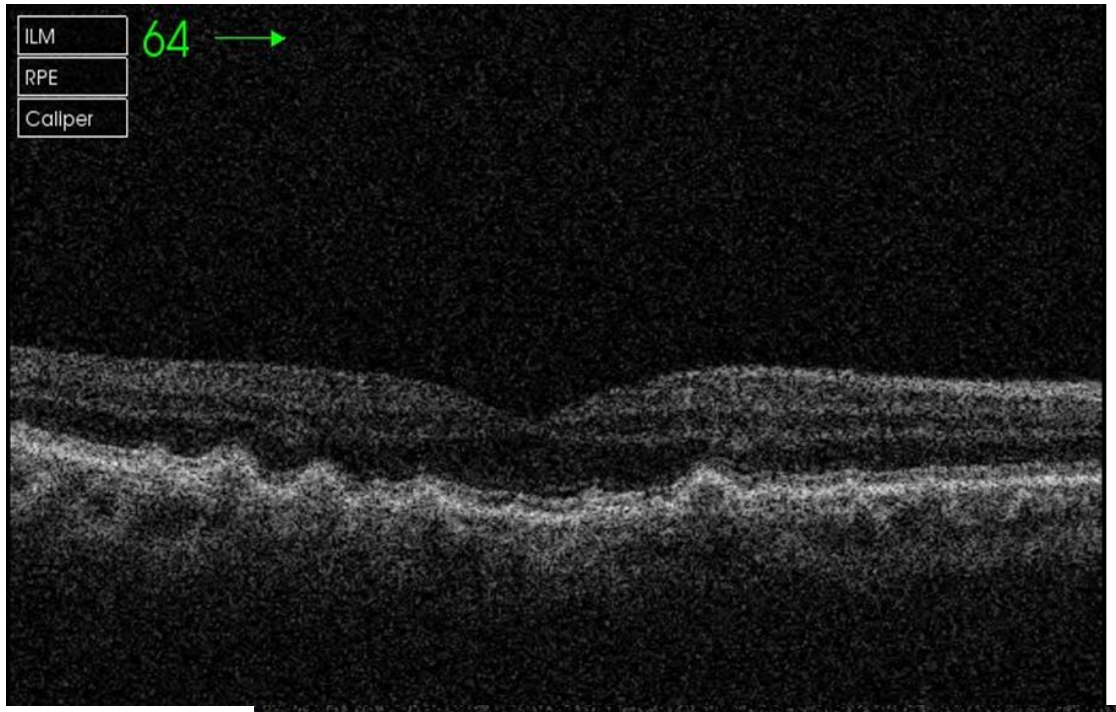


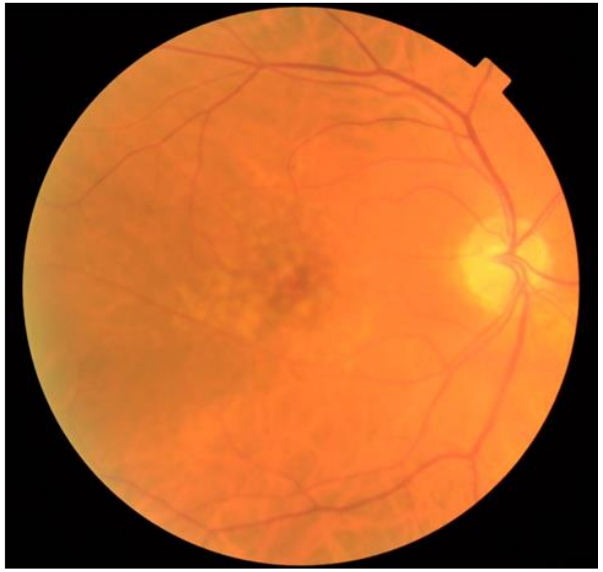
Laser Scars

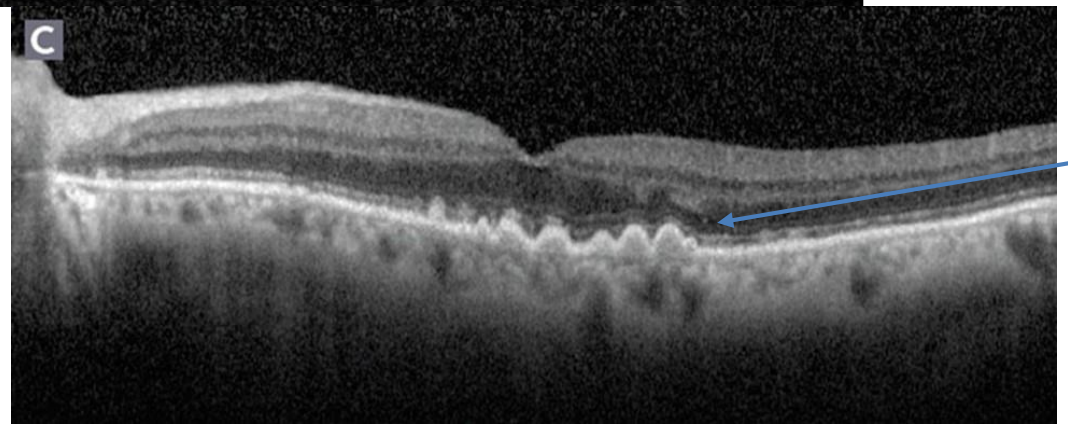


Laser scars in RPE/ photoreceptors

Macular drusen



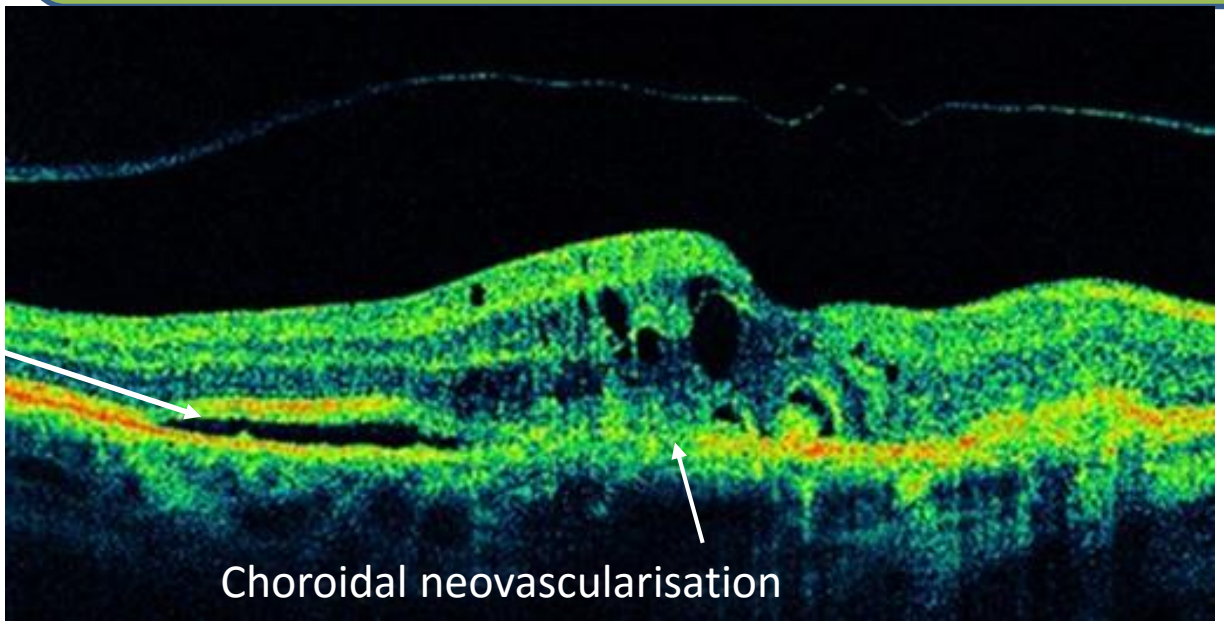


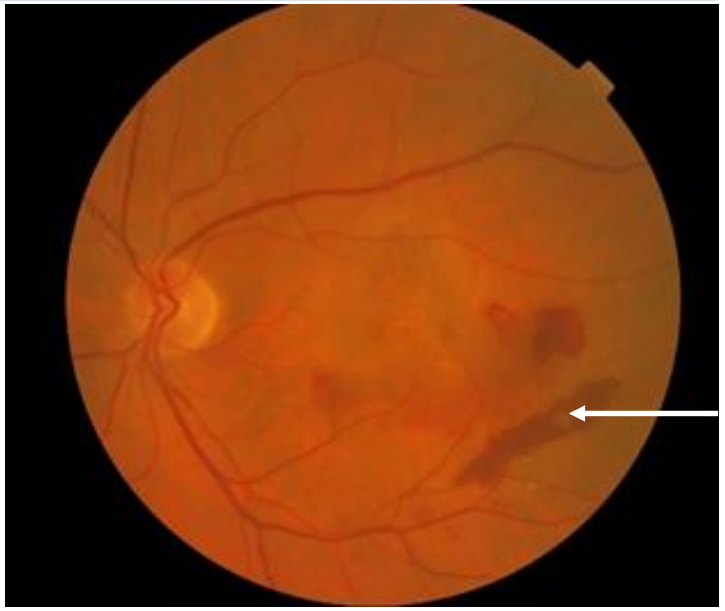


Drusen deposits in Bruch's membrane

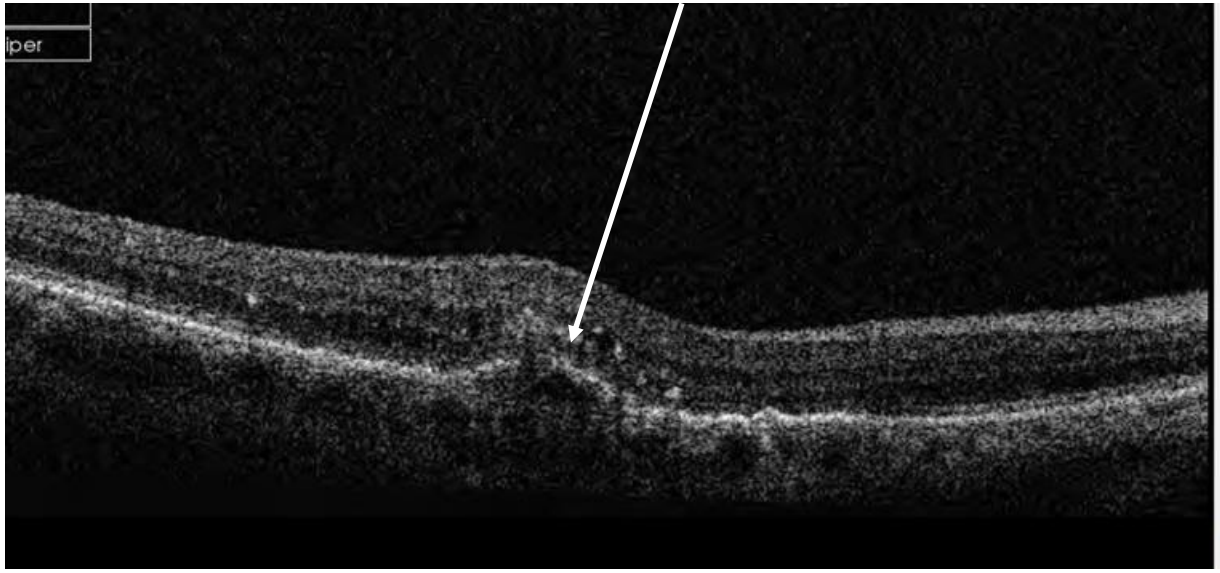
Wet Age-related Macular Degeneration

Sub-retinal fluid

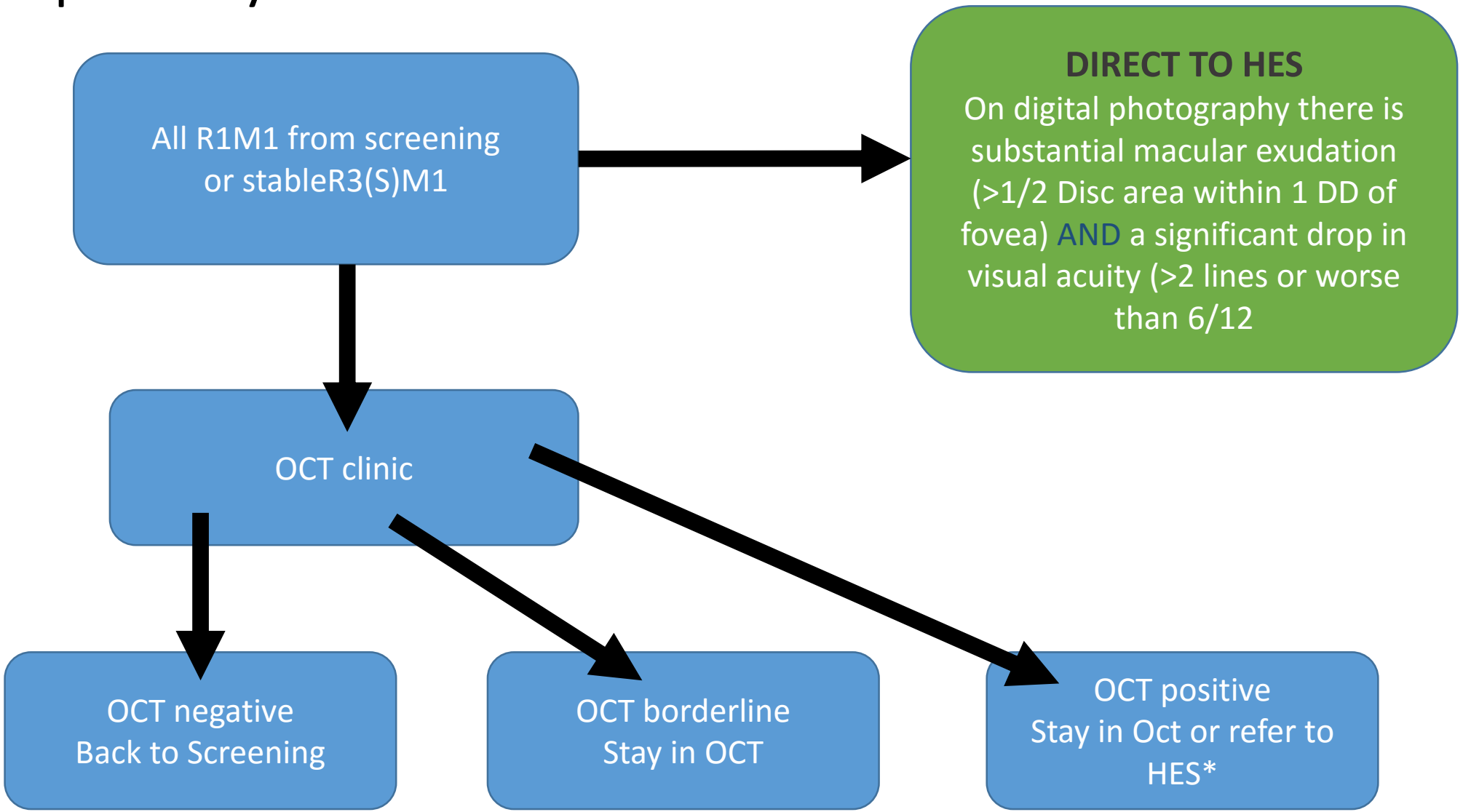




Sub-retinal haemorrhage

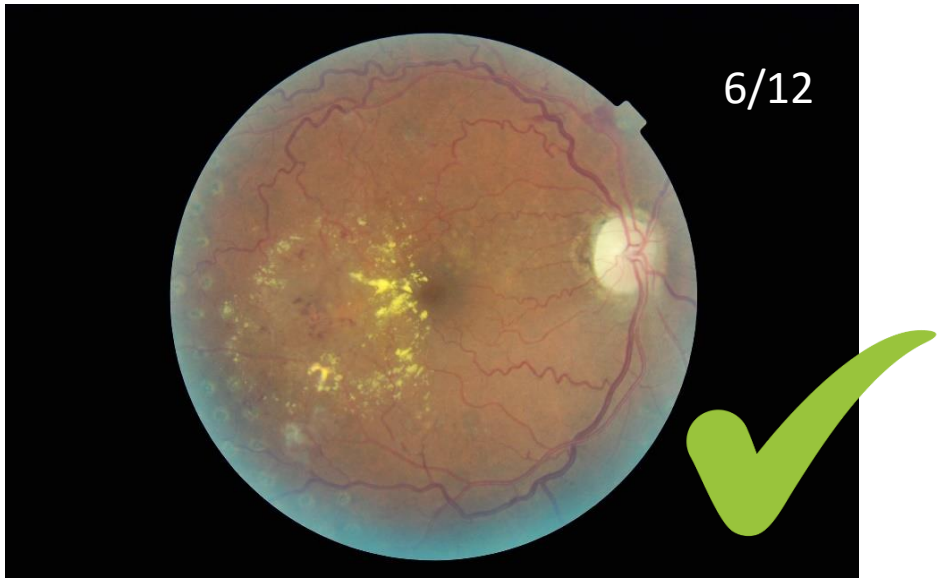


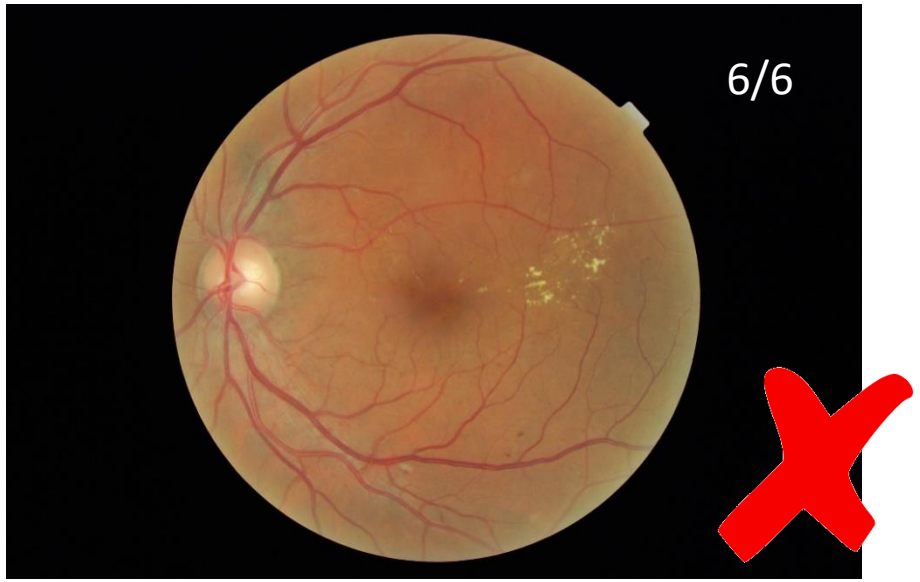
OCT pathway for M1's

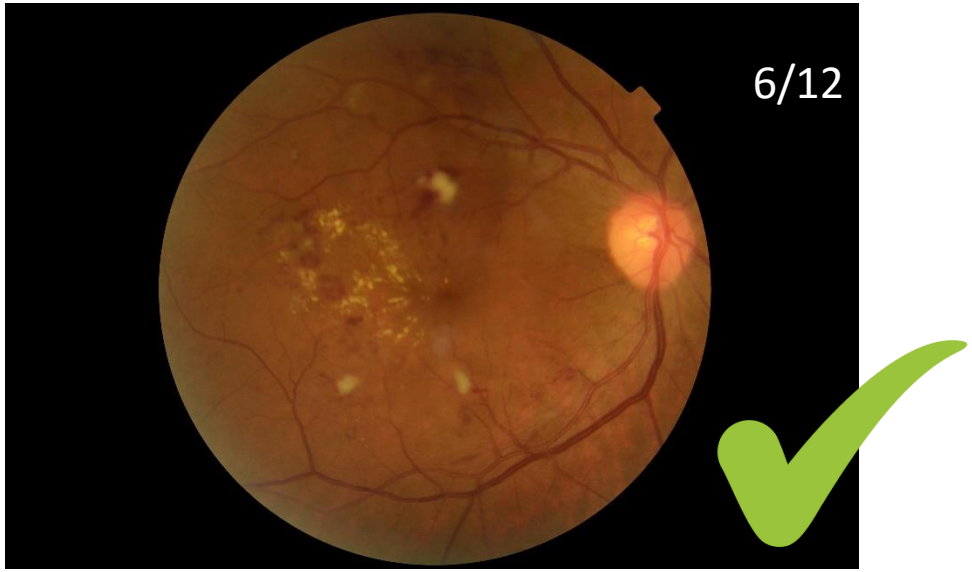


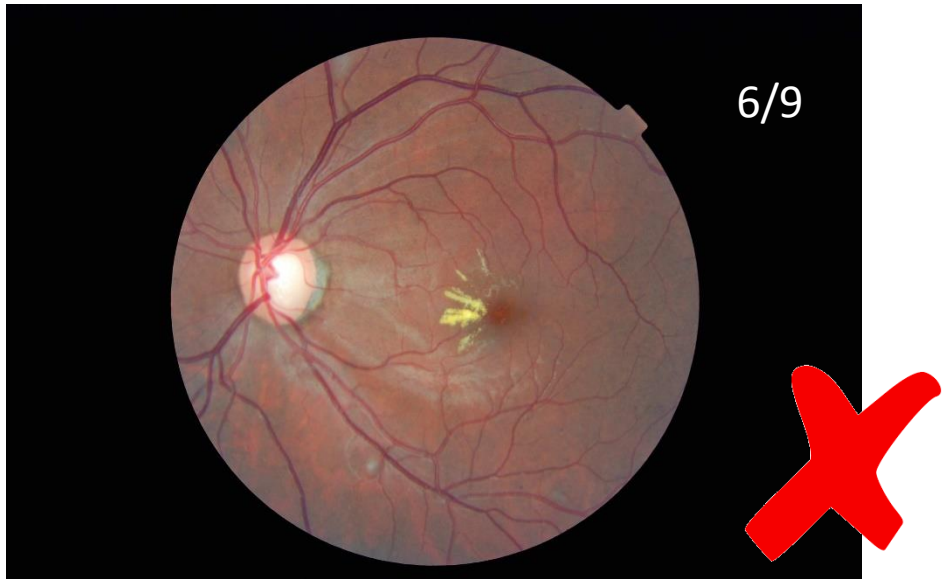
* According to local protocol

Direct to HES (>1/2 DA & VA 6/12 or worse)







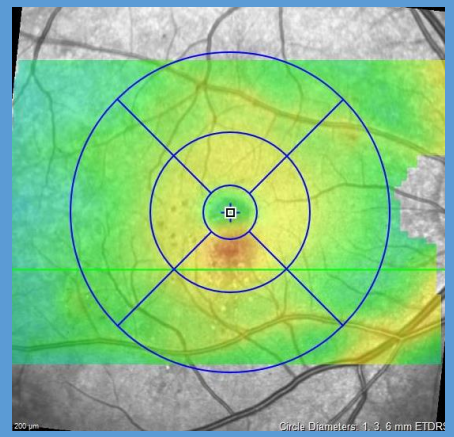


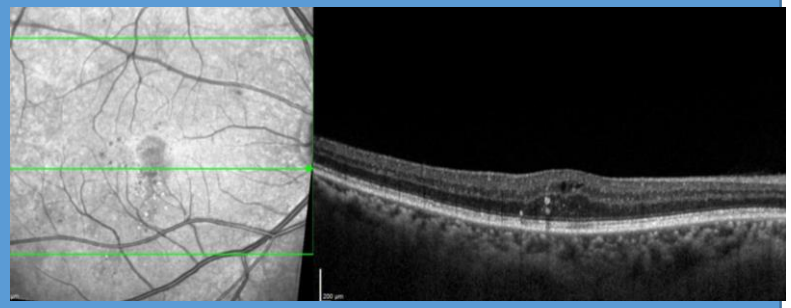
Definitions

OCT grade	OCT negative	OCT borderline	OCT positive
Diabetes	No intra-retinal cysts or subretinal fluid or solitary intraretinal lesion AND NO change in ILM contour BACK to SCREENING	Presence of intra-retinal cysts or solitary intra-retinal lesions (due to diabetes) AND NO change in ILM contour STAY IN SURVEILLANCE	1) Presence of intra-retinal cysts or intra-retinal lesions (due to diabetes) AND with a change in ILM contour 2) Parafoveal thickening of greater than 0.5 disc area 3) Area of thickening >1.0 disc area within the macula region 4) Any R3A REFER TO HES/STAY IN SURVEILLANCE* (local protocol)
Non DR			Wet AMD, Drusen, VMT, CRVO, BRVO

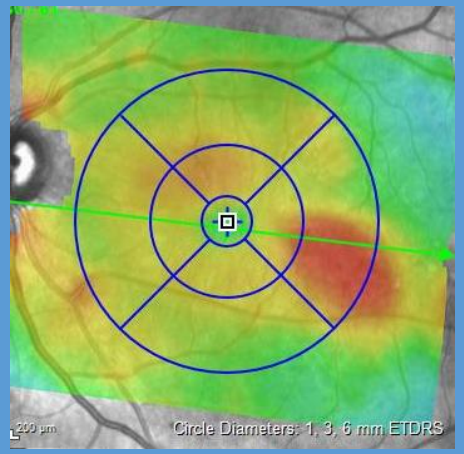
OCT positive -3 definitions

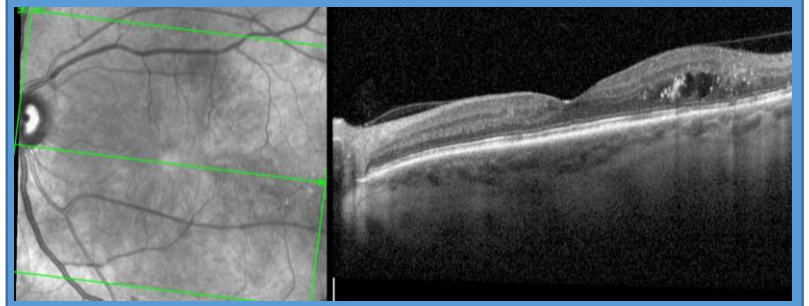
(1) An area of retinal thickening of greater than 1/2 disc area the edge of which is within 1 disc diameter of the central fovea



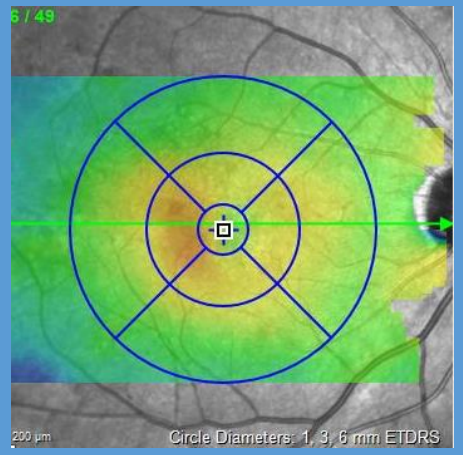


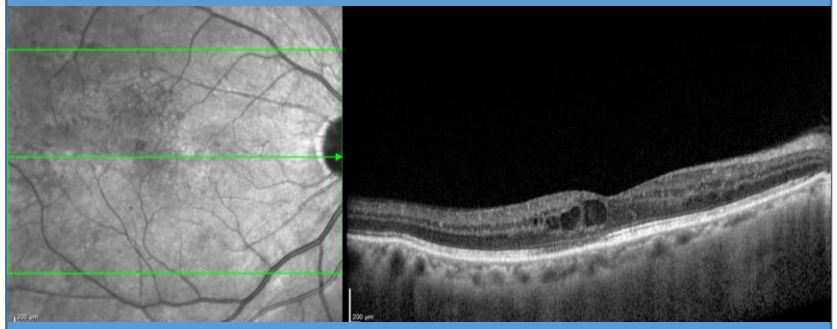
(2) An area of retinal thickening of greater than 1.0 disc area within the NHS DESP definition of the macula





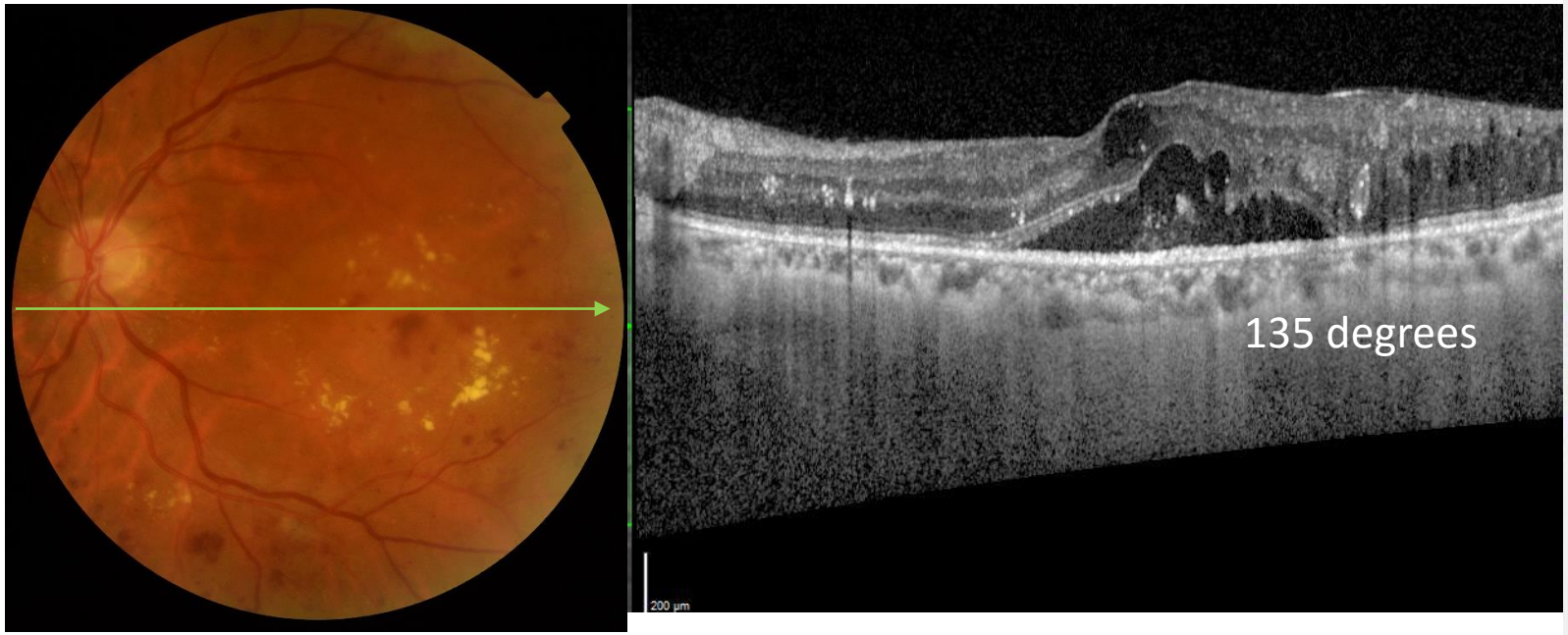
(3)Any cystic change or single lesion in the retina from diabetes resulting in a change of the foveal ILM contour

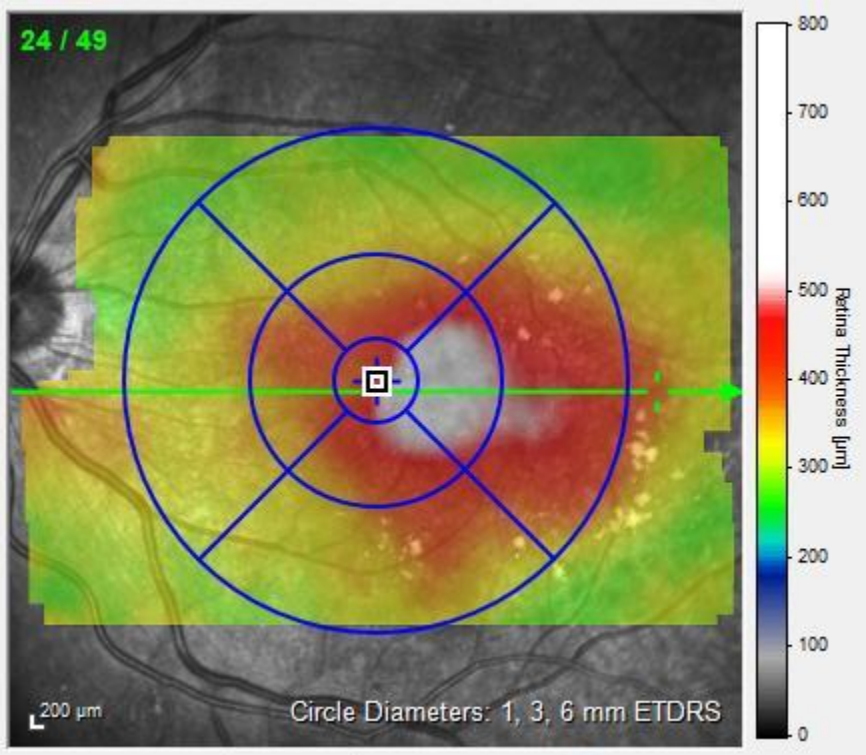




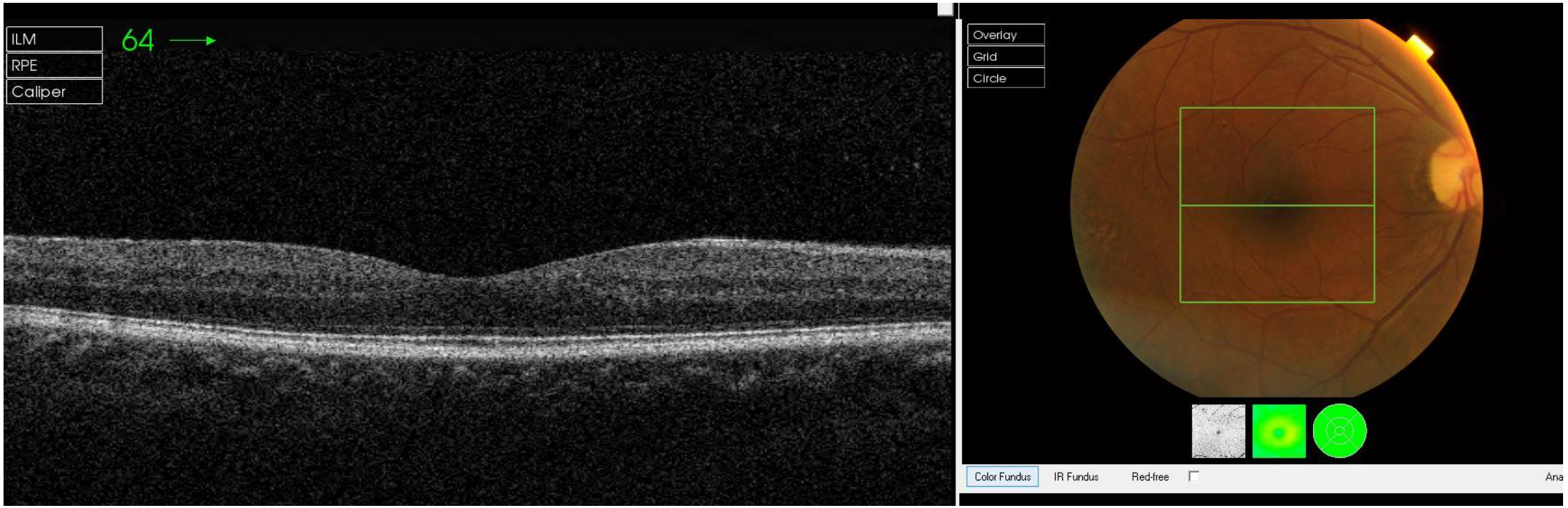
Severe Diabetic Macular oedema

>400 microns – central macular thickness
Fast track to Med Ret CLINIC For Anti-VEGF injection Therapy

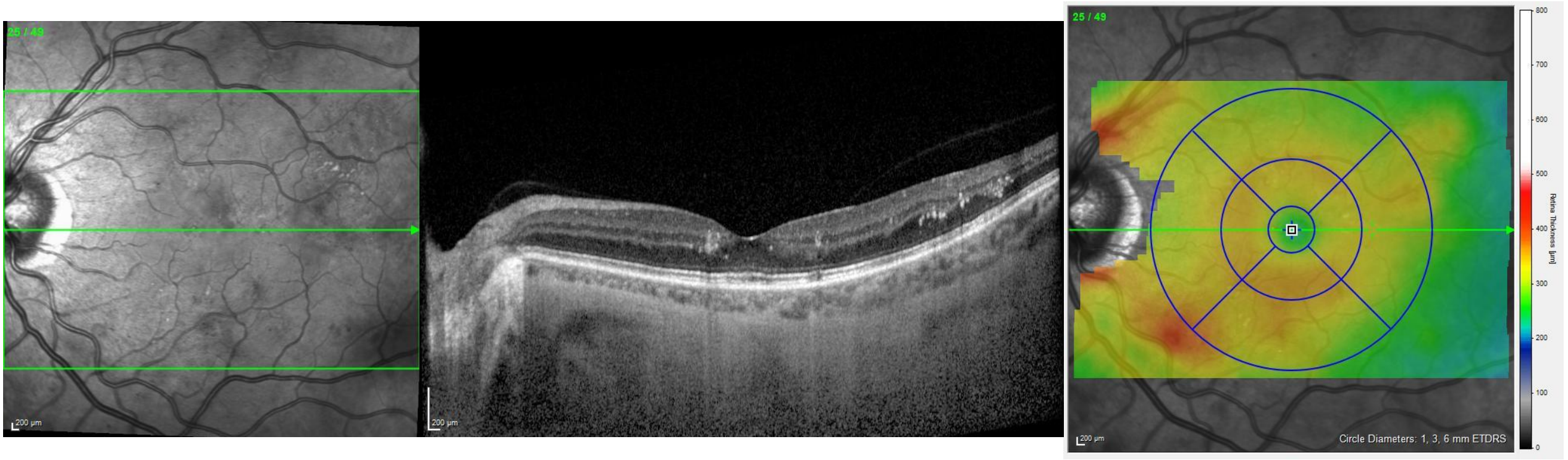




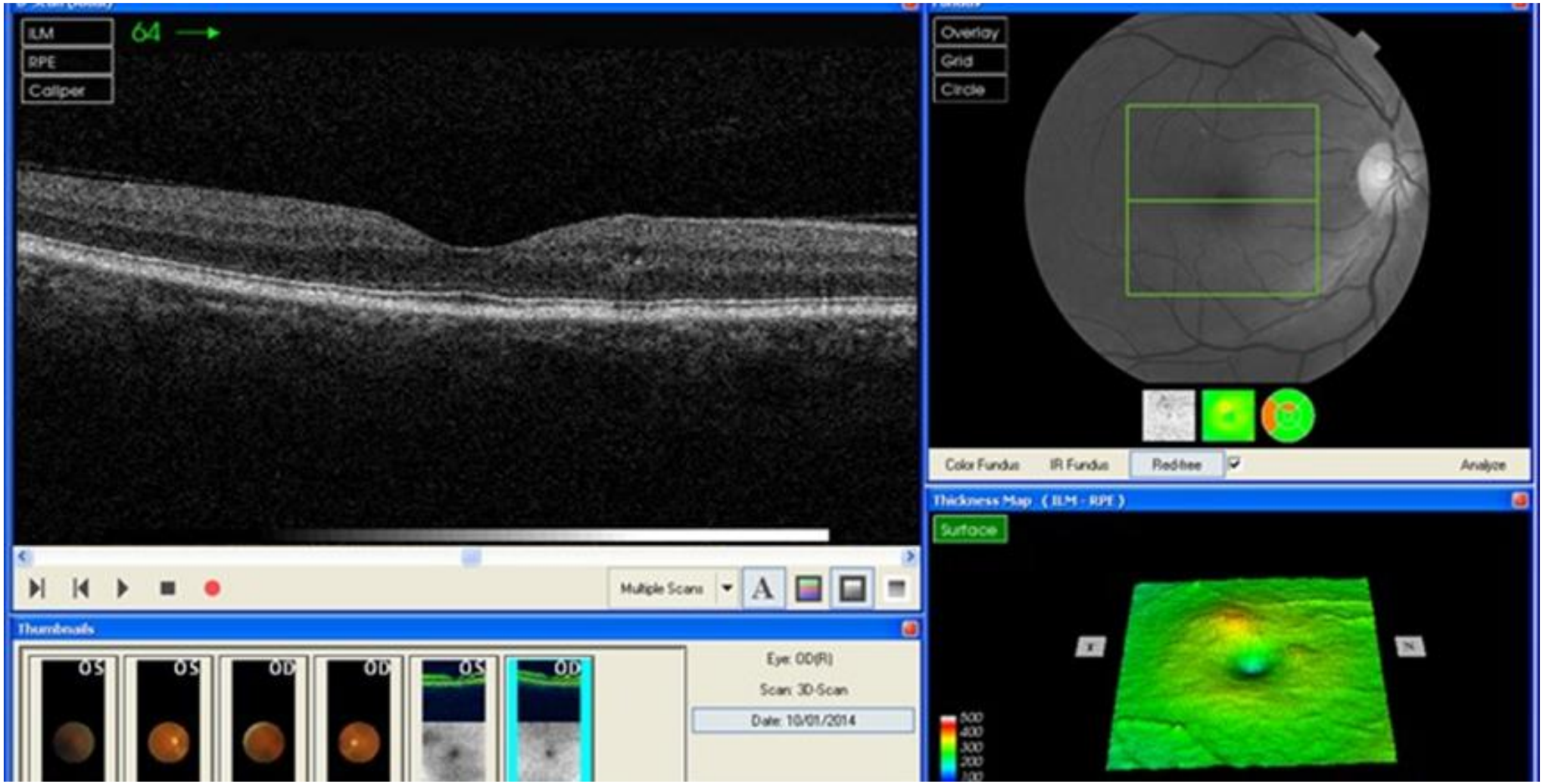
Case 1) OCT negative- Back to Screening



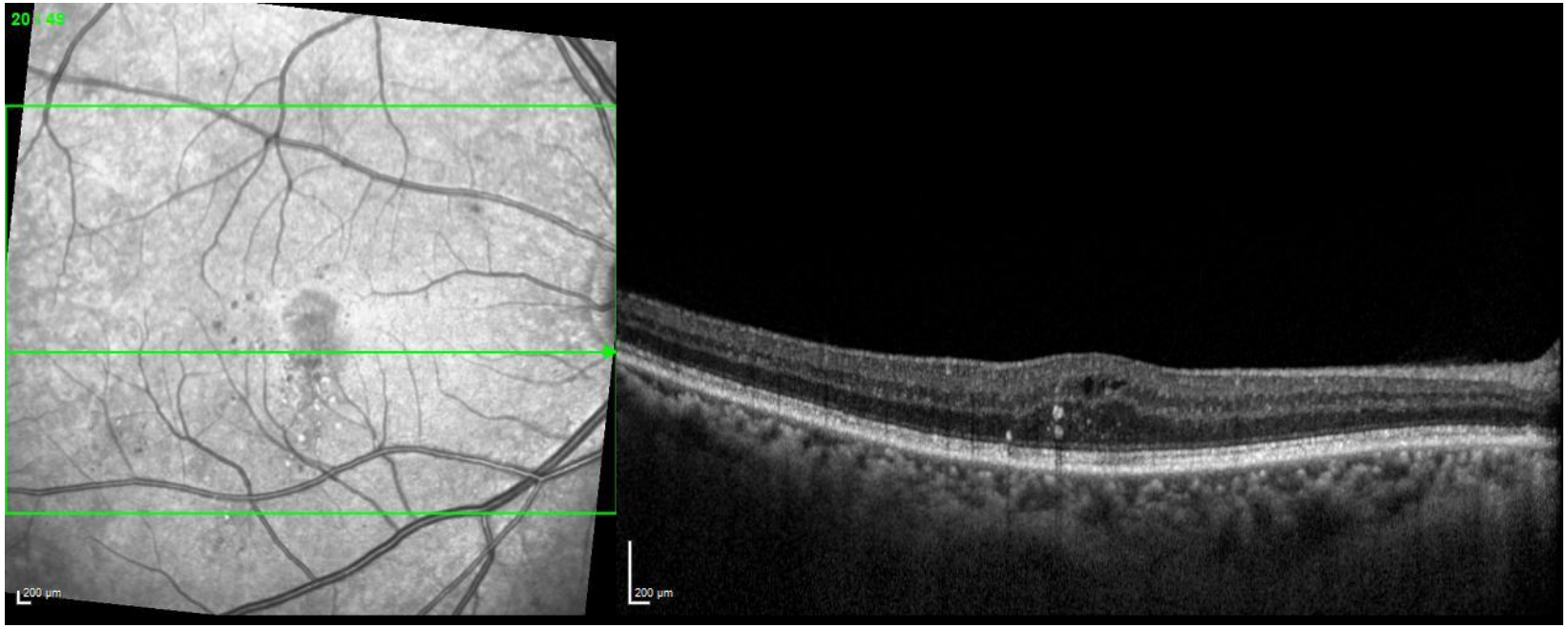
Case 2) OCT borderline- stay in OCT surveillance

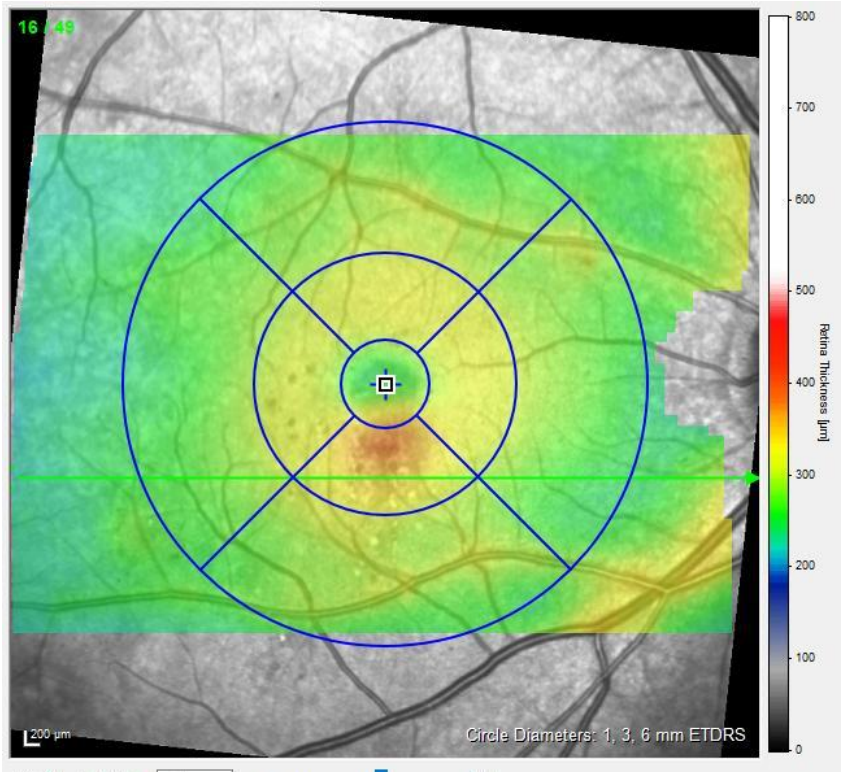


Case 3) OCT borderline- stay in surveillance



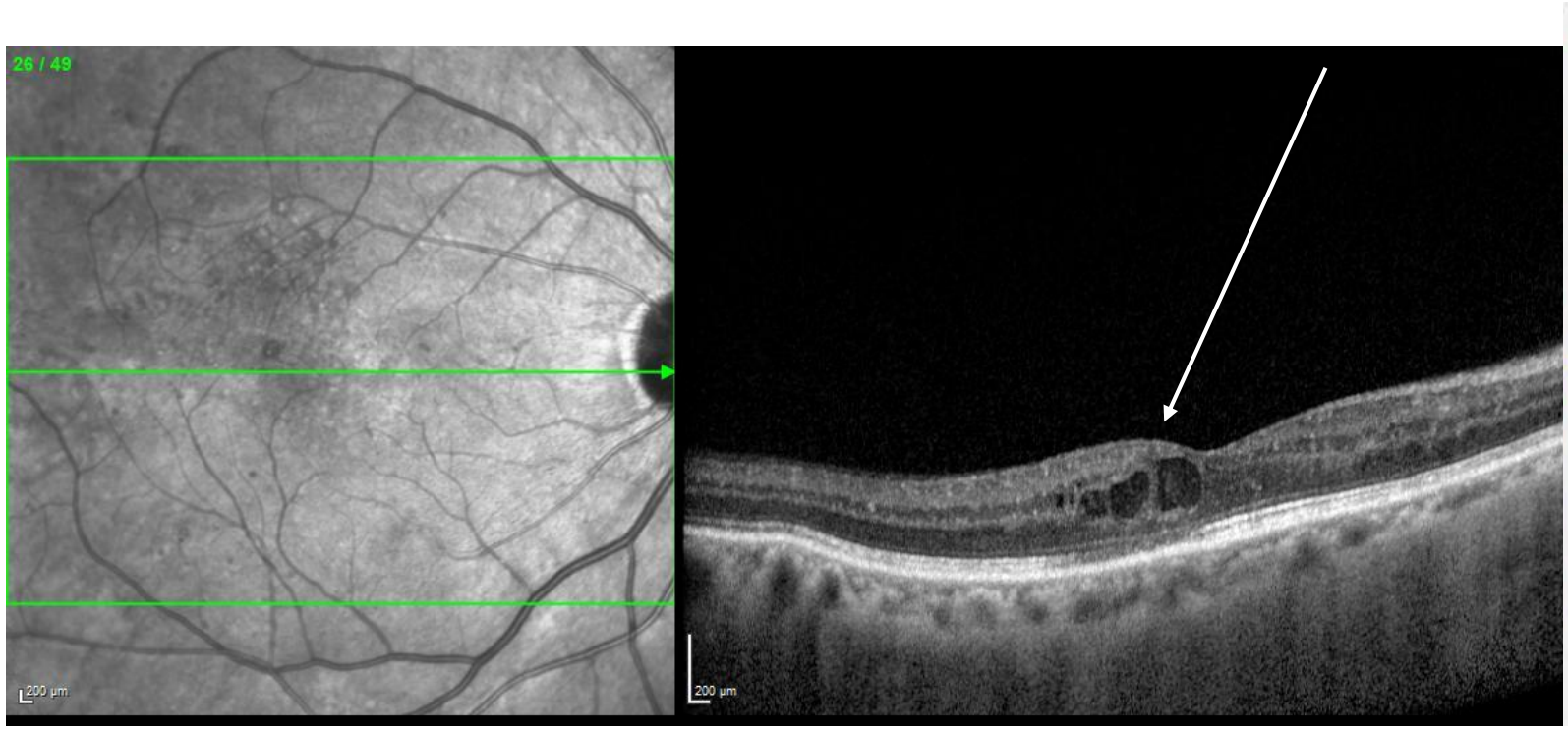
Case 4) – OCT positive (>1/2 DA within 1DD of fovea)

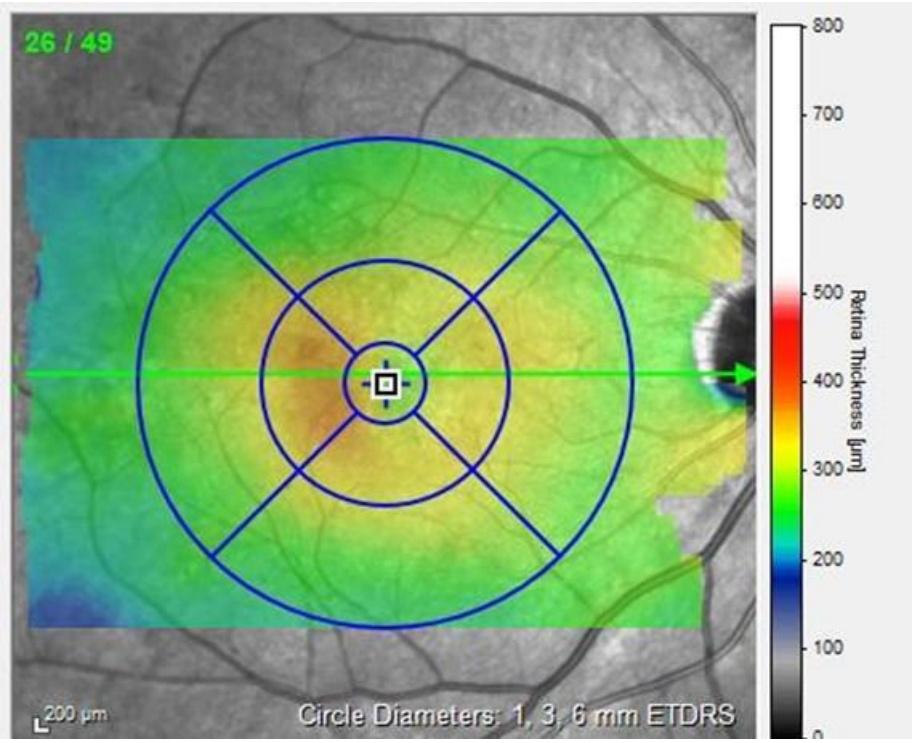




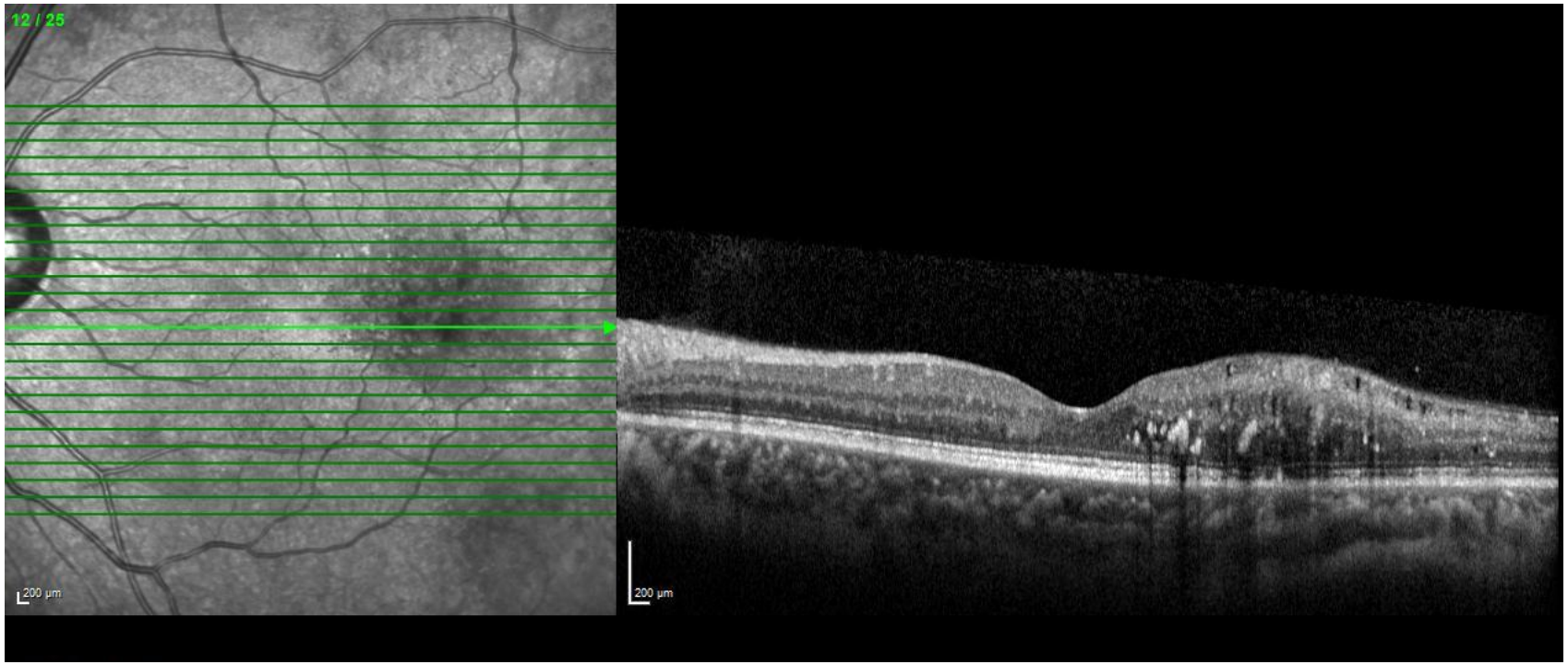
Refer to HES or stay in surveillance

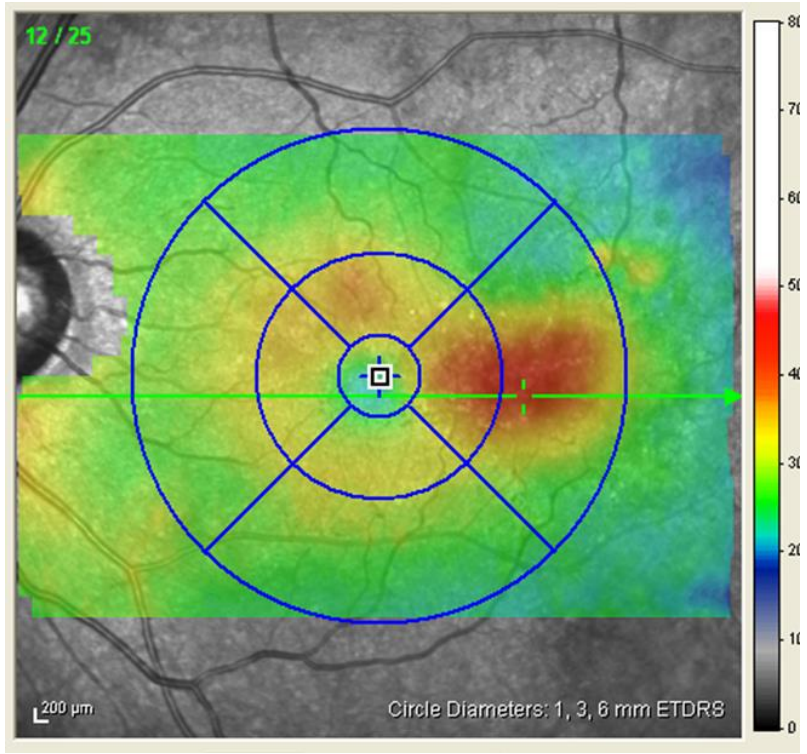
Case 5) OCT positive (loss of ILM contour)





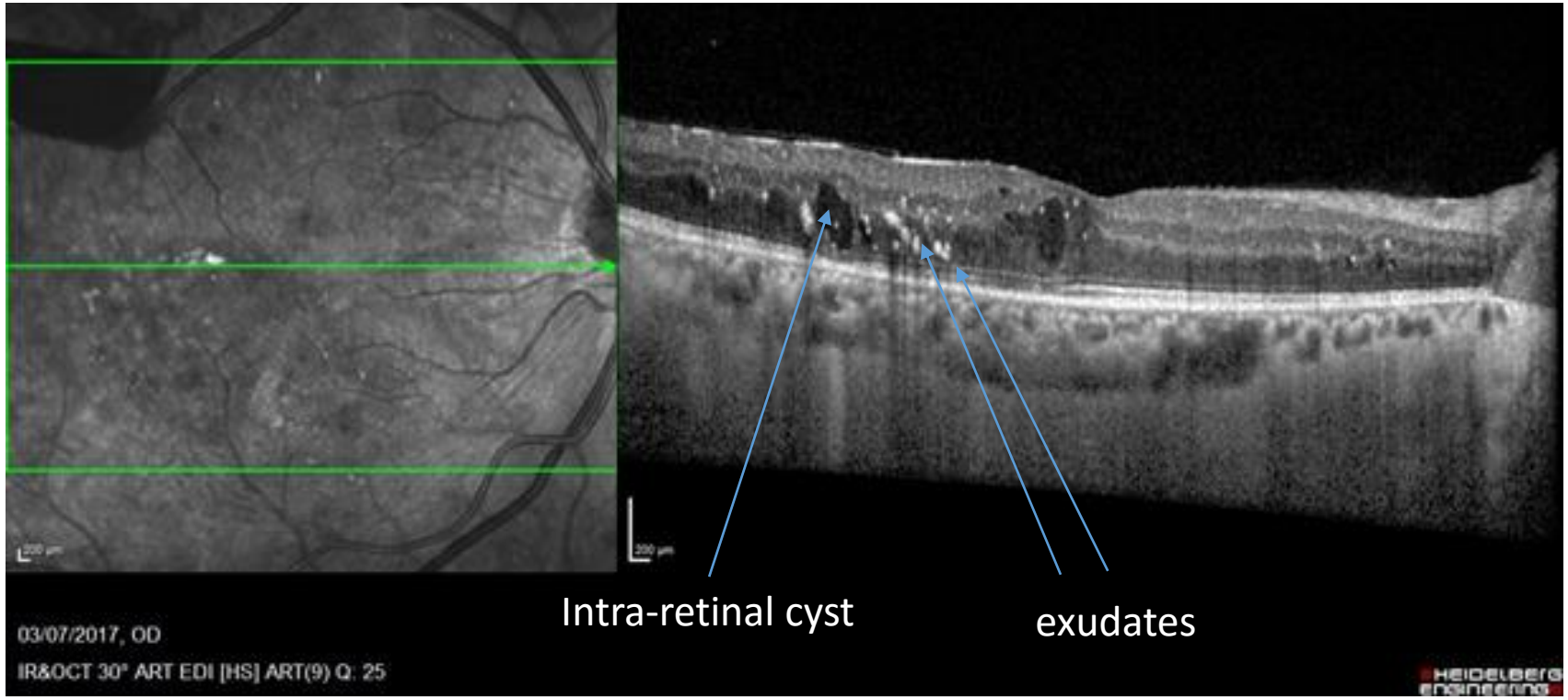
Case 6) OCT positive (>1DA in macular area)

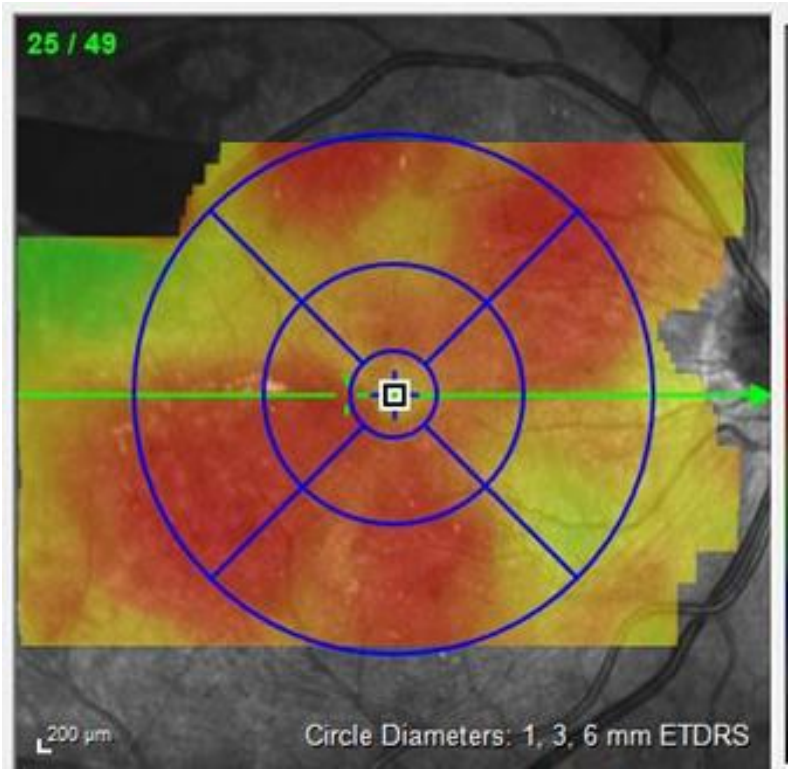




Refer to HES

Case 7) OCT positive with significant thickening & pre-retinal haem

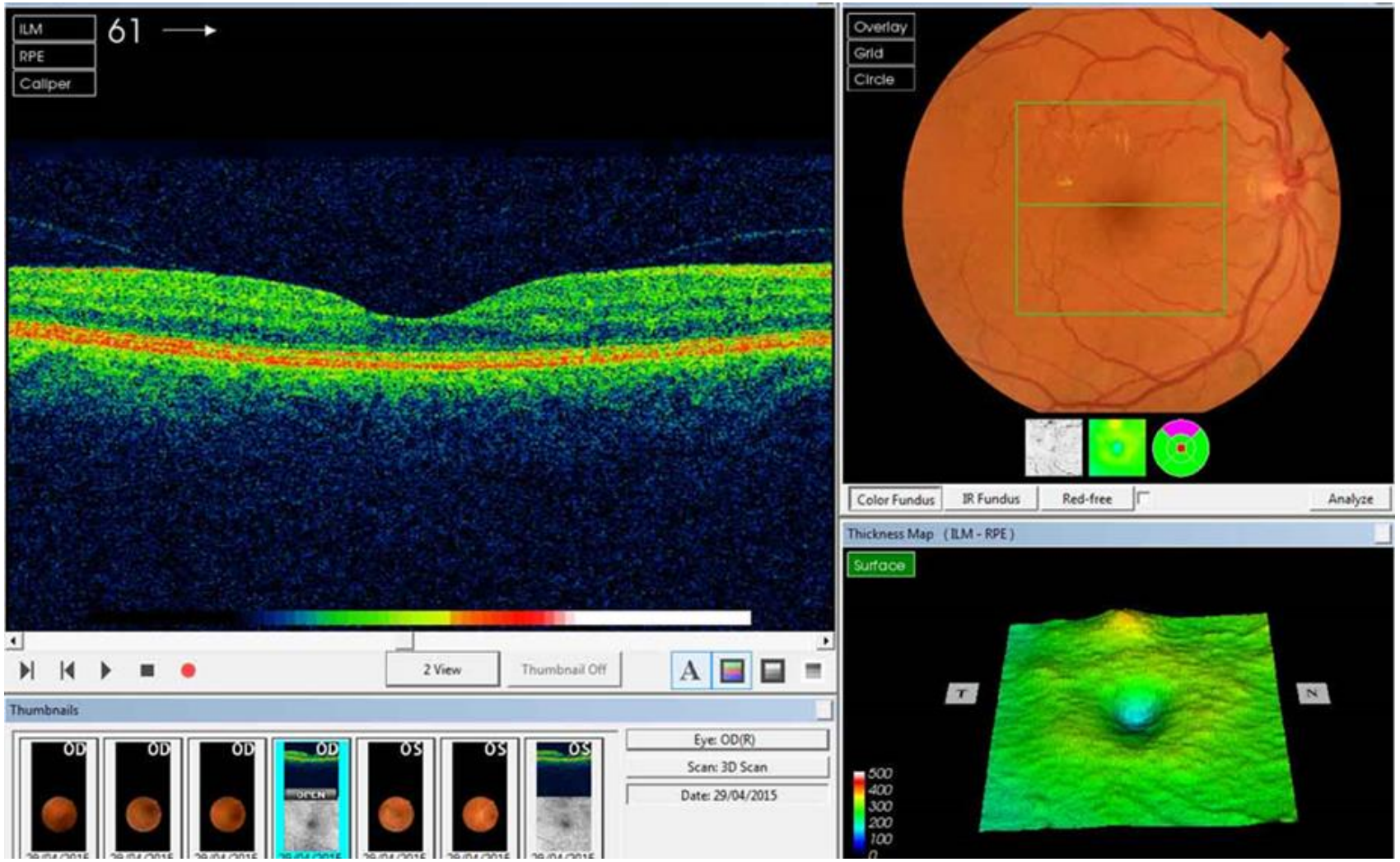




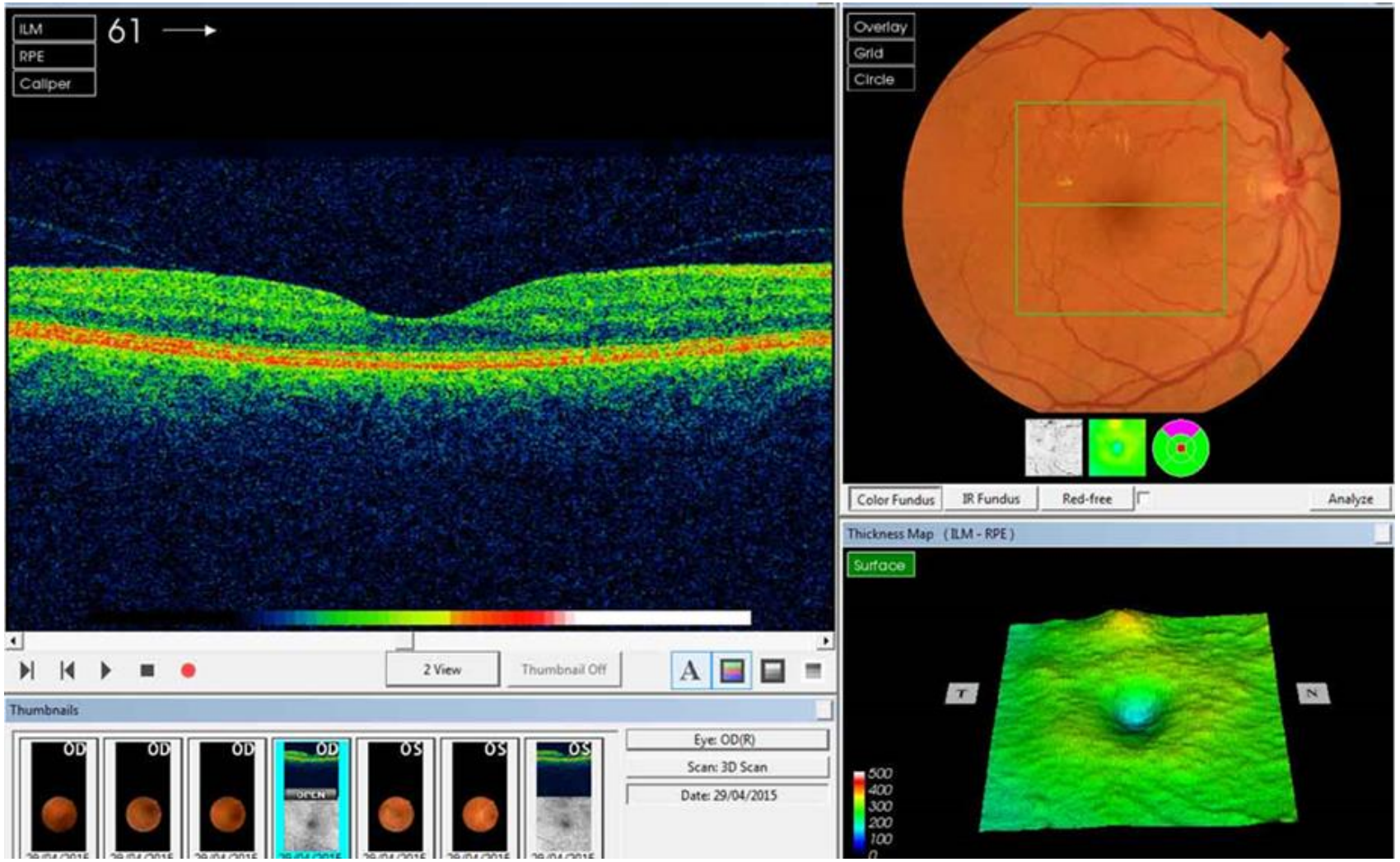
Refer to HES

QUIZ

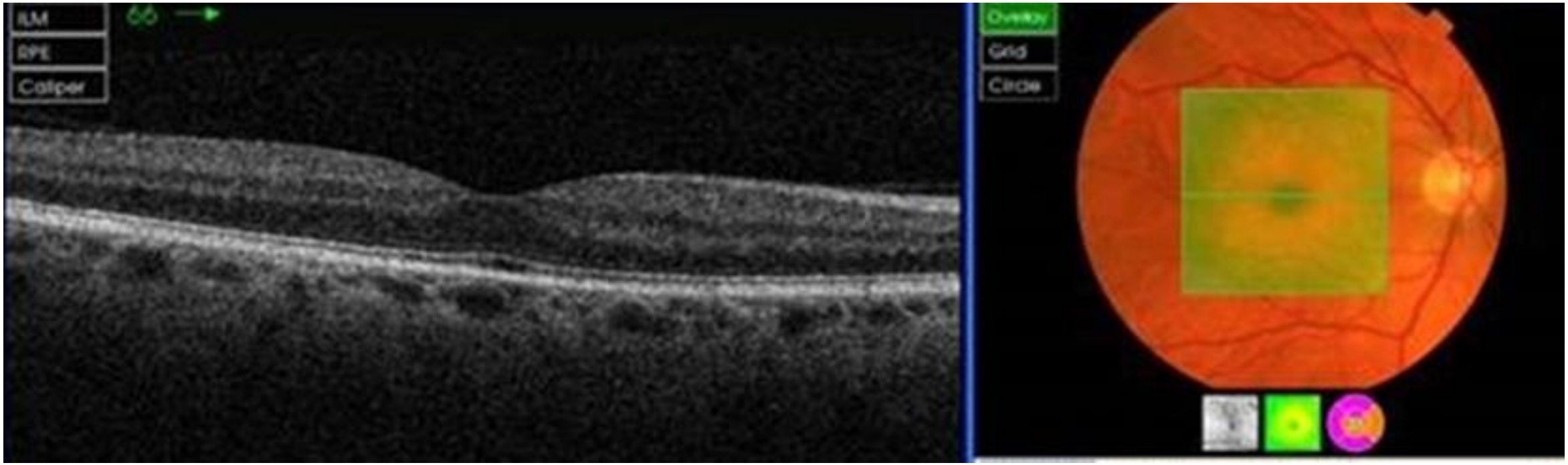
CASE A


ILM
RPE
Caliper
61
2 View
Thumbnail Off
Thumbnails
OD
OS
Eye: OD(R)
Scan: 3D Scan
Date: 29/04/2015
Overlay
Grid
Circle
Color Fundus
IR Fundus
Red-free
Analyze
Thickness Map (ILM - RPE)
Surface
T
N
500
400
300
200
100

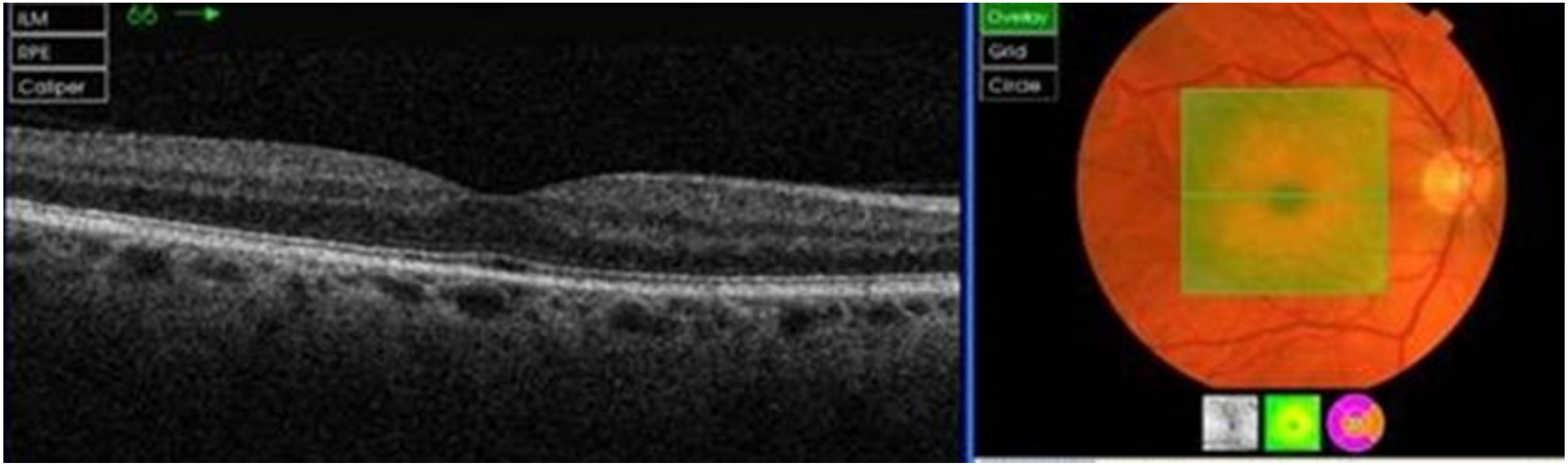
CASE A- OCT borderline (<1DA in macula)



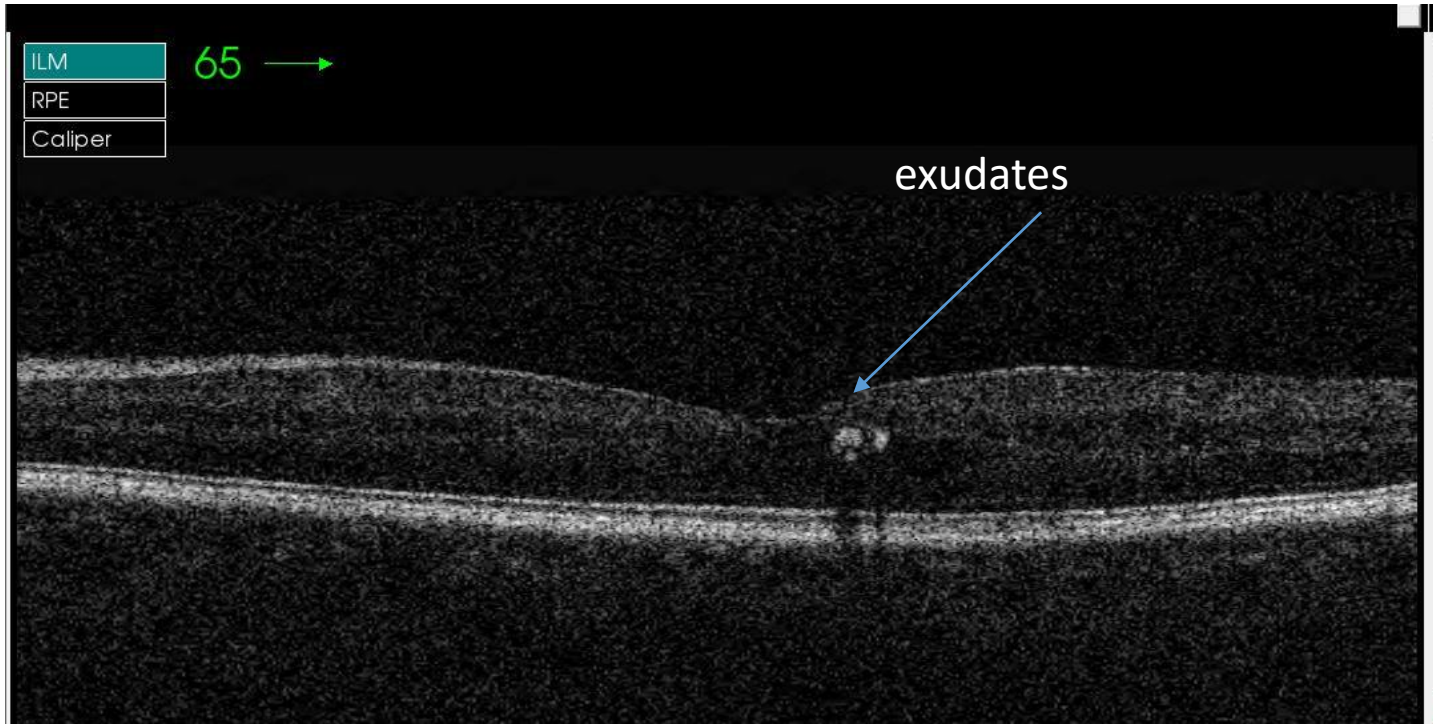
CASE B

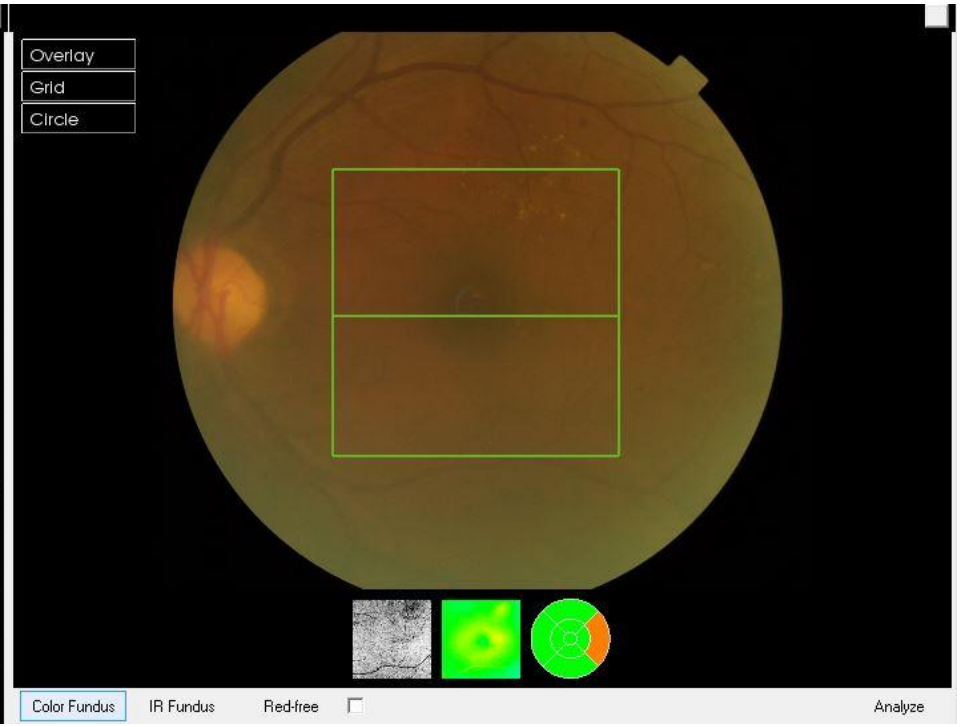


CASE B- OCT negative

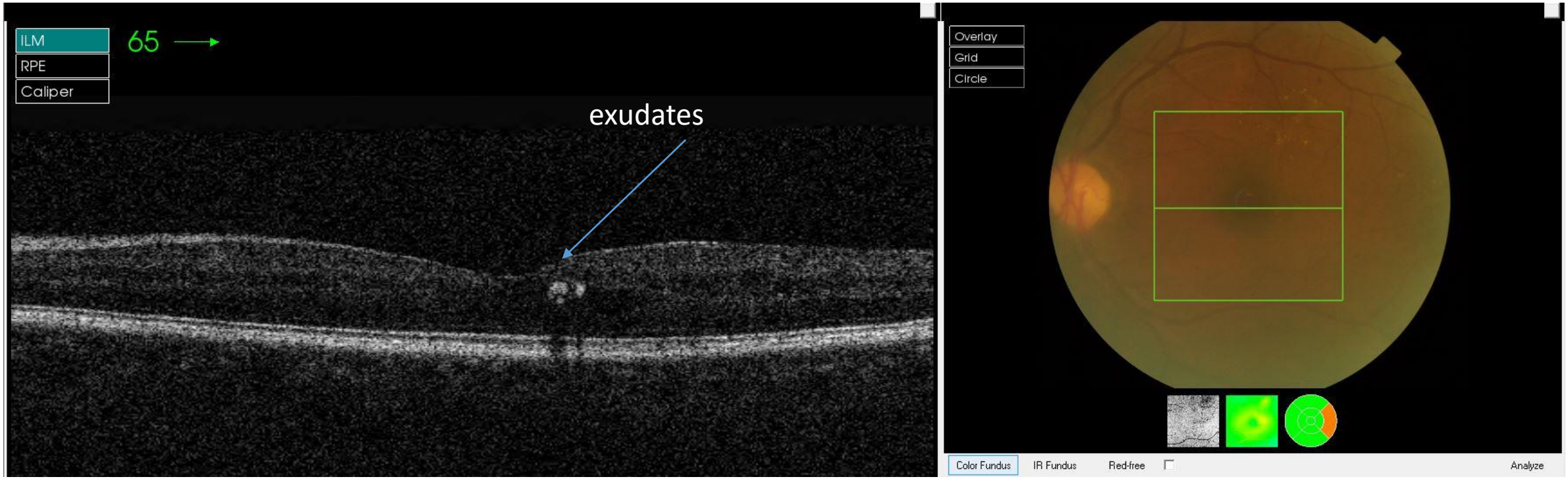


CASE C

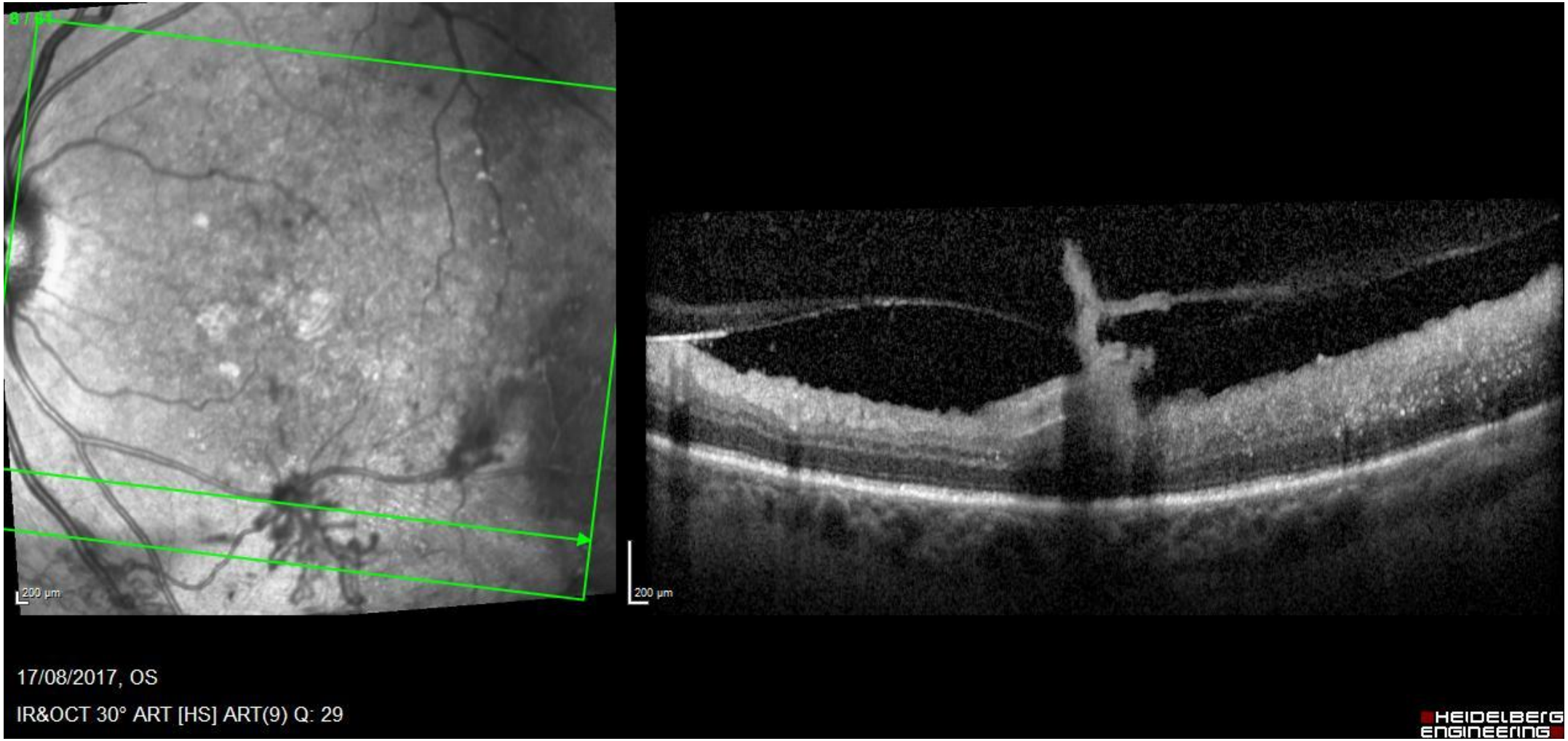

ILM
RPE
Caliper
65
exudates


Overlay
Grid
Circle
Color Fundus
IR Fundus
Red-free
Analyze

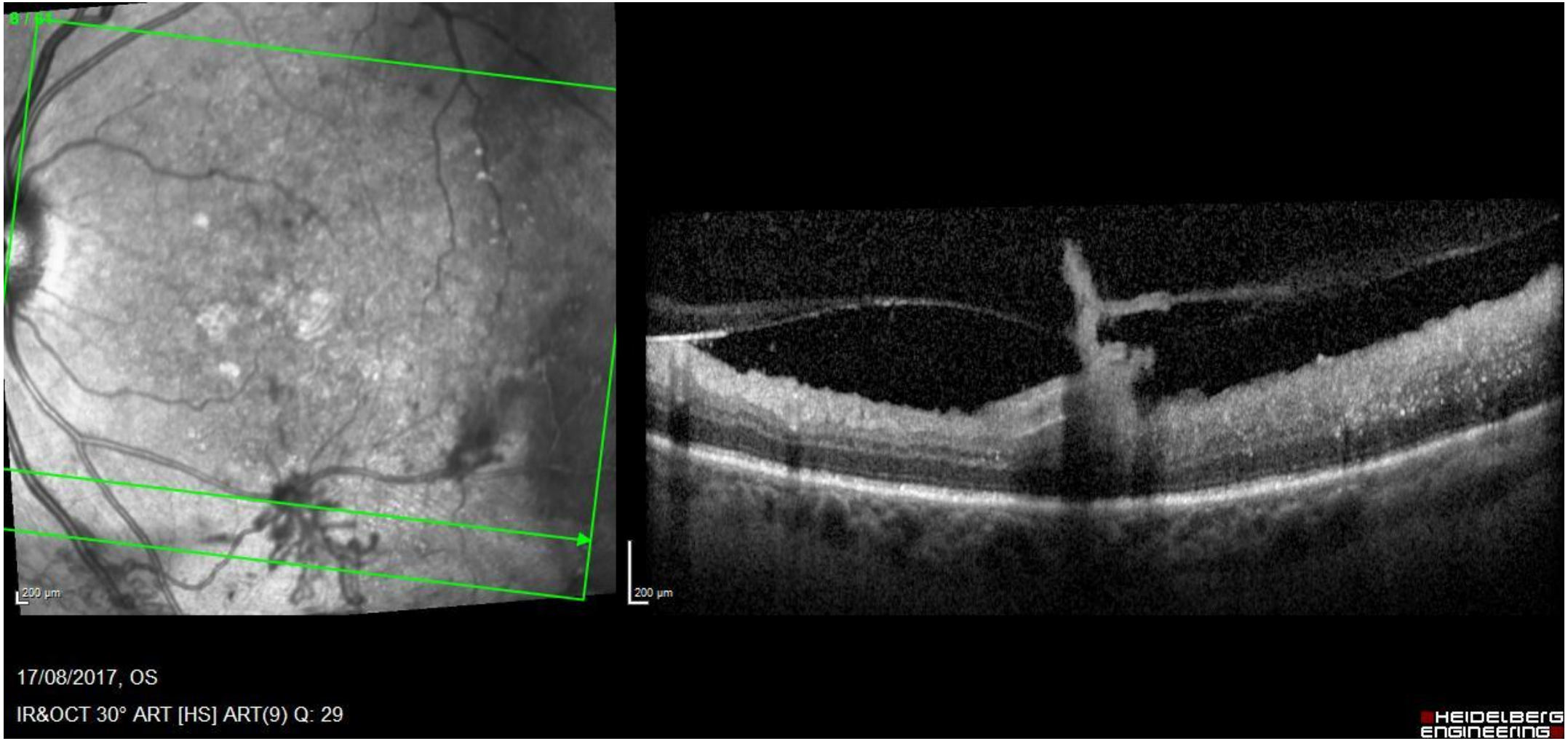
CASE C- OCT borderline (exudates present) no change in ILM contour



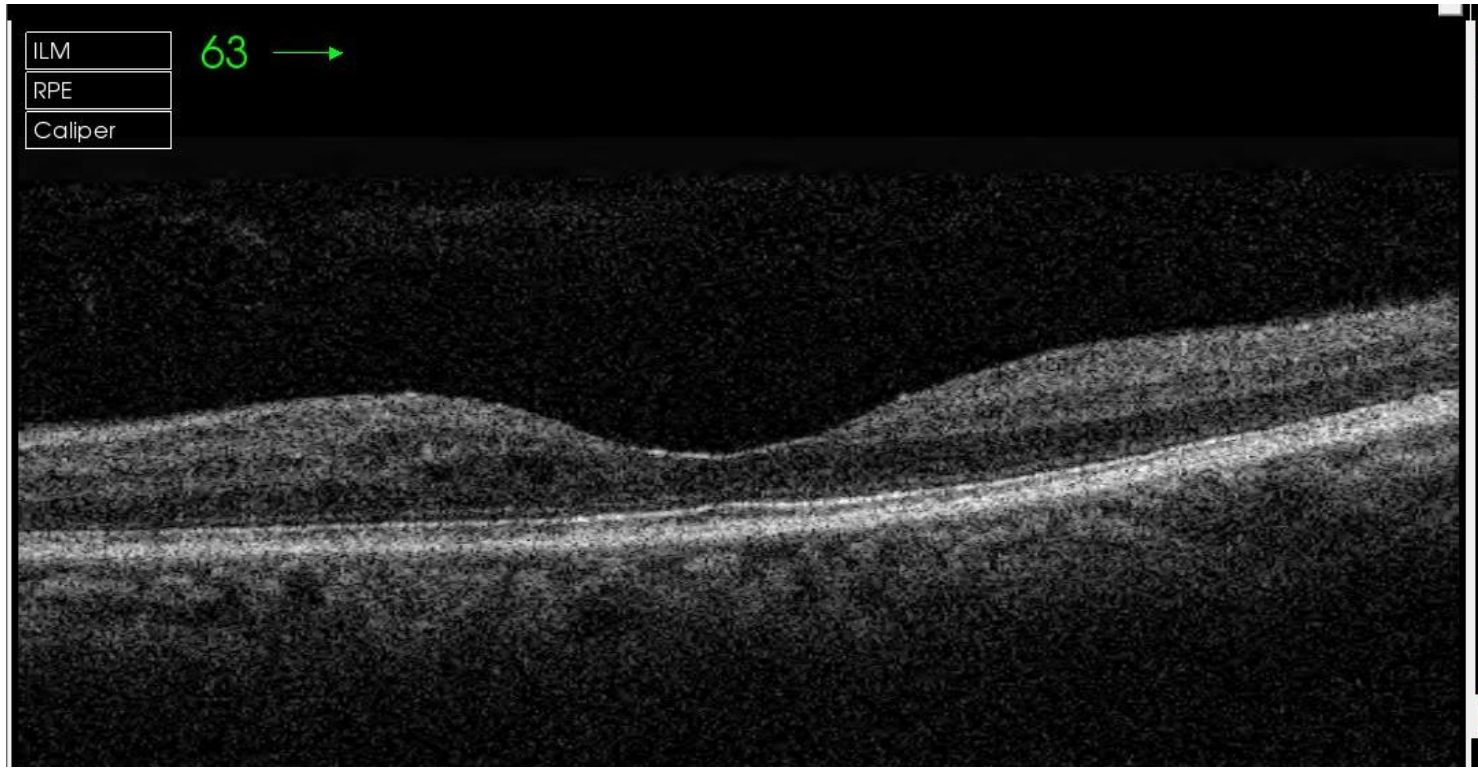
CASE D

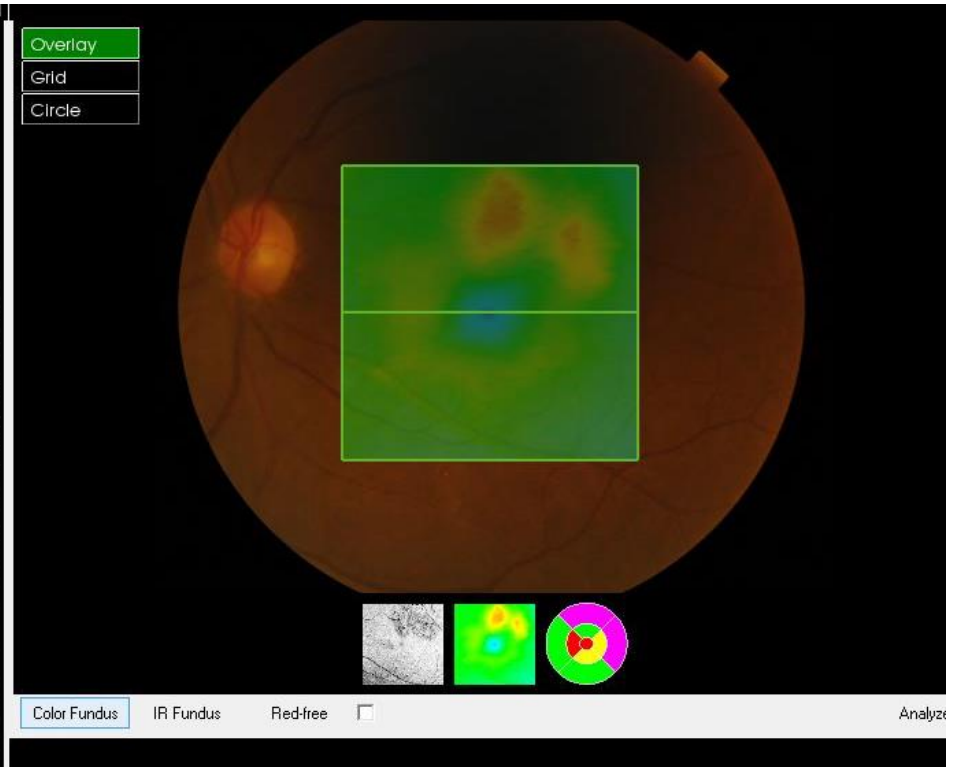

200 µm
200 µm
17/08/2017, OS
IR&OCT 30° ART [HS] ART(9) Q: 29
HEIDELBERG ENGINEERING

CASE D- NVE – Urgent R3A referral

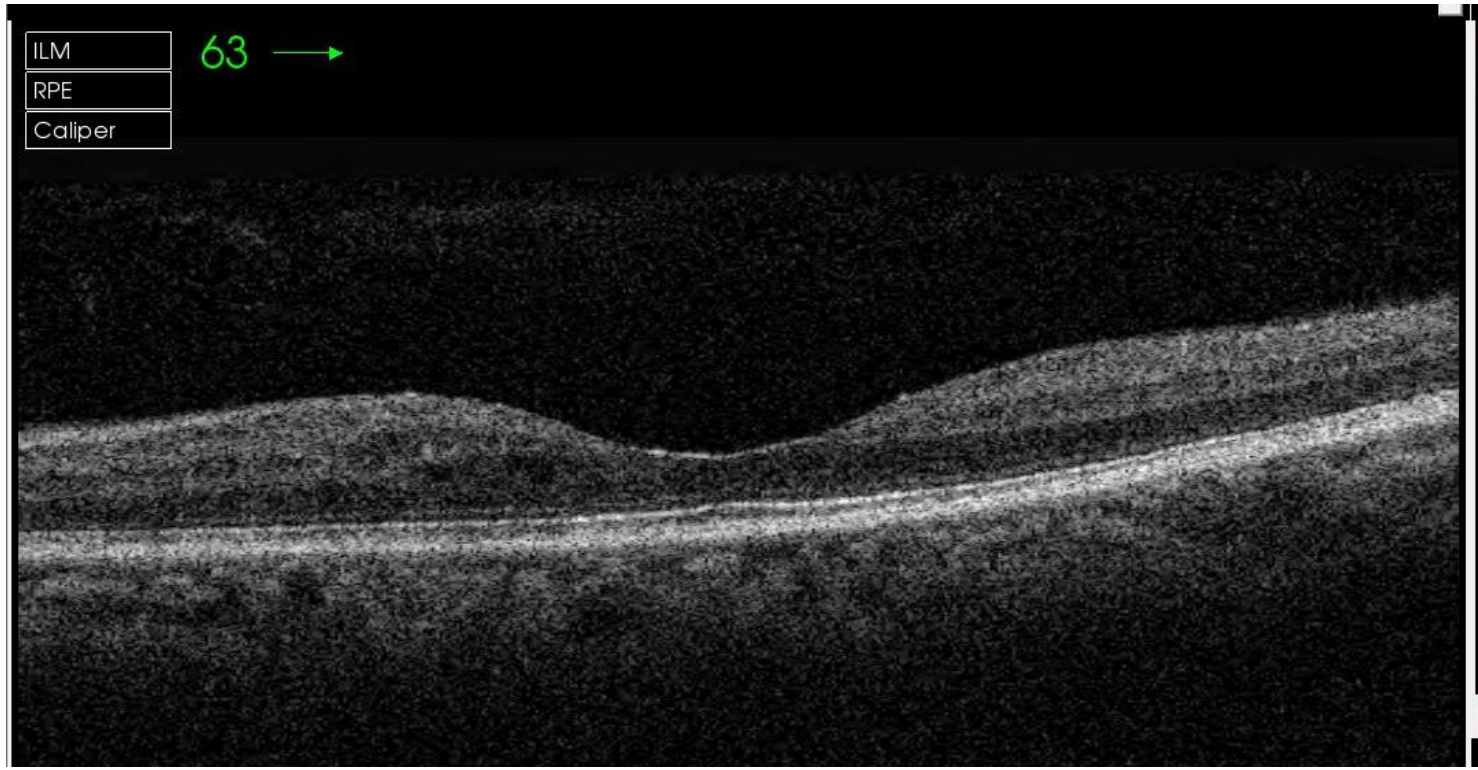


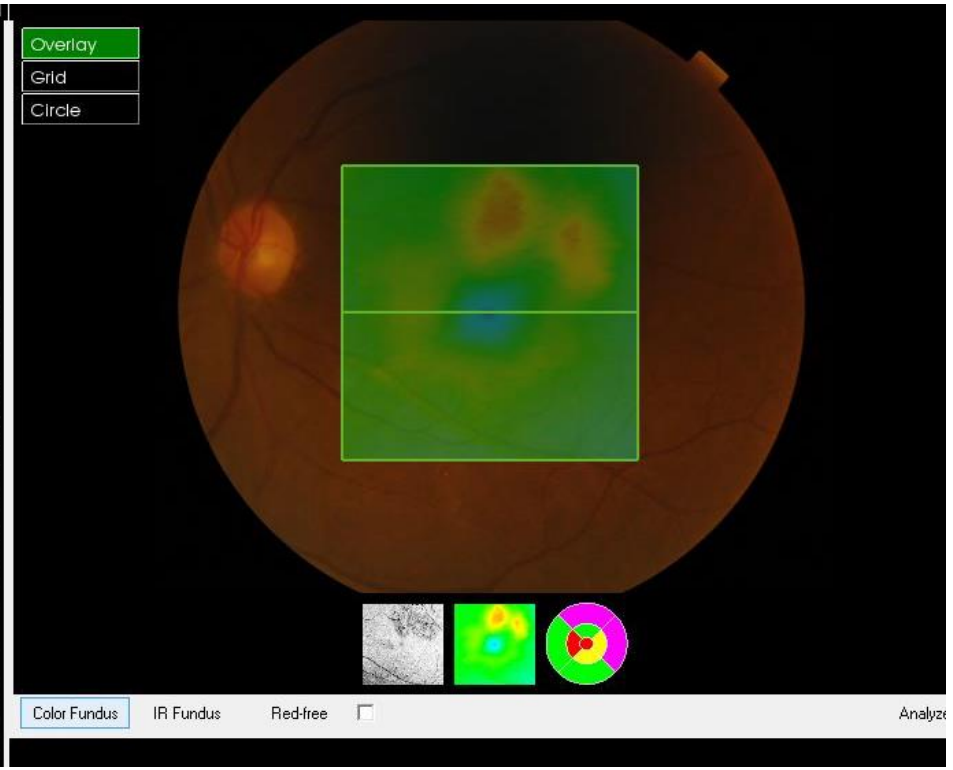
CASE E


ILM
RPE
Caliper
63

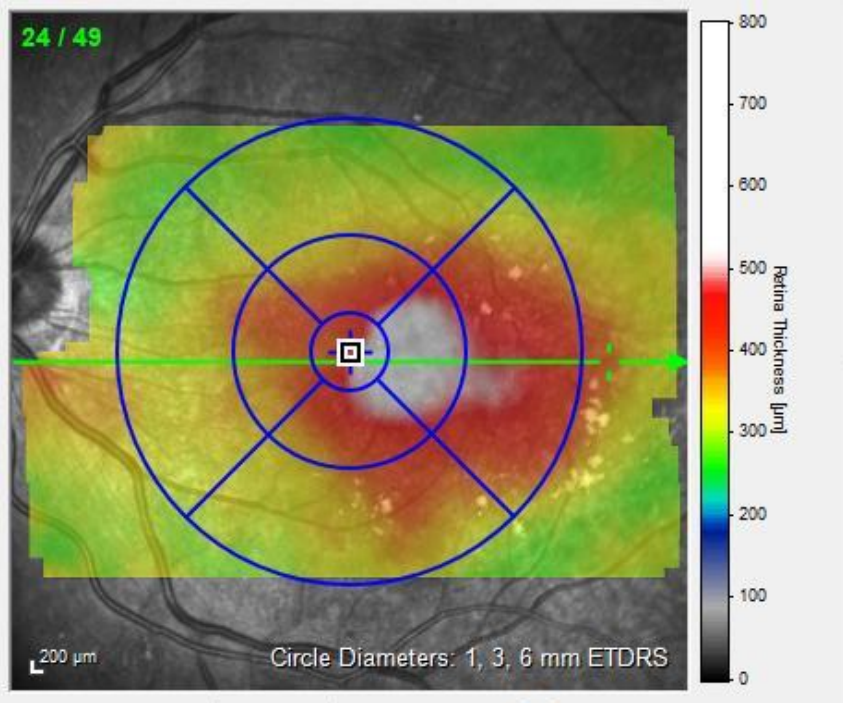

Overlay
Grid
Circle
Color Fundus
IR Fundus
Red-free

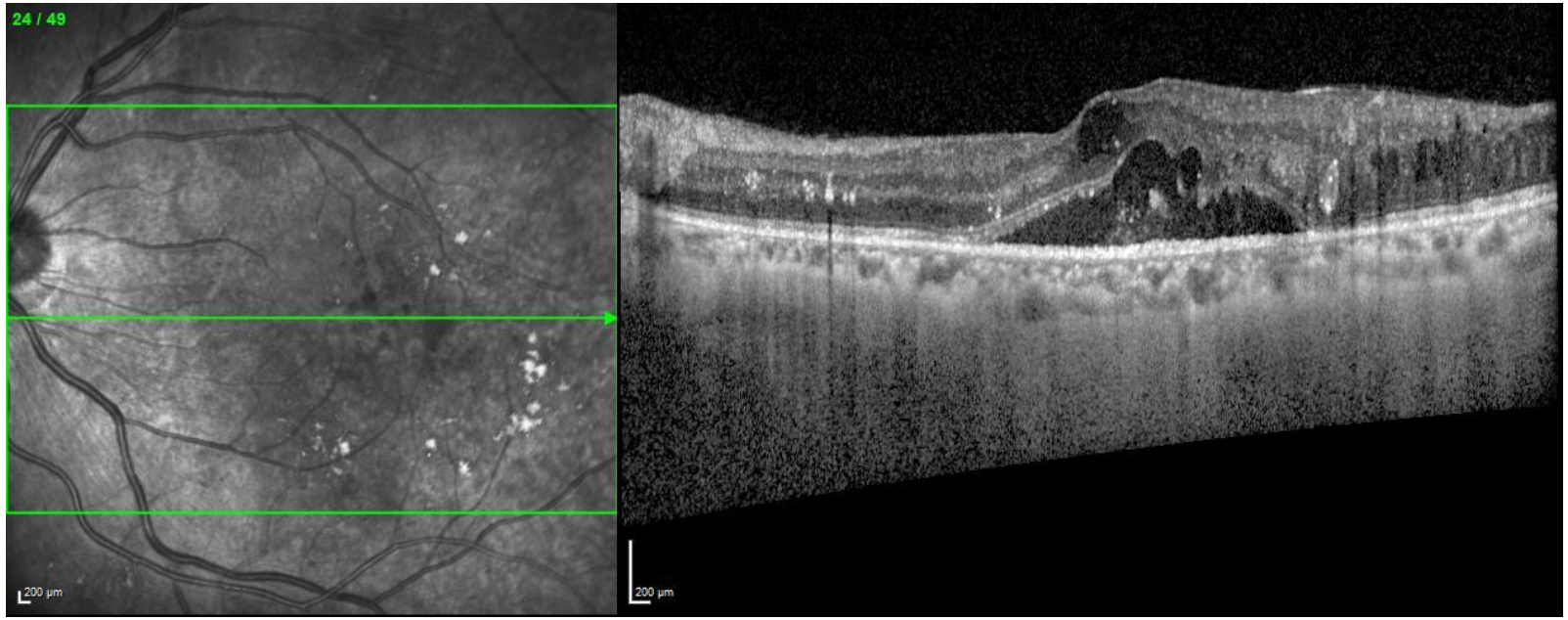
CASE E- OCT positive (>1DA in macula)



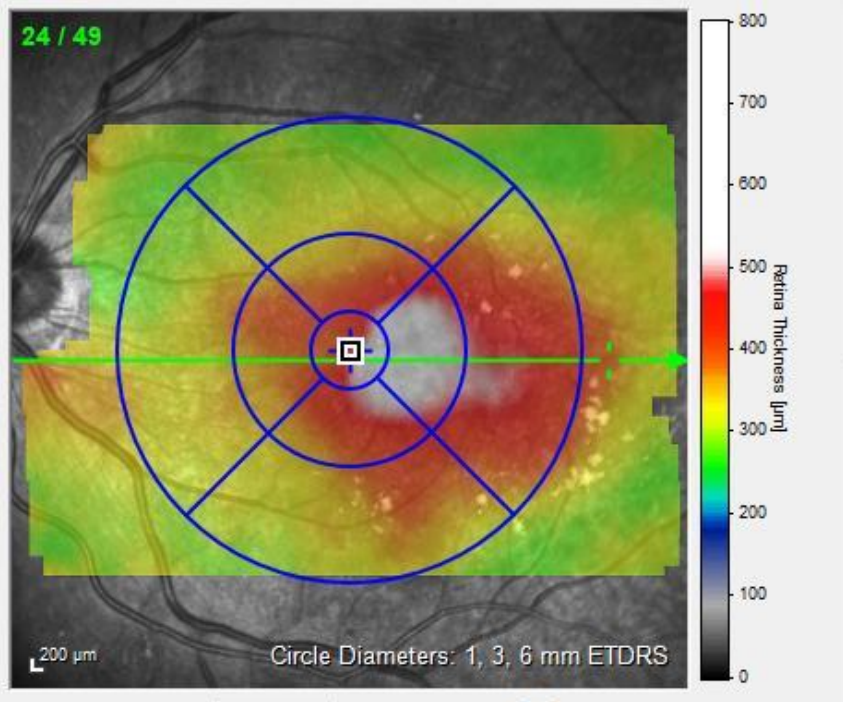


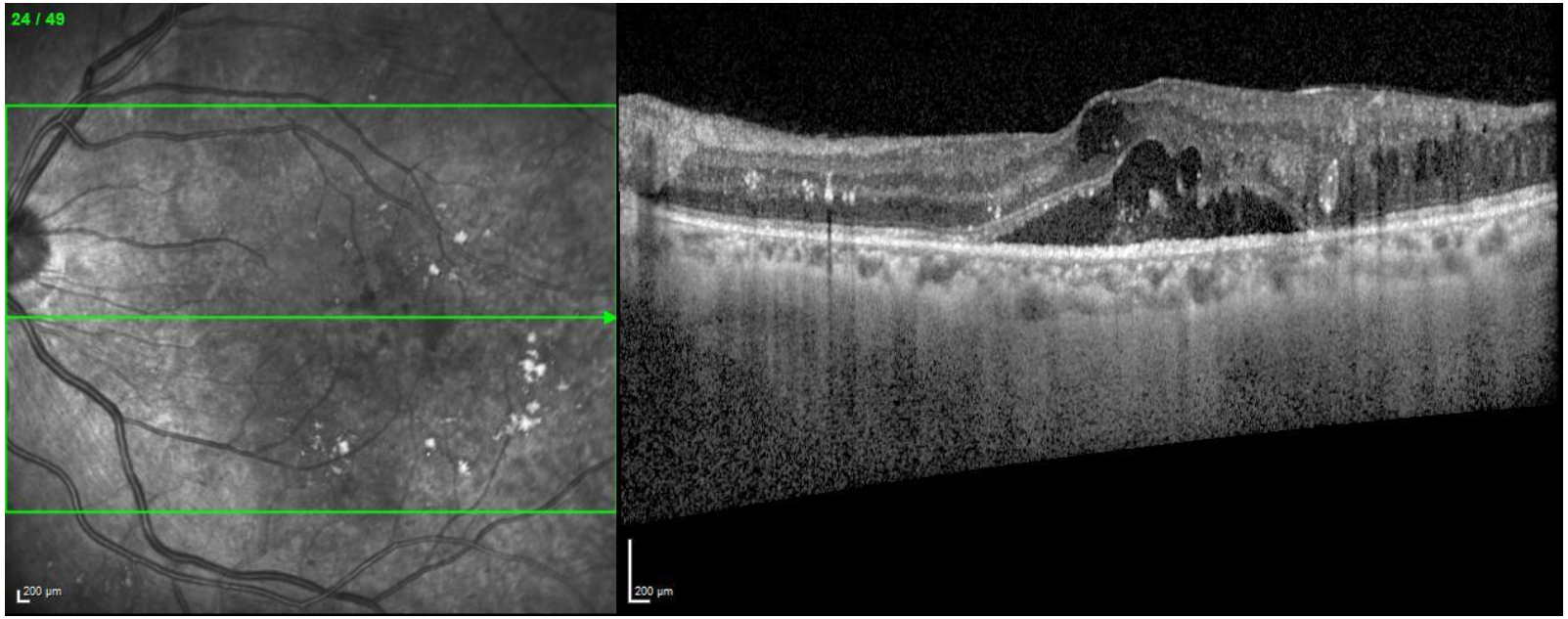
CASE F


24 / 49
800
700
600
500
400
300
200
100
0
Retina Thickness [µm]
200 µm
Circle Diameters: 1, 3, 6 mm ETDRS

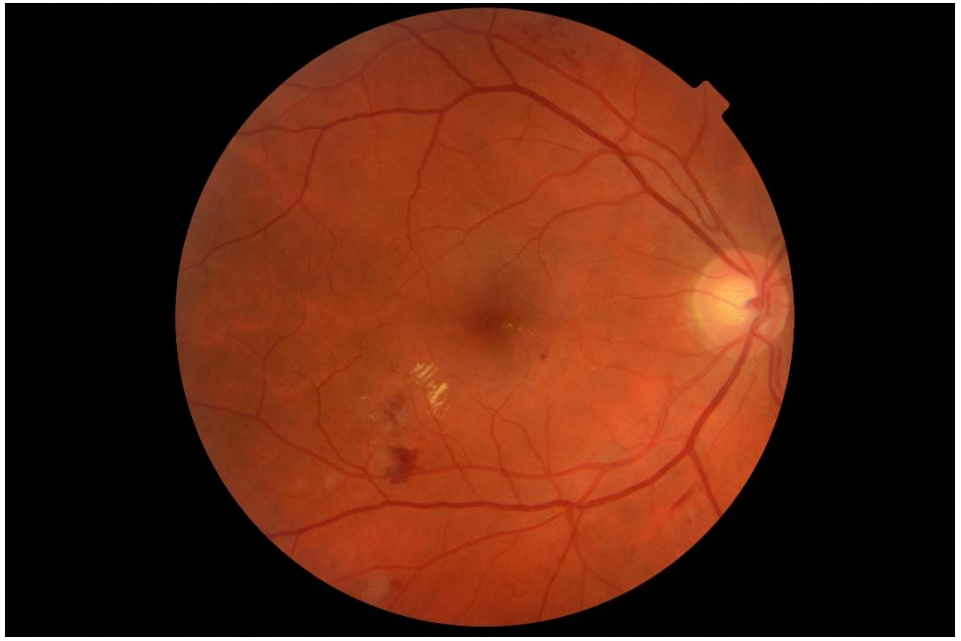

24 / 49
200 µm
200 µm

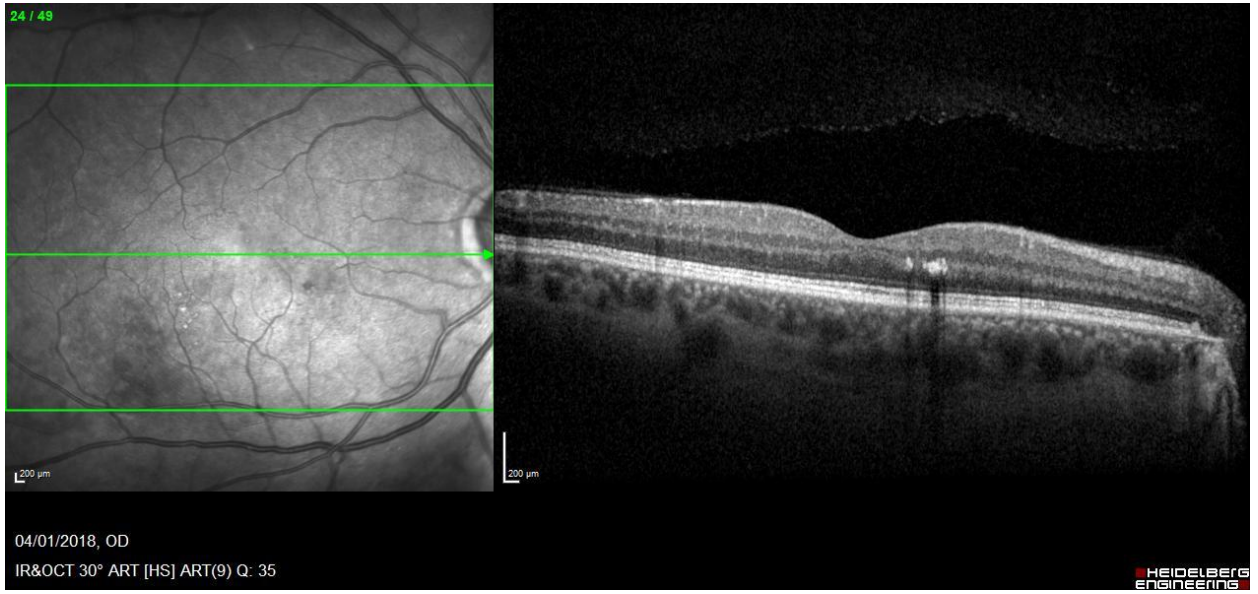
CASE F- OCT Positive (Fast Track to Clinic >400 microns thickness)



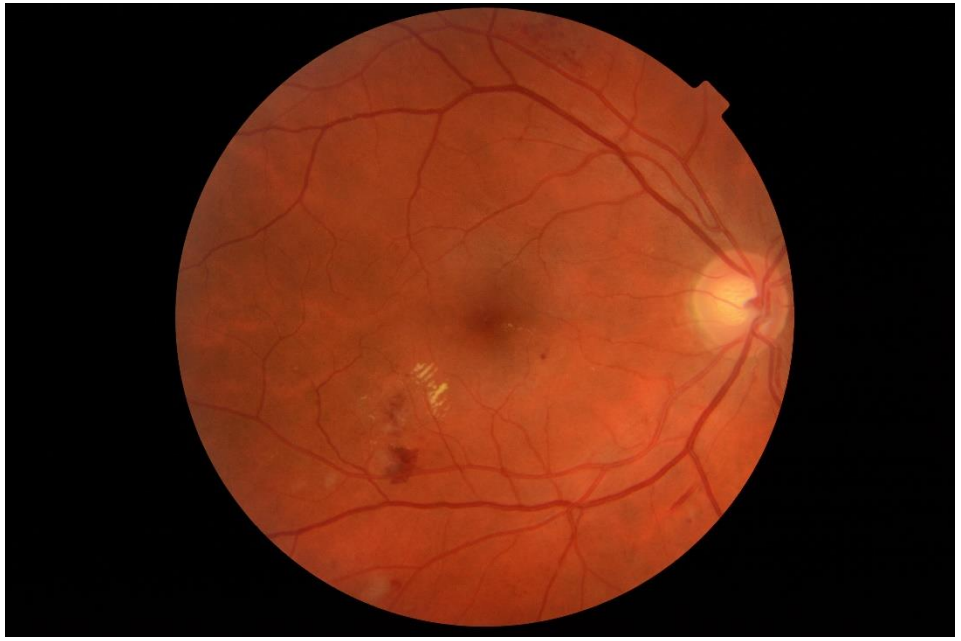


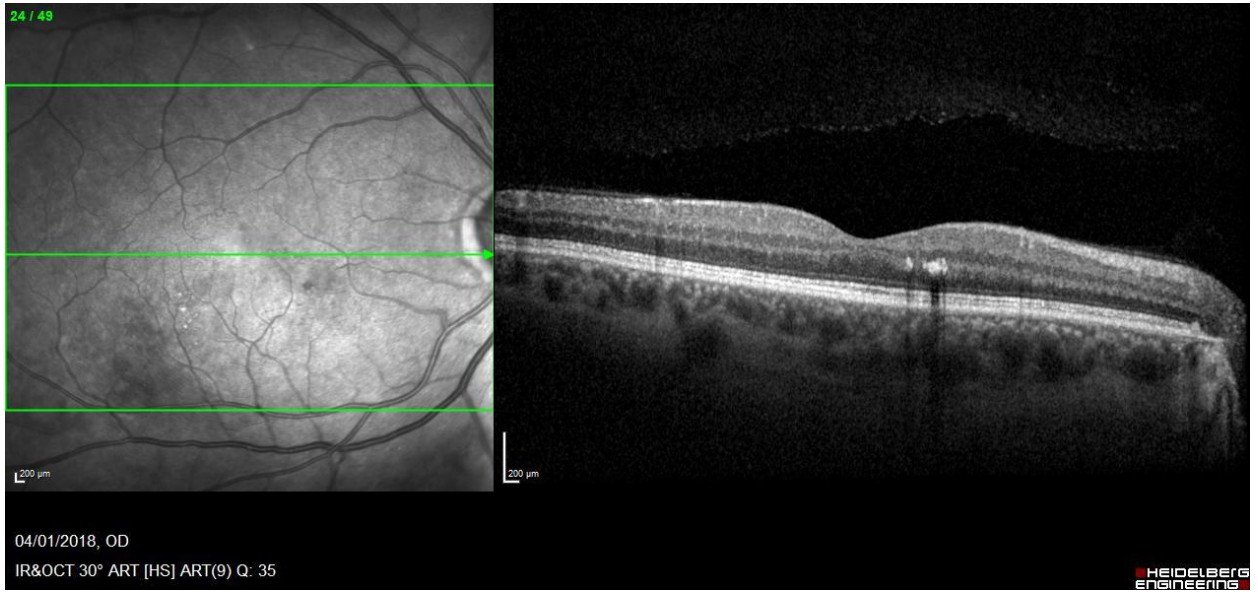
CASE G



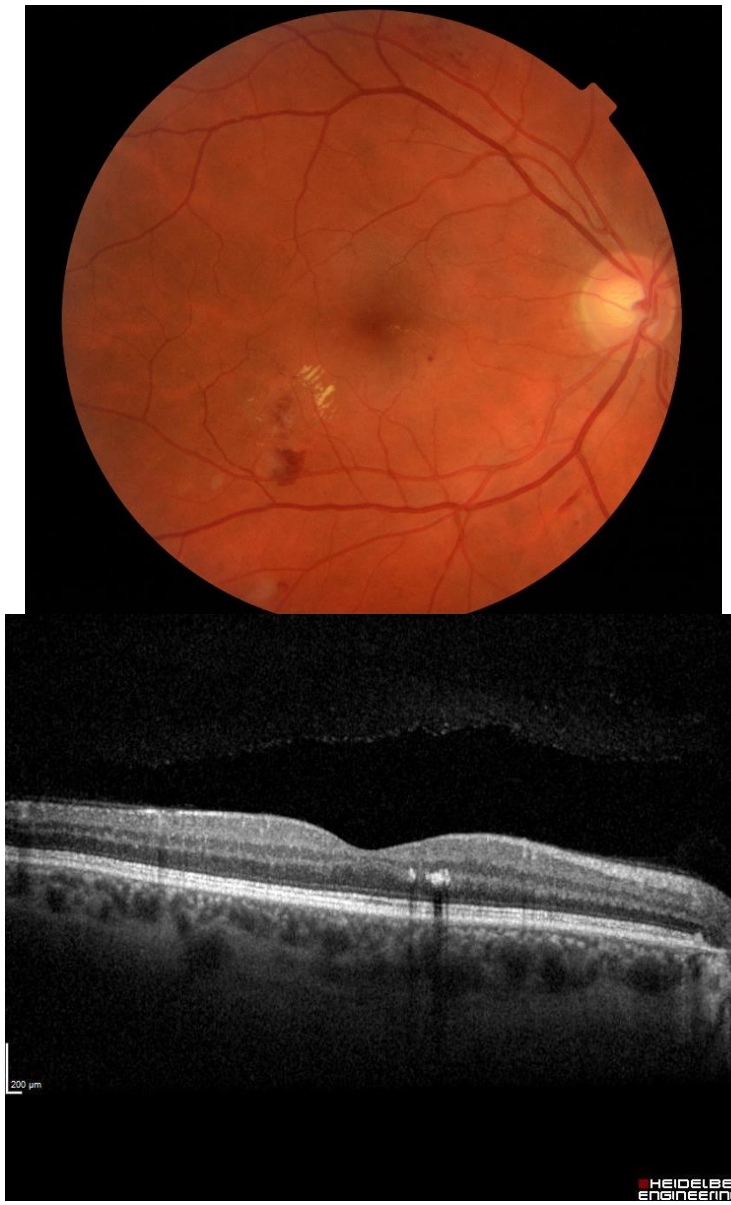

24 / 49
200 µm
200 µm
04/01/2018, OD
IR&OCT 30° ART [HS] ART(9) Q: 35
HEIDELBERG ENGINEERING

CASE G ? OCT Borderline- no change in contour BUT……

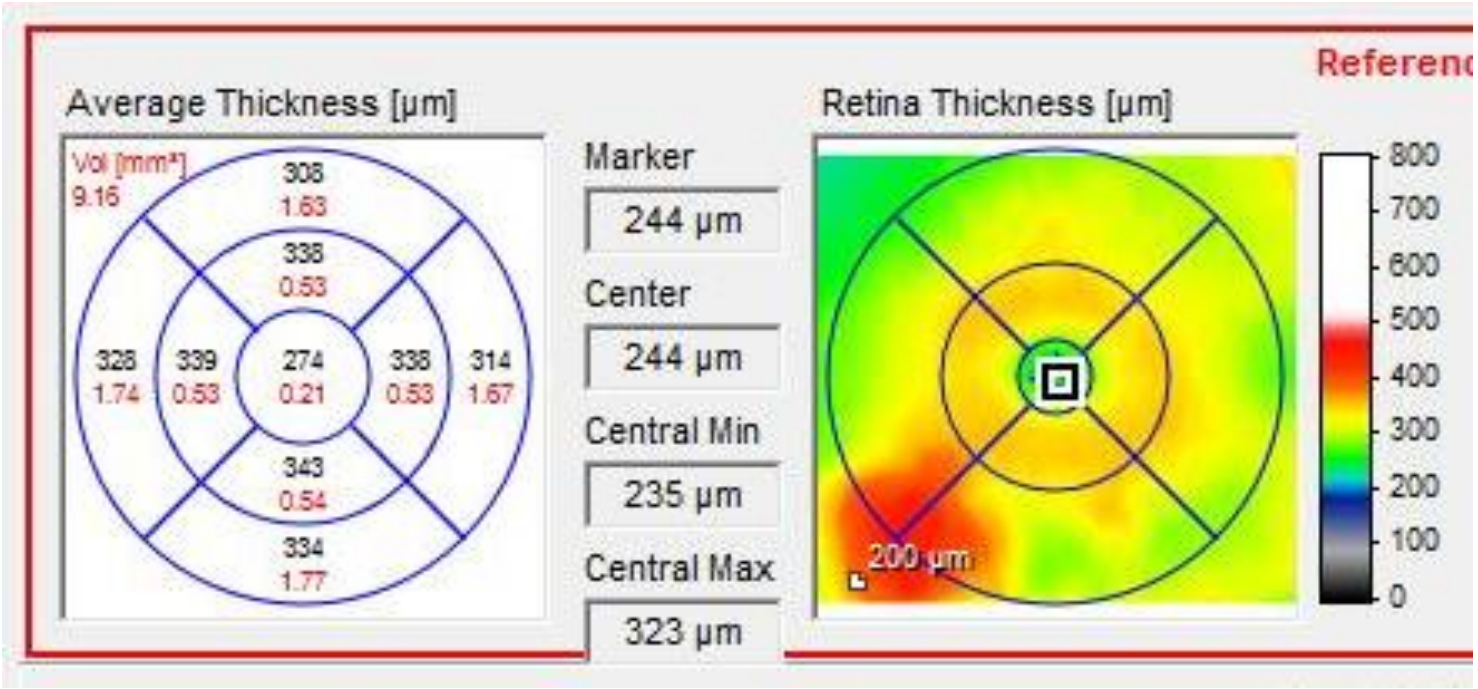




CASE G



Always look at the” Map view”
>1DA thickening within the Macular Area
OCT positive



Thank you

Samantha.mann@gstt.nhs.uk