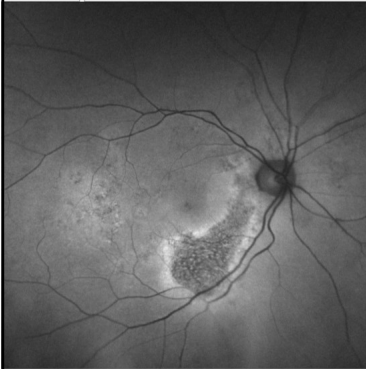




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# Grand Rounds: Advanced Imaging

Paula Katalinic

Principal Optometrist, Centre For Eye Health



## Topography of Diabetic Macular Edema with Optical Coherence Tomography

Michael R. Hee, PhD,<sup>1</sup> Carmen A. Puliafito, MD,<sup>2</sup> Jay S. Duker, MD,<sup>2</sup> Elias Reichel, MD,<sup>2</sup> Jeffrey G. Coker, BS,<sup>2</sup> Jason R. Wilkins, BS,<sup>2</sup> Joel S. Schuman, MD,<sup>2</sup> Eric A. Swanson, MS,<sup>2</sup> James G. Fujimoto, PhD<sup>3</sup>

**Objective:** This study aimed to develop a protocol to screen and monitor patients with diabetic macular thickening using optical coherence tomography (OCT), a technique for high-resolution cross-sectional imaging of the retina.

**Design:** A cross-sectional pilot study was conducted.

**Participants:** A total of 150 eyes of 107 patients with diabetic retinopathy, 55 eyes from 31 patients with diabetes but no ophthalmoscopic evidence of retinopathy, and 73 eyes from 41 healthy volunteers were studied.

**Intervention:** Six optical coherence tomograms were obtained in a radial spoke pattern centered on the fovea. Retinal thickness was computed automatically from each tomogram at a total of 600 locations throughout the macula. Macular thickness was displayed graphically as a false-color topographic map and was reported numerically as averages in each of nine regions.

**Main Outcome Measures:** Correlation of OCT with slit-lamp biomicroscopy, fluorescein angiography, and visual acuity was measured.

**Results:** Optical coherence tomography was able to quantify the development and resolution of both foveal and extrafoveal macular thickening. The mean  $\pm$  standard deviation foveal thickness was  $174 \pm 18 \mu\text{m}$  in normal eyes,  $178 \pm 17 \mu\text{m}$  in diabetic eyes without retinopathy, and  $256 \pm 114 \mu\text{m}$  in eyes with nonproliferative diabetic retinopathy. Foveal thickness was highly correlated among left and right eyes of normal eyes (mean  $\pm$  standard deviation difference of  $6 \pm 9 \mu\text{m}$ ). Foveal thickness measured by OCT correlated with visual acuity ( $r^2 = 0.79$ ). A single diabetic eye with no slit-lamp evidence of retinopathy showed abnormal foveal thickening on OCT.

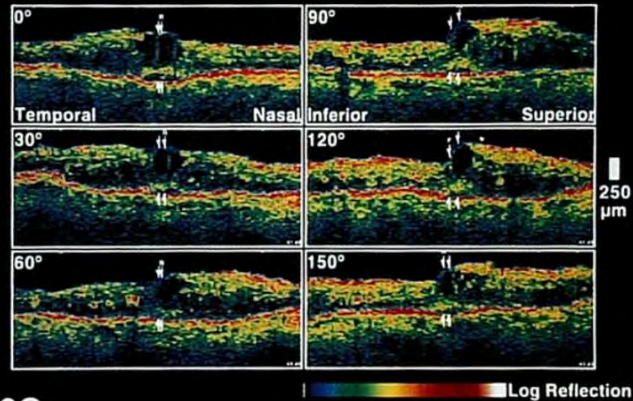
**Conclusions:** Optical coherence tomography was a useful technique for quantifying macular thickness in patients with diabetic macular edema. The topographic mapping protocol provided geographic information on macular thickness that was intuitive and objective. *Ophthalmology* 1998;105:360-370

Macular edema is a common cause of vision loss in patients with diabetic retinopathy. Although fluorescein angiography provides a qualitative assessment of vascular leakage in macular edema, actual macular thickening is better correlated with visual acuity<sup>1</sup> and is the standard by which potential laser treatment is evaluated. Macular edema is clinically significant, as defined by the Early

Treatment Diabetic Retinopathy Study (ETDRS) protocol, if retinal thickening is observed within  $500 \mu\text{m}$  of the center of the foveal avascular zone.<sup>2</sup>

Optical coherence tomography (OCT) is a new retinal imaging technique that has applications in the diagnosis and management of a variety of diseases of the macula and optic nerve.<sup>3-10</sup> Optical coherence tomography produces cross-sectional images of optical reflectivity in the retina in analogy to ultrasound B-scans, but with higher resolution. Measurements of retinal thickness may be obtained directly from the tomograms, either by manually measuring the distance between the inner and outer retinal boundaries or by using computer image processing techniques. In patients with diabetes and diabetic retinopathy, single measurements of central foveal thickness using OCT correlate with visual acuity and provide a means of monitoring macular thickening before and after laser therapy.<sup>11</sup>

In this article, we extend OCT to perform retinal thickness measurements at multiple locations covering the entire macula so that retinal thickening also may be assessed in the perifoveal and surrounding macula. A standardized scanning protocol and image analysis method that displays macular thickness topographically is investigated for the early screening of macular thickening in patients with diabetes and for following the progression or regression of edema after treatment.



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<sup>3</sup>Linscott Laboratory, Massachusetts Institute of Technology, Lexington, Massachusetts.

Presented in part at the Association for Research in Vision and Ophthalmology Annual Meeting, Fort Lauderdale, Florida, April, 1996.

Supported in part by NIH Grant R01-4-4711208-01, Bethesda, Maryland; 1993, Grant 10004-04-0171, Arlington, Virginia, as an unrestricted departmental grant from Research to Prevent Blindness, Inc., New York, New York, and the Massachusetts Lions Eye Research Fund, Inc., Boston, Massachusetts.

Carmen A. Puliafito and James G. Fujimoto are consultants for Humphrey Instruments, Inc. Reprint requests to Carmen A. Puliafito, MD, The New England Eye Center, Tufts University School of Medicine, 750 Washington Street, Box 456, Boston, MA 02111.

## Aim



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- Challenge your skills in differential diagnosis
- Share some interesting pathology we've seen at CFEH
- Consider the pathophysiology, diagnosis and management of these conditions
- What is the role of imaging?



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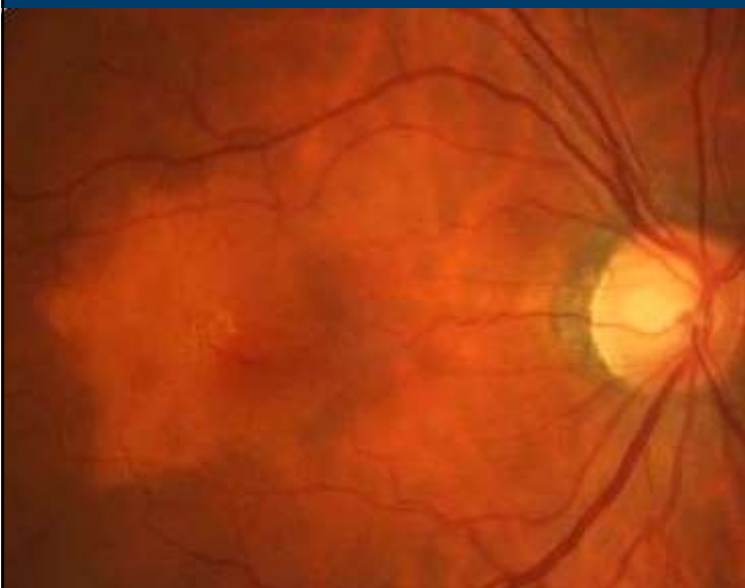
# Case 1



## Asymptomatic 54 year old Asian male

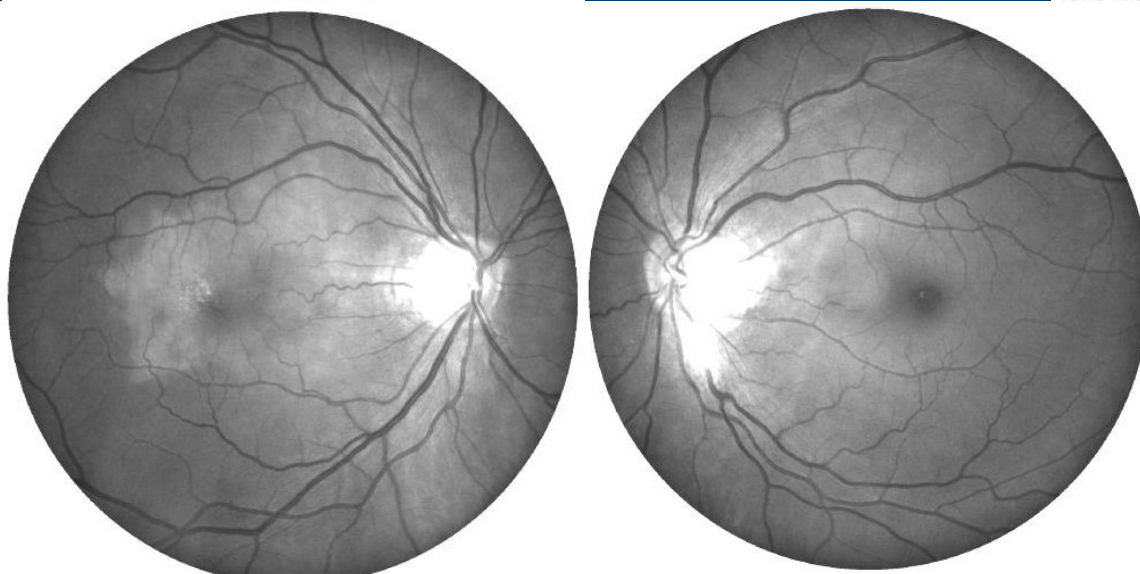


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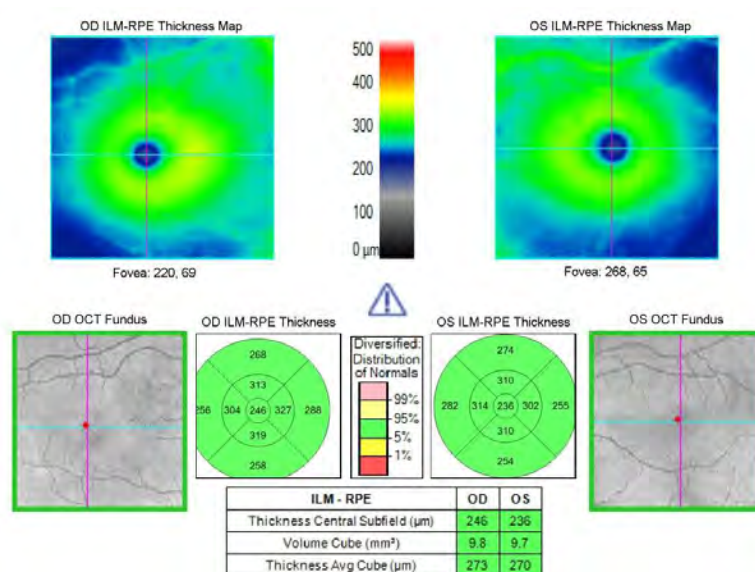


- Referred for assessment due to his unusual macular appearance
- Good general health (Sovac)
- Aided VA: 6/4.8 OD & 6/4.8<sup>-1</sup> OS
- Low myopic Rx
- Amsler grid - clear R & L
- Contrast sensitivity (MARS test): borderline OD & WNL OS

## Posterior pole photos



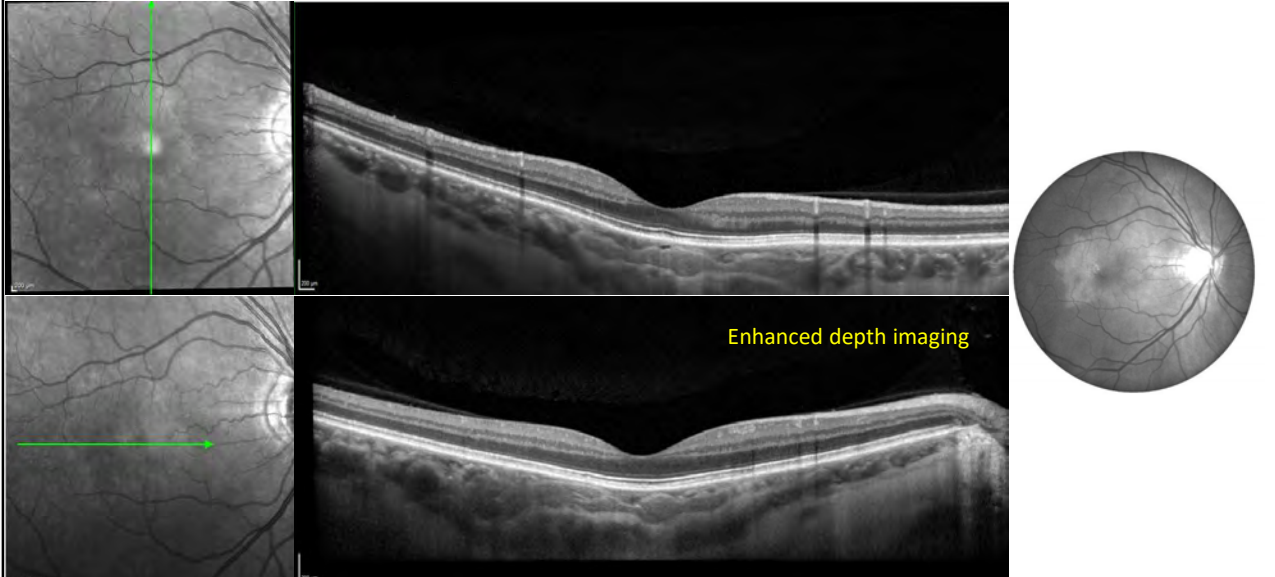
## Macular thickness



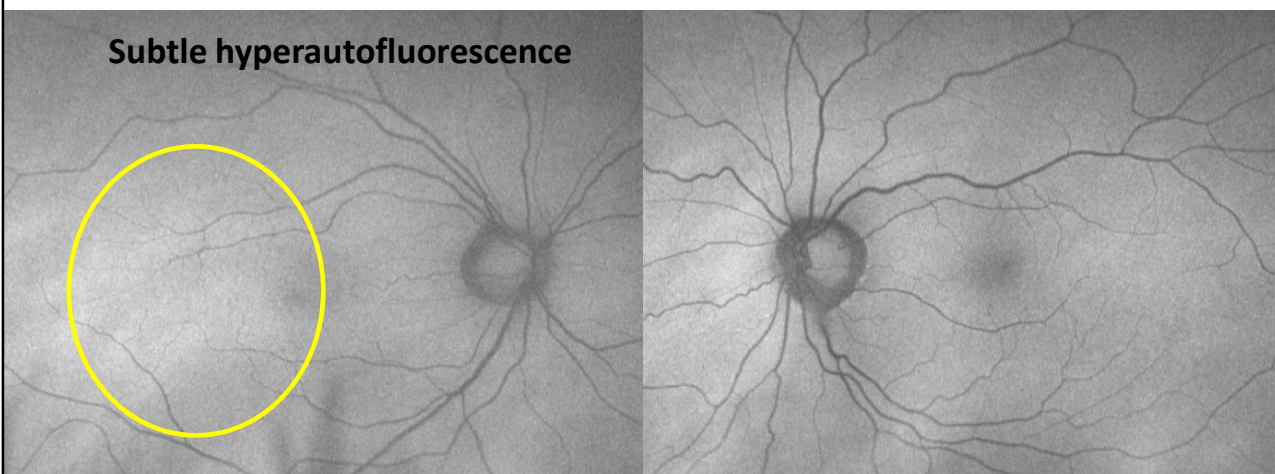
Maculae classified as  
WNL - "green disease"



## Spectralis OCT line scans

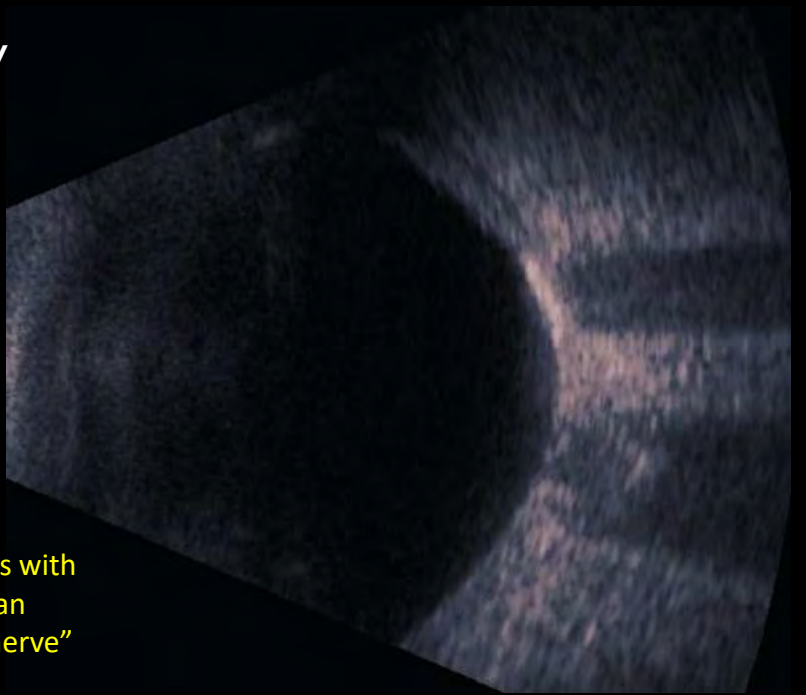


## Fundus autofluorescence (Optomap)



## B-Scan ultrasonography

Highly reflective choroidal mass with acoustic shadowing that gives an appearance of “pseudo-optic nerve”

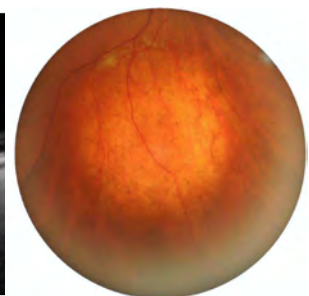
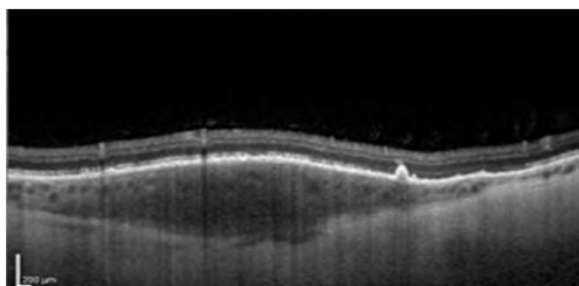


## Differential diagnoses



- Amelanotic choroidal naevus

### AMELANOTIC CHOROIDAL NAEVUS



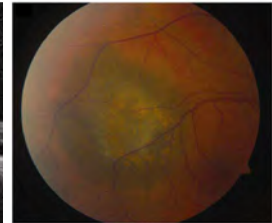
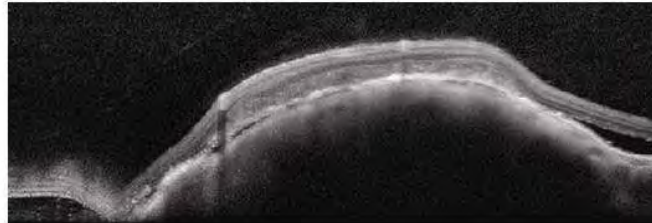
## Choroidal tumours

SOURCE: Say EA, Shah SU, Ferenczy S, Shields CL. Optical Coherence Tomography of Retinal and Choroidal Tumors. Journal of Ophthalmology Volume 2011, Article ID 385058

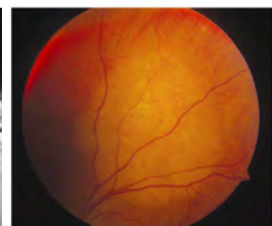
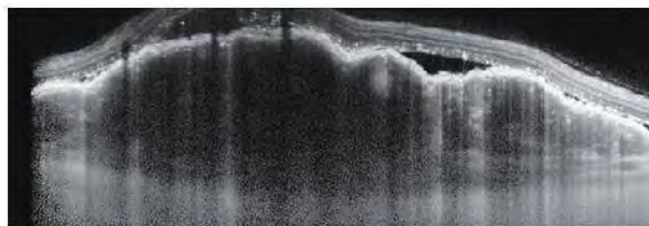


### SMALL CHOROIDAL MELANOMA

- Amelanotic choroidal naevus
- Amelanotic choroidal melanoma
- Choroidal metastasis



### CHOROIDAL METASTASIS



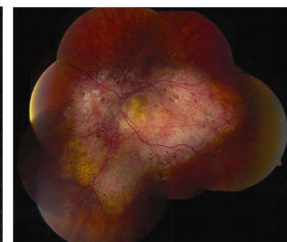
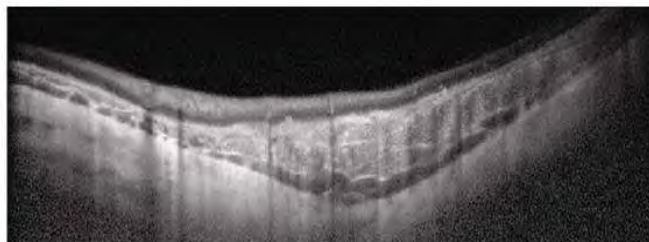
## Other tumours

SOURCE: Say EA, Shah SU, Ferenczy S, Shields CL. Optical Coherence Tomography of Retinal and Choroidal Tumors. Journal of Ophthalmology Volume 2011, Article ID 385058

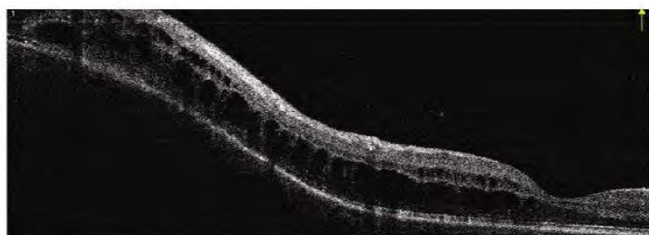


### CHOROIDAL OSTEOMA

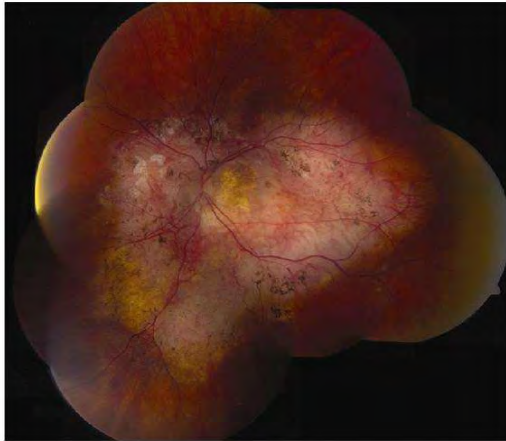
- Amelanotic choroidal naevus
- Amelanotic choroidal melanoma
- Choroidal metastasis
- Choroidal osteoma
- Choroidal hemangioma
- Choroidal granuloma (TB, sarcoid)
- Sclero-choroidal calcifications



### CHOROIDAL HEMANGIOMA



## Choroidal osteoma

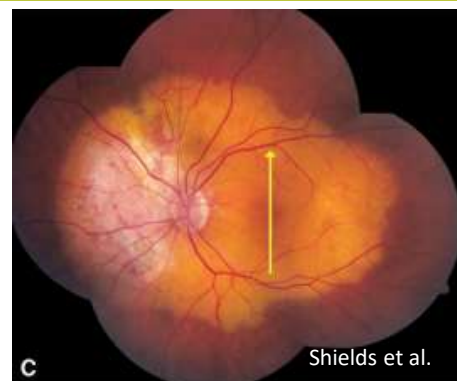


- Benign intraocular tumour: **mature bone replacing choroid**
- Unknown aetiology
- Predilection for young adult women
- First manifests teens to early 20s
- Shows growth in 51% of patients by 10 years

## Choroidal osteoma: PROGNOSIS

Long-term VA poor (<6/60) in 56-58% patients due to:

- subretinal fluid
- RPE alterations
- subretinal haemorrhage from CNV
- tumour decalcification beneath the fovea



### CLINICAL APPEARANCE

**Decalcified portion:**  
thin, atrophic, yellow-grey  
**Calcified portion:**  
thicker and more orange

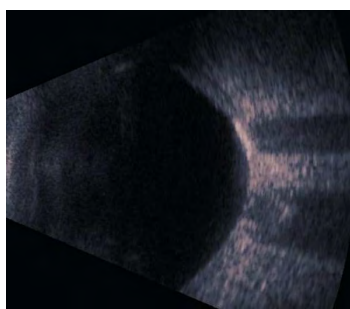


## Management



- Refer to confirm diagnosis
- Observe asymptomatic/stable choroidal osteomas
- Monitor for CNVM or enlargement
  - OCT, anti-VEGF if indicated
- Use of PDT to decalcify extrafoveal tumours (to prevent further growth) has been proposed

## Osteoma: Take Home Points



- B-Scan ultrasonography and OCT are the most useful tests for diagnosing choroidal osteoma
- Long term VA prognosis is poor in over half of patients
- Monitor for complications including CNVM and associated subretinal haemorrhages and macular atrophy



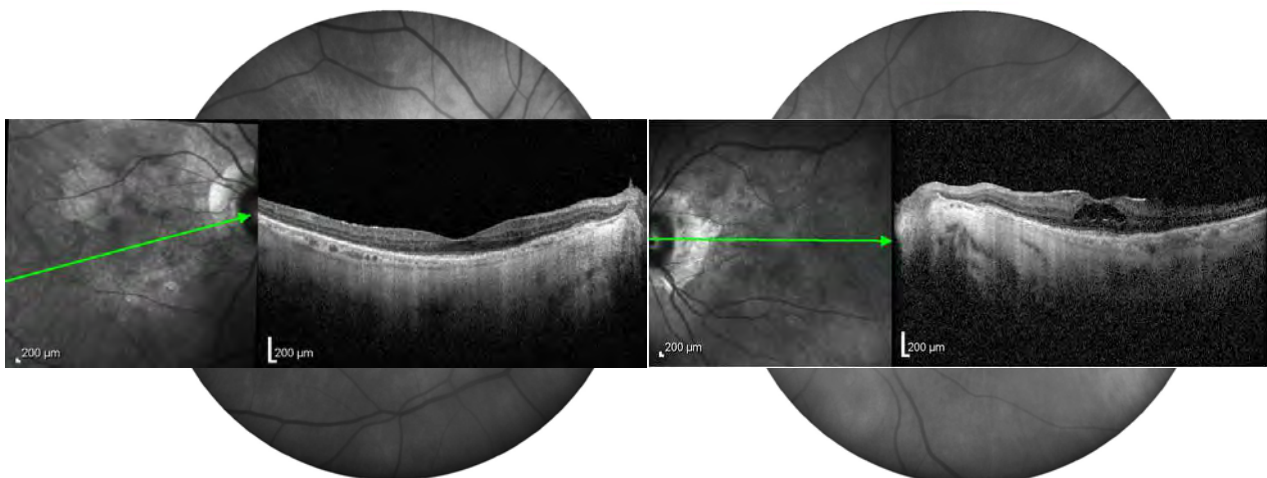
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## Case 2

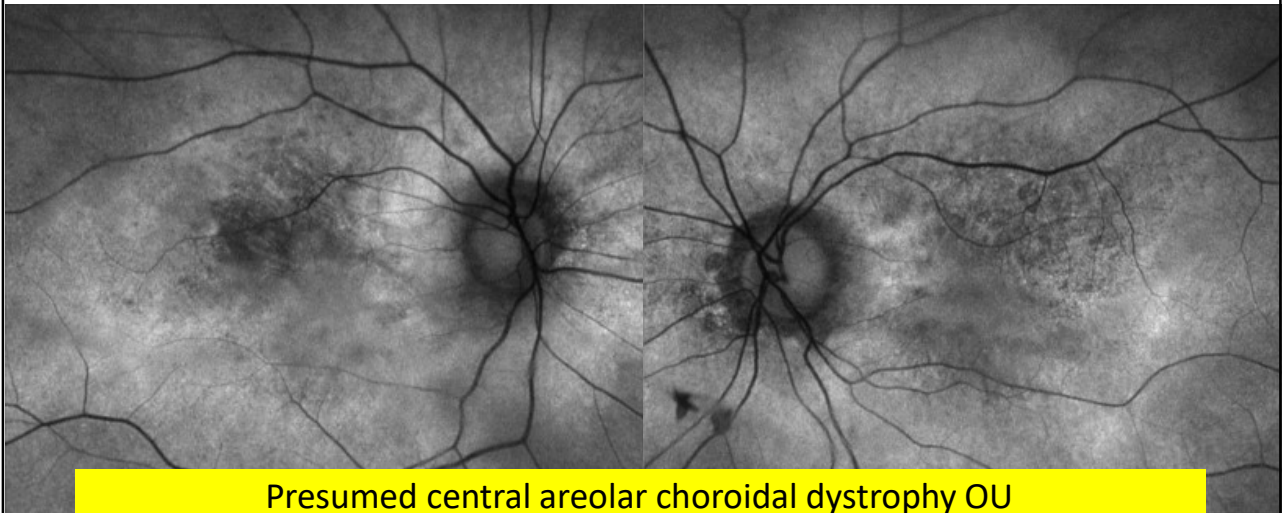


### 84 year old Caucasian female

- Referred for macular assessment
- Type 2 diabetes – unsure of HbA1c
- Aided VA OD: 6/9.5-2 and OS: 6/12



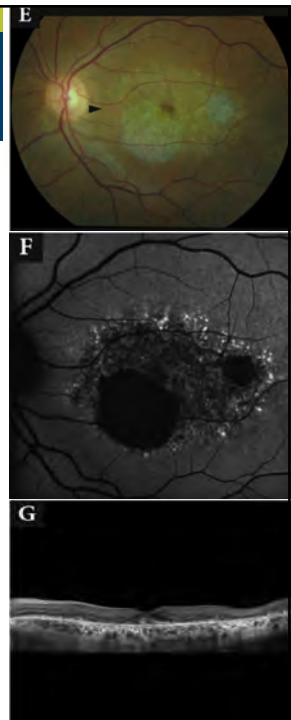
## FAF imaging (Optos)

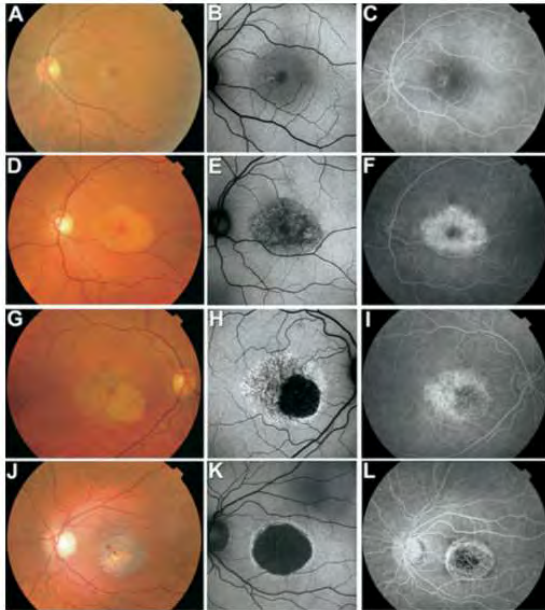


Presumed central areolar choroidal dystrophy OU  
ERM with presumed lamellar macular hole secondary to VMT OS

## Central areolar choroidal dystrophy

- Hereditary retinal disorder primarily affecting the retina
  - Most cases are autosomal dominant
  - Mutations in the peripherin-2/RDS gene most common cause
- Decrease in VA usually occurs in 4<sup>th</sup> and 5<sup>th</sup> decade
  - Marked VA loss usually related to geographic atrophy
  - Can be confused with AMD: Usually no flecks or drusen though some can show drusen-like deposits





Boon CJF et.al. Ophthalmology 2009;116:771

## Central areolar choroidal dystrophy

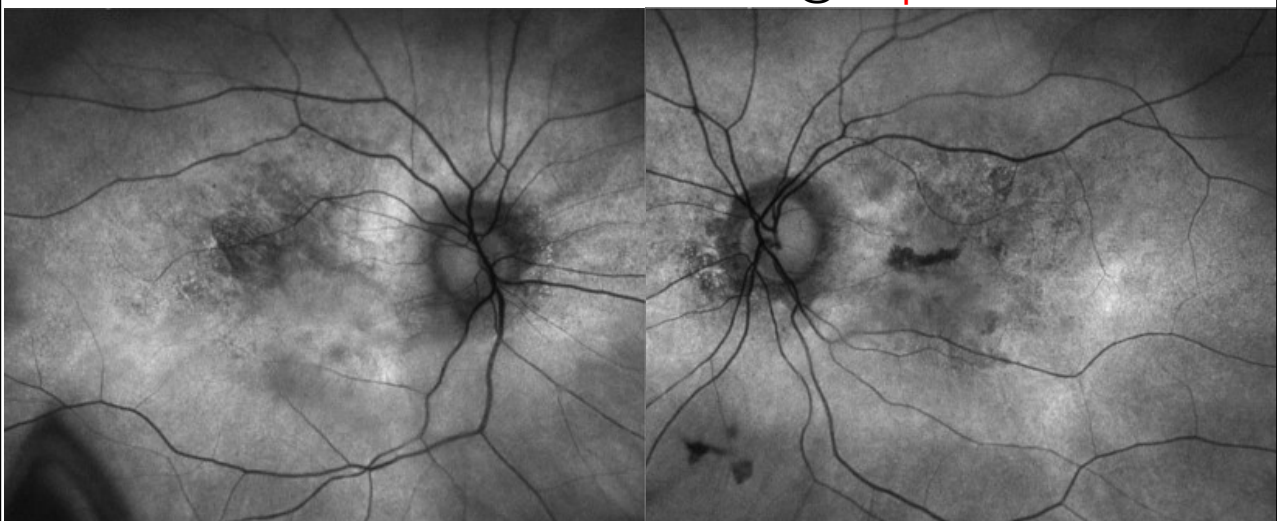
- **Stage 1:** Mild parafoveal pigmentation
- **Stage 2:** Round to oval hypopigmentation in macula
- **Stage 3:** Areas of well-defined chorioretinal atrophy outside the central fovea with dense hypo-AF (within slight hypopigmentation)
- **Stage 4:** CR atrophy involves fovea

## 7-month follow-up

Aided VA

OD: 6/19-2 OD (PH 6/19-1) **prev 6/9**

OS: HM@1m **prev 6/12**

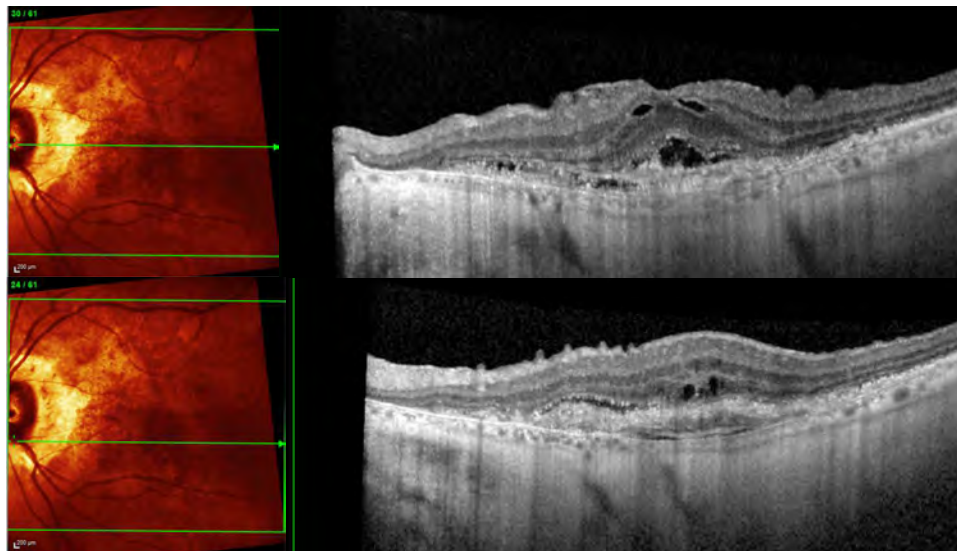




# 7-month follow-up: OCT



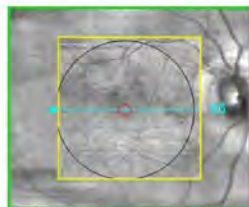
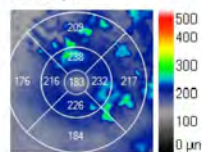
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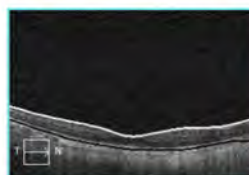
## Macular Change:Macular Cube 512x128

OD ☒ OS
 Registration : Automatic  
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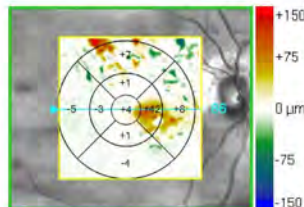
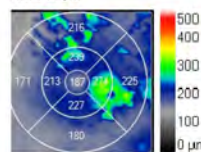
Fovea: 238, 66



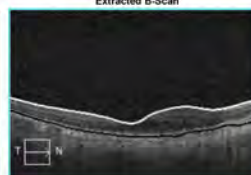
Overlay: OCT Fundus Transparency: 0 %


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Fovea: 238, 66



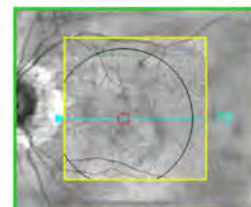
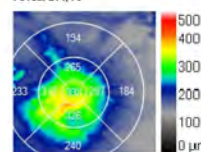
Overlay: ILM-RPE Difference Transparency: 0 %



## Macular Change:Macular Cube 512x128

OD ☐ OS ☒
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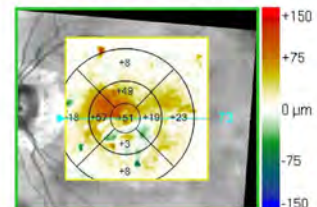
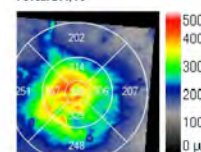
Fovea: 214, 73



Overlay: OCT Fundus Transparency: 0 %


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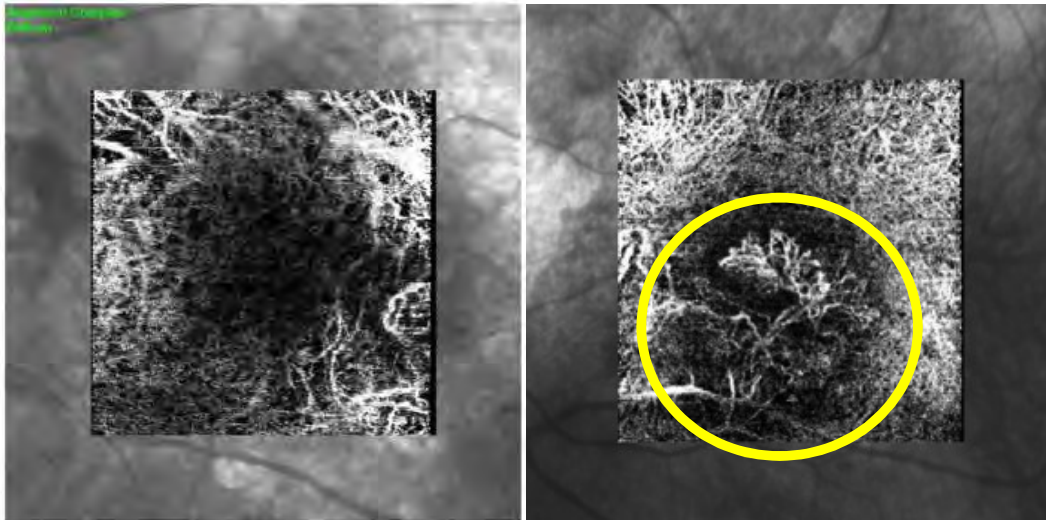
Fovea: 214, 73



Overlay: ILM-RPE Difference Transparency: 0 %



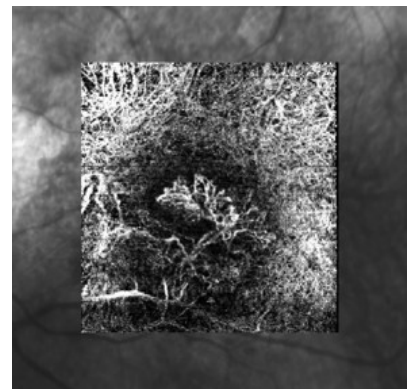
## OCT Angiography: avascular complex



## Diagnosis and management



- Presumed central areolar choroidal dystrophy OU
- Secondary CNV OS
- Cystoid macular oedema and suspected CNV OD
- **Urgent referral to ophthalmologist**





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## Case 3



47 year old Caucasian female

- Referred for assessment of the peripheral retina
- History of myopia and longstanding poor vision OS
- Symptoms of brief, blue flashes in her central vision for ~2 years (most recently 2 weeks ago)



## 47 year old Caucasian female

- MHx: Recurrent kidney disease (under investigation), low iron, transient vertigo
- Meds: Avapro, iron, folic acid, Noten, remifemin, vitamins D, B6, B12
- FHx: Possible macular degeneration (mother)

## Clinical assessment



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- **Aided acuities** were 6/6-I OD and 6/38 OS (pinhole 6/12-I).
- **Rx:** R: -5.75/-1.75 x 15 & L: -14.50/-3.24 x 148
- **IOP (iCare):** 16/17 @ 11.23am.
- **Axial length (Lenstar):** R: 25.74mm & L: 30.20mm

Measuring mode	Mode	Right eye		Left eye	
		Phakic		Phakic	
Axial length	AL	25.74 mm	±0.025 mm	30.20 mm	±0.029 mm
Cornea thickness	CCT	542 µm	±1.7 µm	548 µm	±1.8 µm
Aqueous depth	AD	2.63 mm	±0.005 mm	2.71 mm	±0.006 mm
Lens thickness	LT	4.26 mm	±0.020 mm	4.31 mm	±0.006 mm
Retina thickness	RT	200** µm	±0.0 µm	200** µm	±0.0 µm
Flat meridian	K1	42.54 D @ 28°	±0.149 D	42.48 D @ 166°	±0.089 D
Steep meridian	K2	43.72 D @ 118°	±0.211 D	44.26 D @ 76°	±0.386 D
Astigmatism	AST	1.18 D @ 118°	±6.0°	1.79 D @ 76°	±3.8°
Keratometric index	n	1.3375		1.3375	

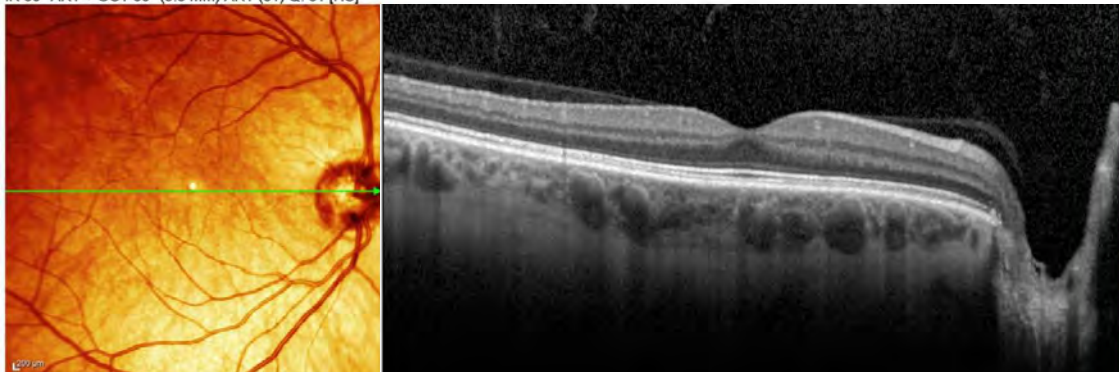


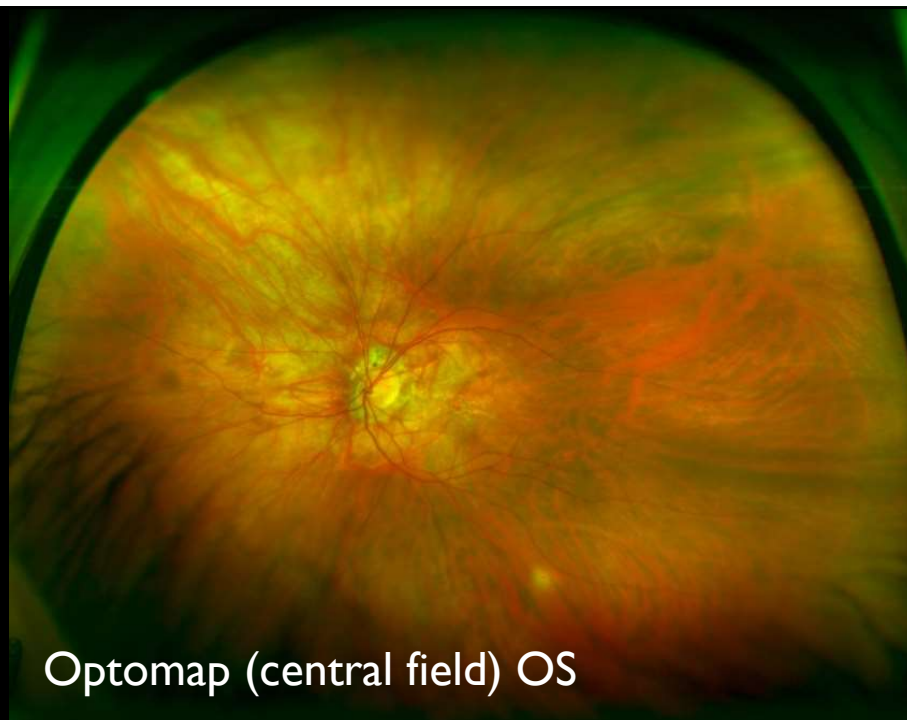


## Spectralis OCT OD Macula

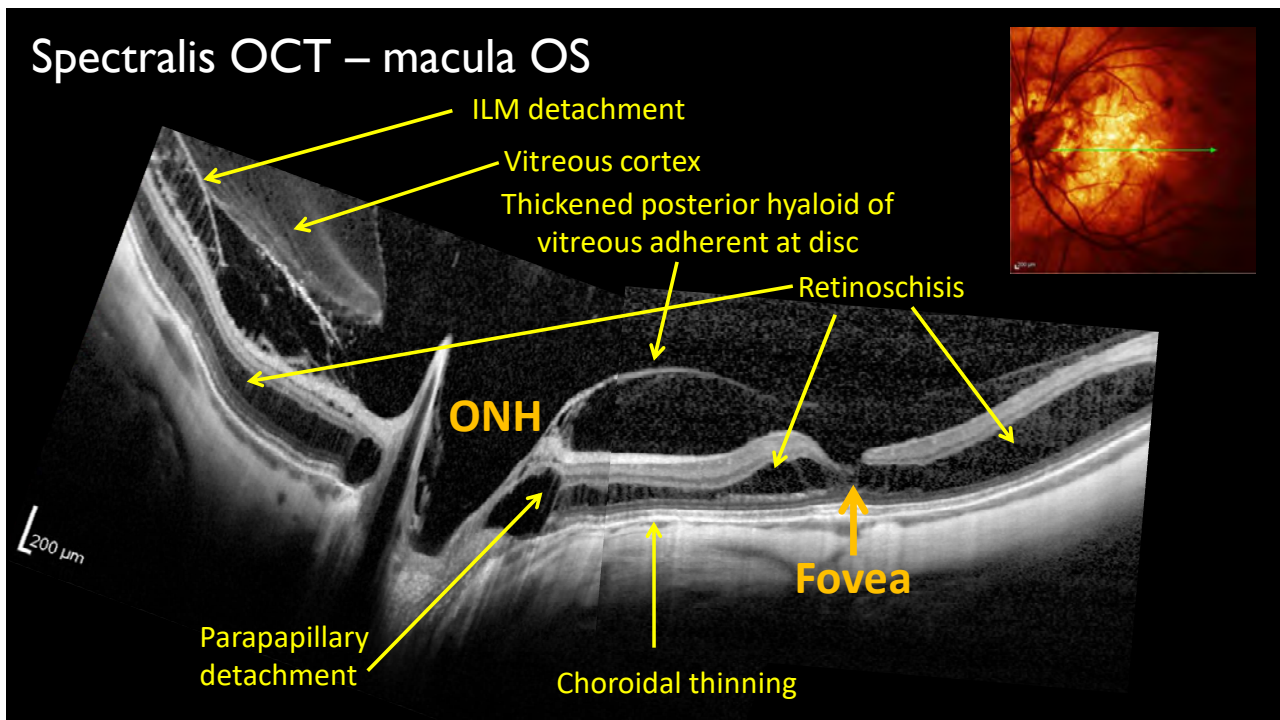


IR 30° ART + OCT 30° (9.6 mm) ART (51) Q: 31 [HS]





## Spectralis OCT – macula OS



## Inner Limiting Membrane Detachment



- Differentiation of ILMD vs. ERM is by presence of **columns** that bridge membrane to the retinal surface
- Differentiation of ILMD vs. incomplete PVD may be difficult
  - ILM might be tightly adhered to posterior cortical vitreous

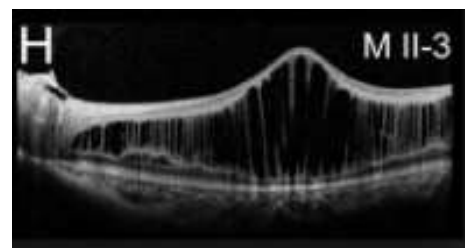


Source: Faghigi et al. OCT in Highly Myopic Eyes. J Oph Vis Res 2010;5(2):110-121

## Differential diagnosis

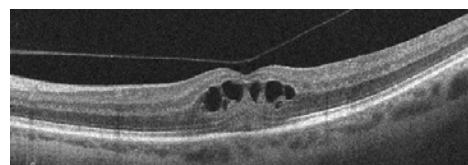


- Familial X-linked retinoschisis
- Vitreomacular traction
- Tractional retinal detachment
- Macular oedema
- Myopic maculoschisis
- Neuroretinitis



**Familial X-linked retinoschisis**

Wang NK et. al. Molecular Vision 2015

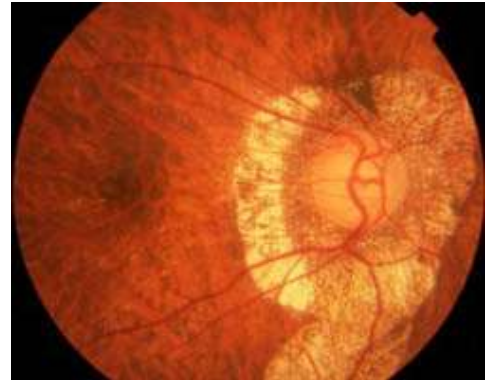


**Vitreomacular traction**

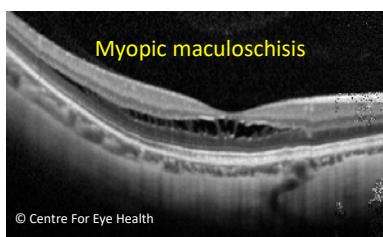
## Pathological Myopia



- Also termed *high myopia* or *degenerative myopia*
- Definition varies – commonly SE Rx  $\geq -6.00\text{D}$  or axial length  $>26\text{mm}$
- Progressive and excessive anteroposterior elongation of the globe **associated with secondary changes to sclera, retina, choroid, vitreous, macula &/or ONH**
- Extent of pathological tissue changes is variable



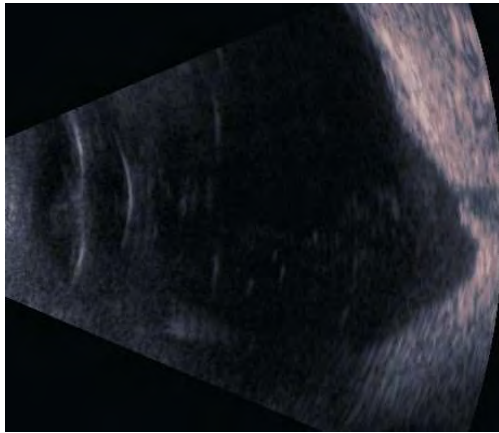
## Myopic maculoschisis



- 9-34% of highly myopic eyes with posterior staphylomas
- On OCT, hyporeflective splitting at outer plexiform layer (OPL)
- Often shows column-like formations across hyporeflective space

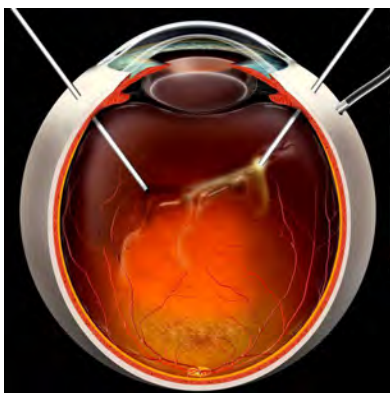


## Myopic maculoschisis



- Multifactorial aetiology likely involving
  - anterior traction
  - progression of the posterior staphyloma
  - intrinsic rigidity of the ILM: *prevents retina from stretching to adjust to contour of staphyloma*
- Symptomatic patients may present with reduced or blurry vision (VA: 6/7.5 to CF) and metamorphopsia

## Myopic maculoschisis: Management

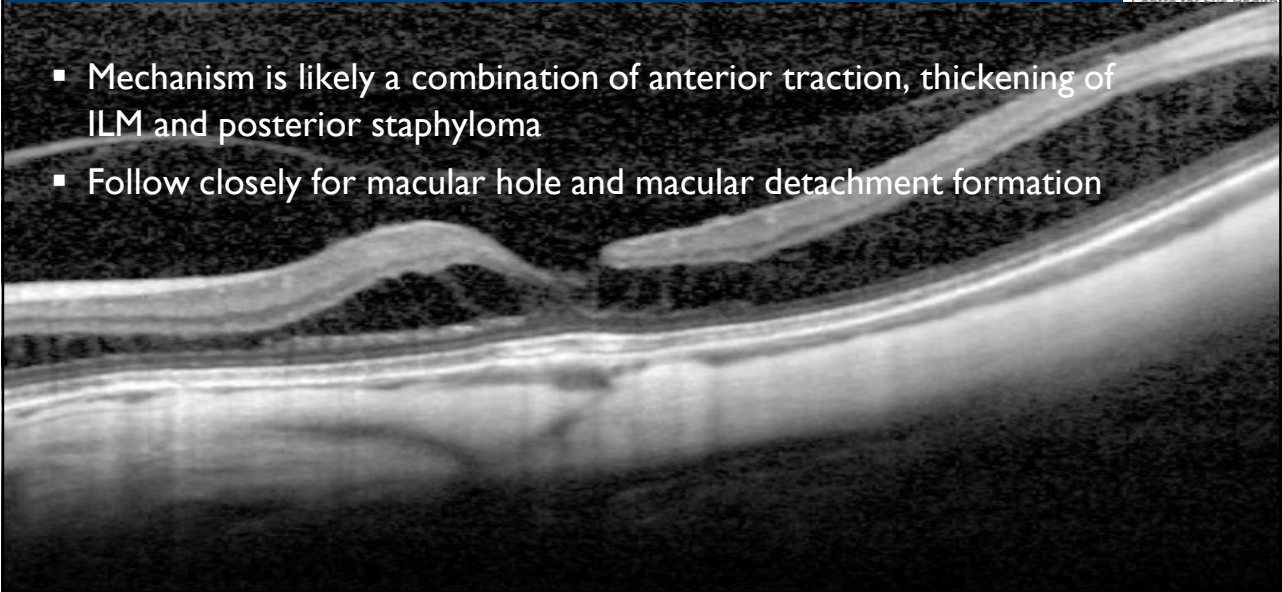


- **Follow** closely for development of macular holes or macular detachment (one study reported half of patients followed over time)
- **Treatment** may include
  - pars plana vitrectomy
  - removal of the posterior hyaloid
  - ILM peeling
  - gas tamponade

## Take Home Points: myopic maculoschisis



- Mechanism is likely a combination of anterior traction, thickening of ILM and posterior staphyloma
- Follow closely for macular hole and macular detachment formation



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## Case 4

## 50 year old Caucasian male



Referred for retinal assessment

No flashes but floaters may be worsening in right eye

Subjective Rx (stable 15 years)

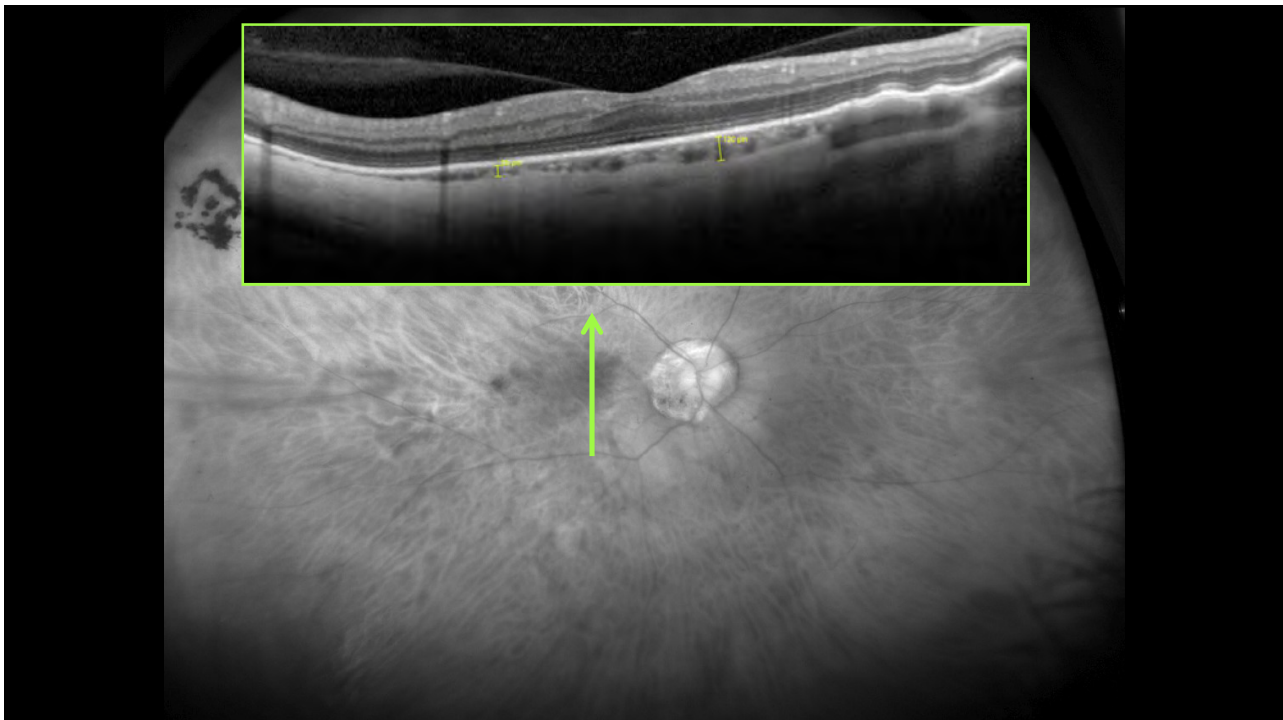
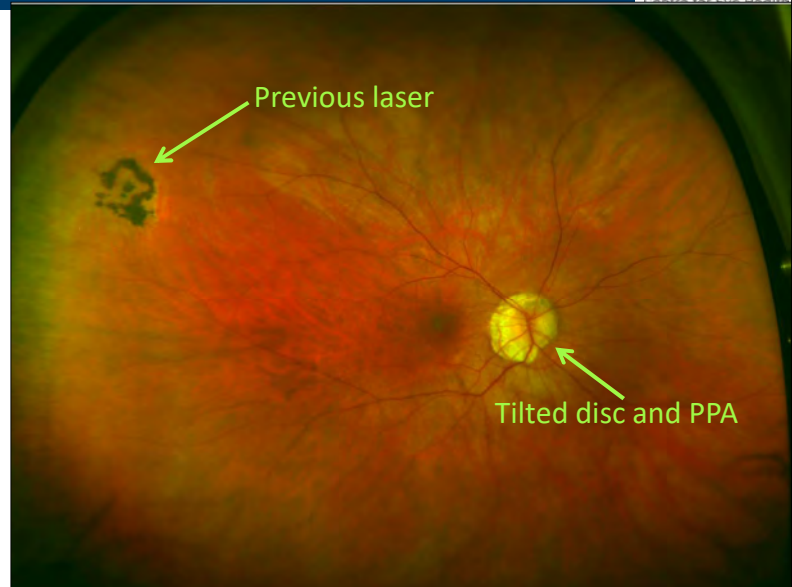
OD -15.00/-1.25 x 50 (6/9<sup>+1\*</sup>)

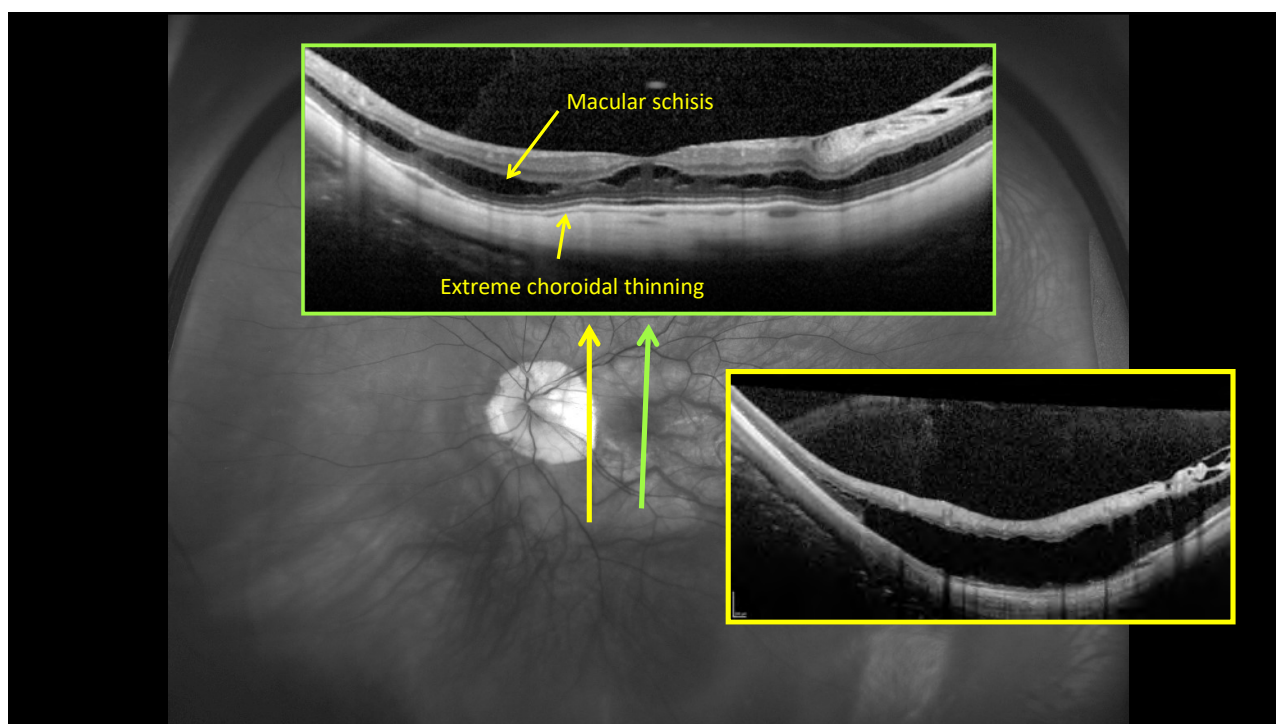
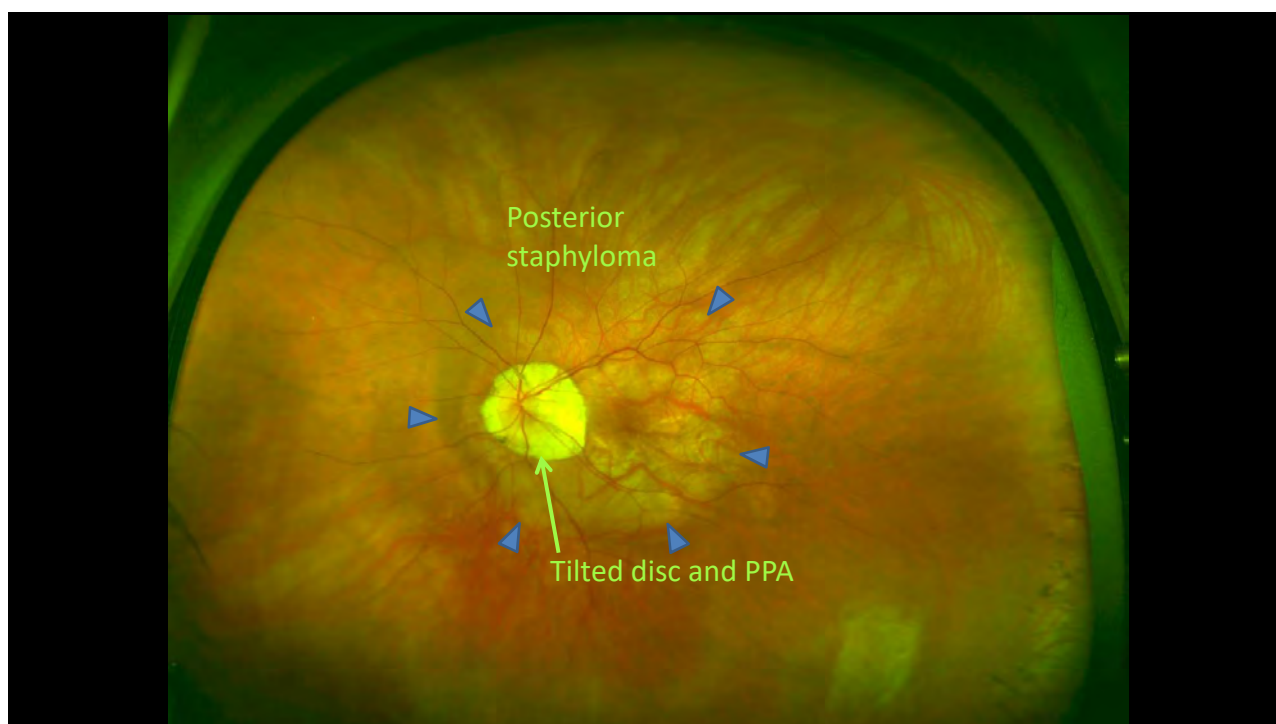
OS -15.00/-1.00 x 160 (6/24<sup>-2\*</sup>)

\*stable compared to ophthal report 12/12

OcHx:

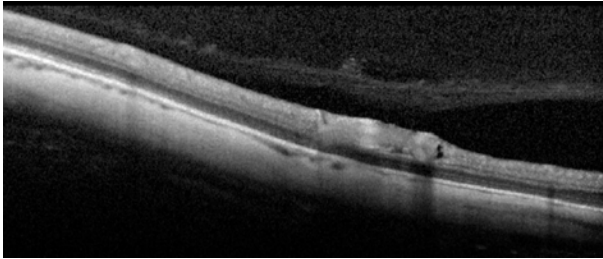
- Retinal tear OD (treated 9 years ago)
- Retinoschisis OS>OD
- Saw retinal specialist 1 year ago who suggested annual monitoring







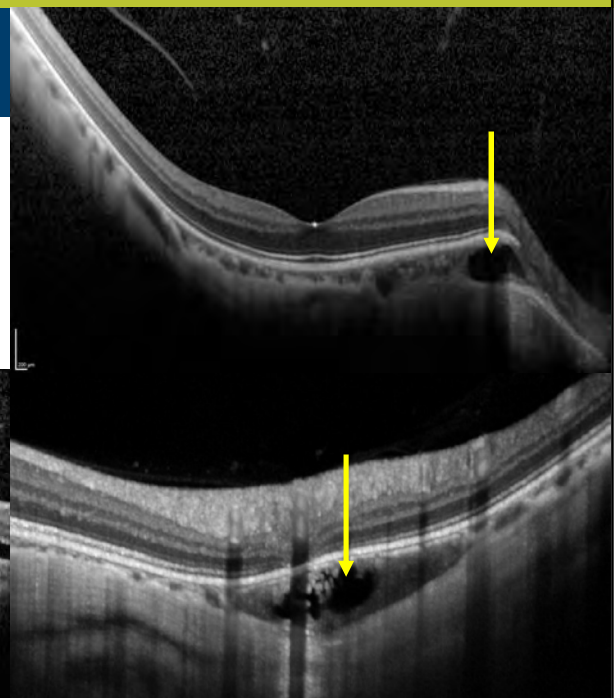
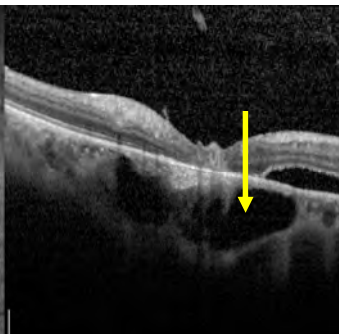
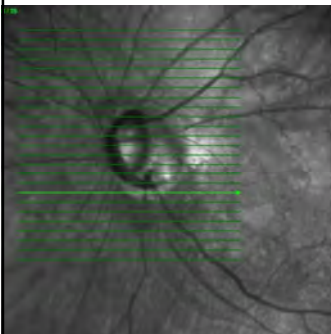
## Choroidal Thinning



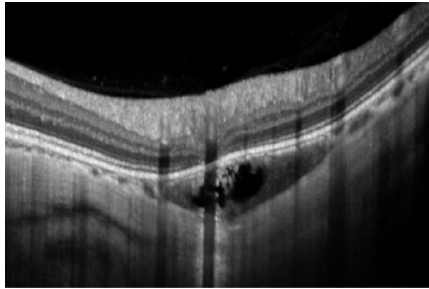
- Occurs with stretching of the globe
- Density of vasculature and circulation are reduced
- Reduced choroidal thickness is well correlated with:
  - Increased axial length & age
  - Decreased visual function (probably related to reduced supply of oxygen & metabolites to the outer retina)

## 10 SECOND DIAGNOSIS

The arrows point to different examples of what myopic pathology?

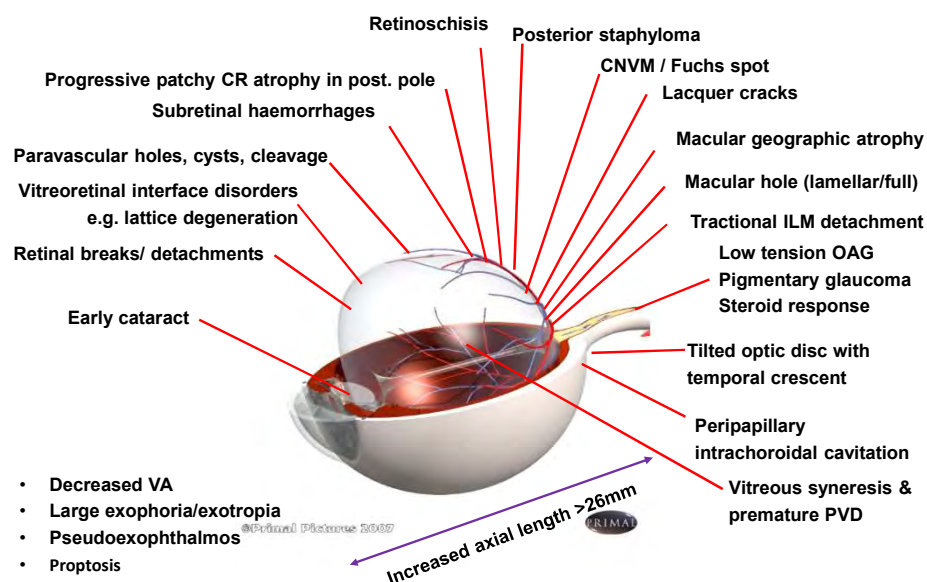


# Intrachoroidal Cavitation



OCT shows a deep hypo-reflectivity in underlying choroid separating RPE from the sclera

- 4.9% to 9.4% of individuals with pathological myopia
- Created by expansion of distance between inner wall of the sclera & posterior surface of Bruch's membrane
- Usually located adjacent to the inferior edge of disc
- Can be associated with visual field loss, particularly in cases of acquired peripapillary pit



## Characteristics of Pathological Myopia

Source: Adapted from Yanuzzi, Retina Atlas, 2010



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Education

## Case 6



### 14 year old Caucasian male



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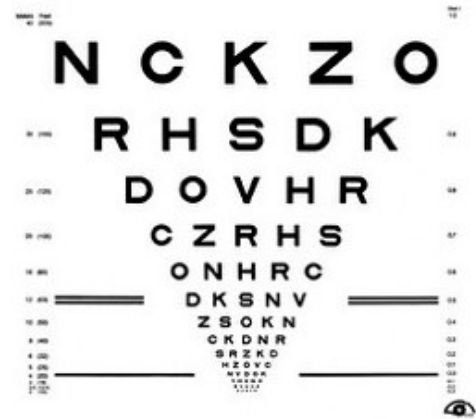
- Referred for further assessment of unusual optic discs
- OcHx:
  - Strabismus surgery OD at 2 years old with subsequent patching
  - Poor vision in left eye since birth
- MHx: Reported good general health
- FHx: Uncle recently had a RD

## Clinical findings



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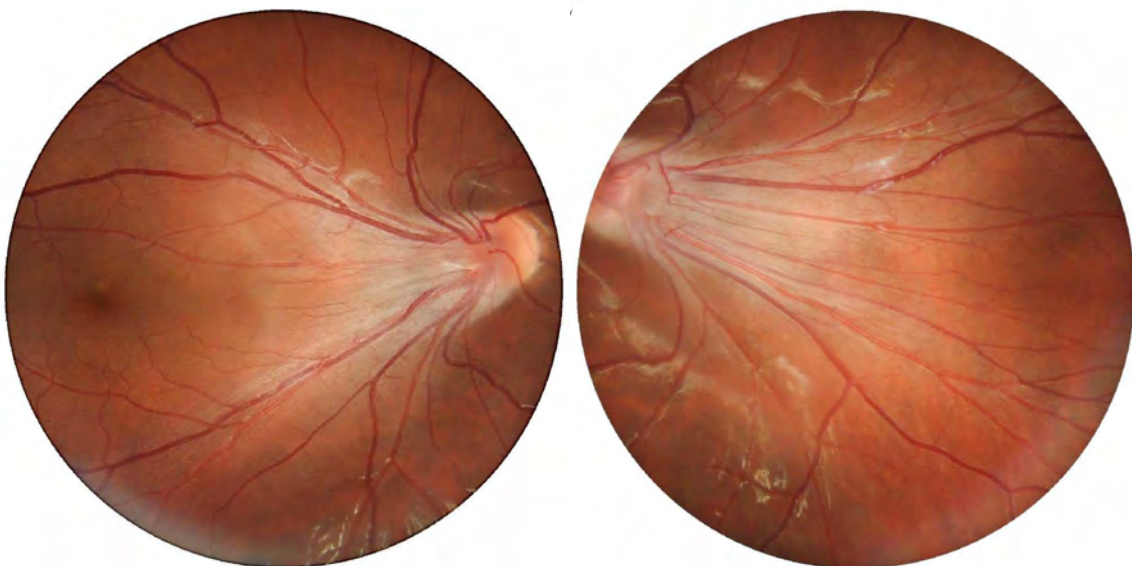
- Entering aided VA R: 6/7.6<sup>+2</sup> L: 1/48<sup>-1</sup>
- Left hypertropia
- Horizontal nystagmus OS>OD
- PERRL no RAPD
- IOP 15/16mmHg @ 2.31pm



## Posterior pole photos

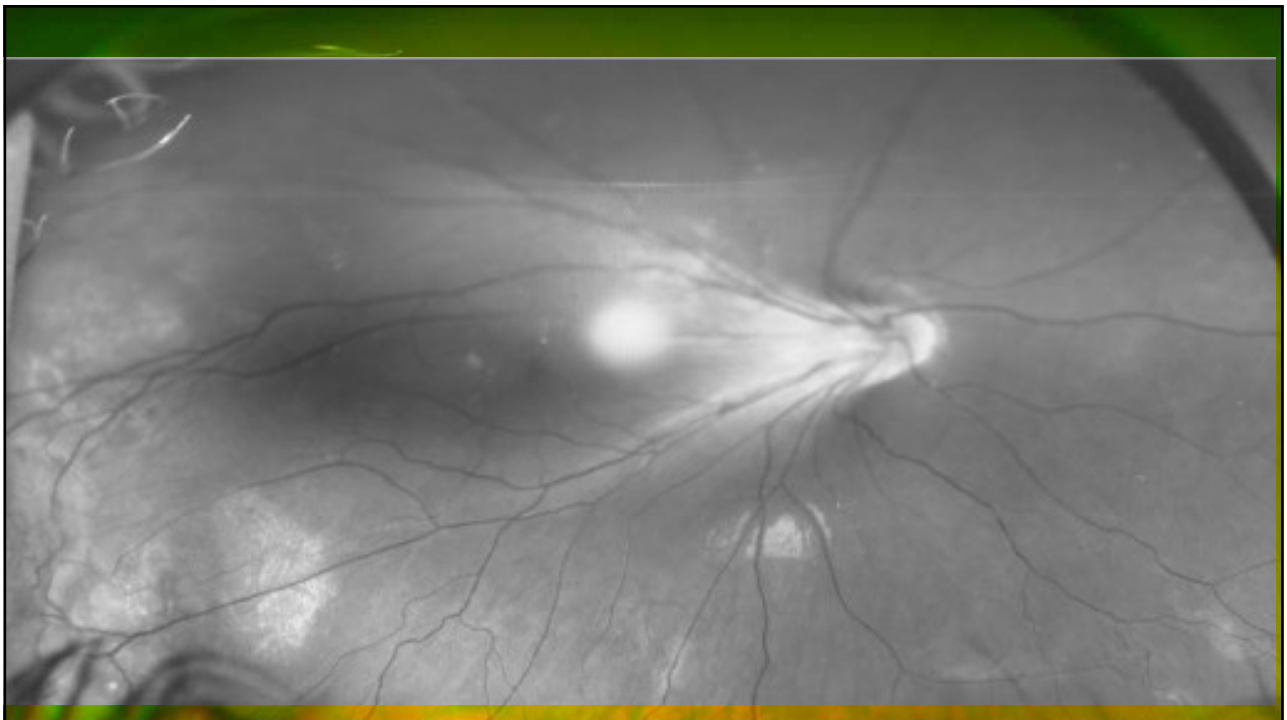
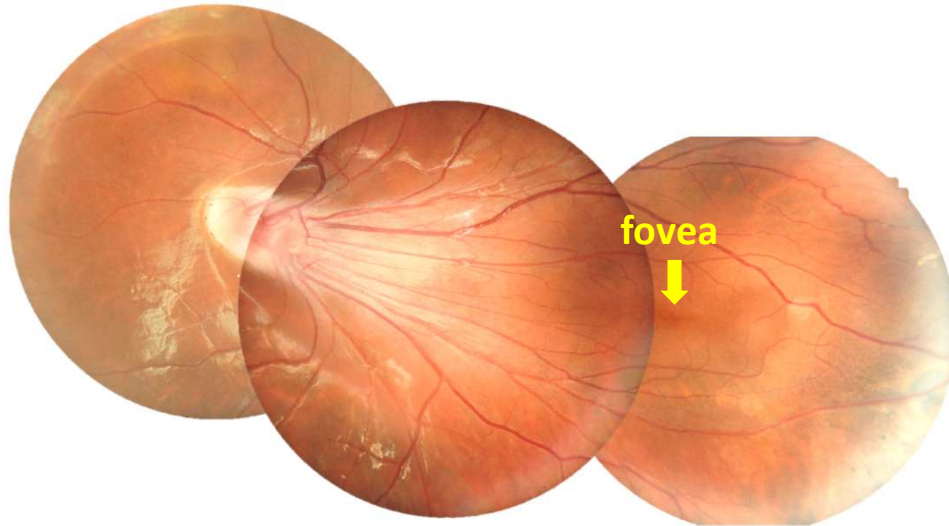


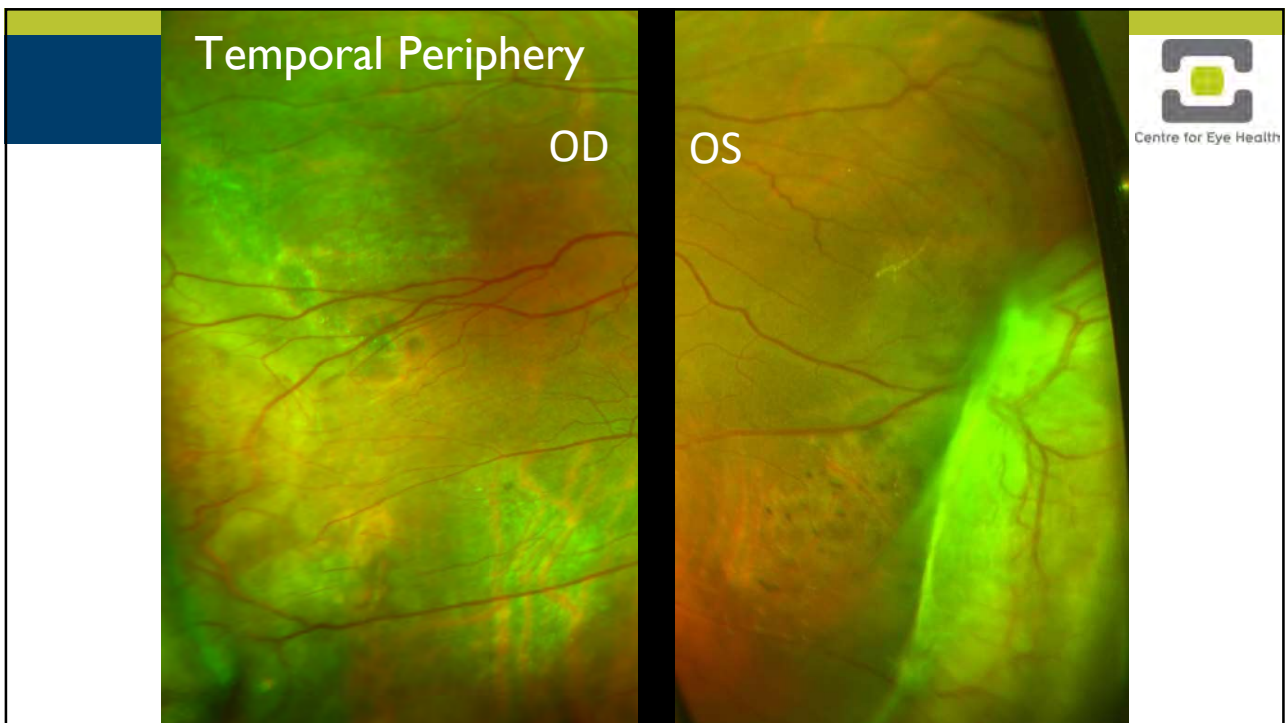
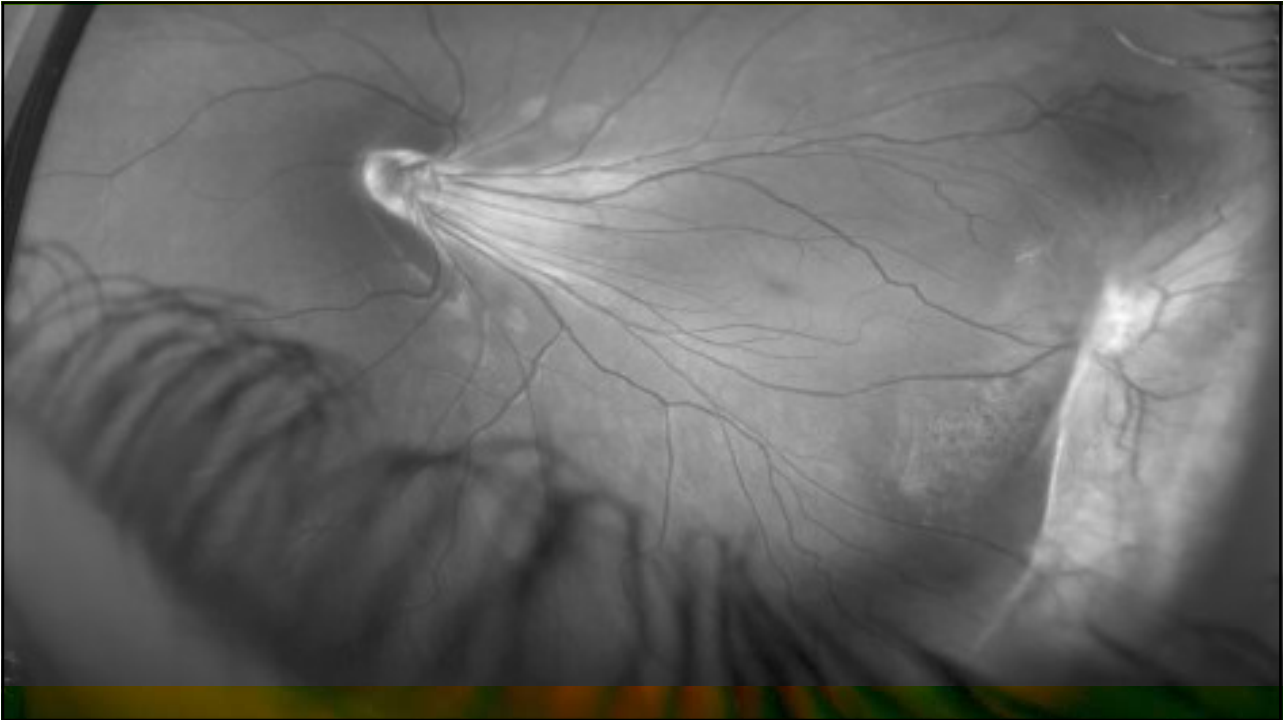
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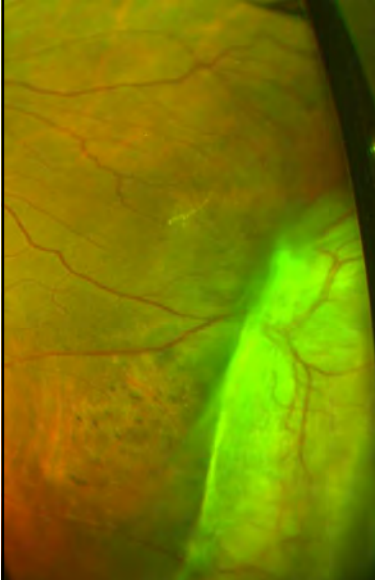


## Left eye - macular dragging





## Differential diagnoses



- Retinal detachment
- White-without-pressure
- Sickle cell retinopathy
- Proliferative diabetic retinopathy
- Retinoschisis
- Retinopathy of prematurity
- Familial exudative vitreoretinopathy (FEVR)

## Additional patient history



- Born 11 weeks premature (29 weeks) with no systemic complications

### DIAGNOSIS

Retinopathy of prematurity (ROP) with  
cicatricial macular dragging

## Retinopathy of Prematurity



- A leading cause of childhood blindness worldwide
- Neovascular disorder which causes loss of vision by means of **macular dragging & retinal detachment**
- Affects premature babies of very low birth weight exposed to high ambient oxygen concentration

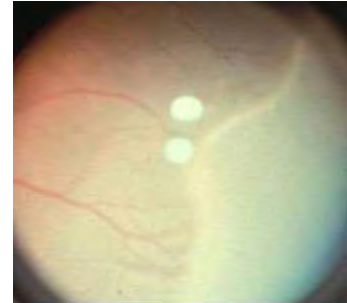


Fig. 2 Stage 2 ROP.  
Source: <http://www.aapos.org/terms/conditions/94>

The incidence of ROP has increased,  
as smaller & younger babies are surviving  
(a number of infants have survived from 21 weeks 6 days)

## Risk factors



- Birth before 32 weeks' gestation
- Birth weight of less than 1500g (esp. <1000g)
- Other possible risk factors include:
  - Supplemental oxygen
  - Hypoxemia (low O<sub>2</sub> in blood)
  - Hypercarbia (high CO<sub>2</sub> in blood)
  - Concurrent illness
  - Genetic factors
  - Birth occurring in a developing country





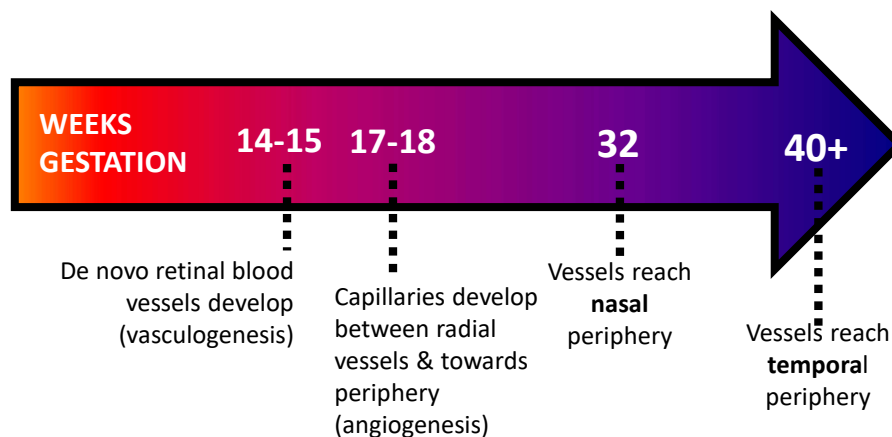
## Incidence of ROP & other ocular effects of prematurity



- ROP develops in >50% of premature infants weighing <1250g at birth
  - 10% of those infants develop extra-retinal angiogenesis (stage 3 ROP)
- ~ 20% of all premature babies will develop **strabismus or refractive error** by 3 years of age



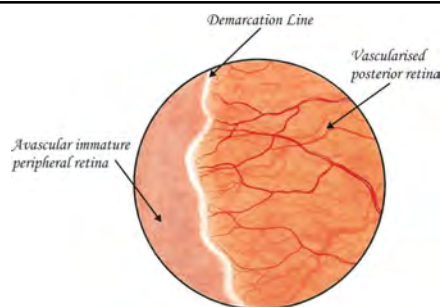
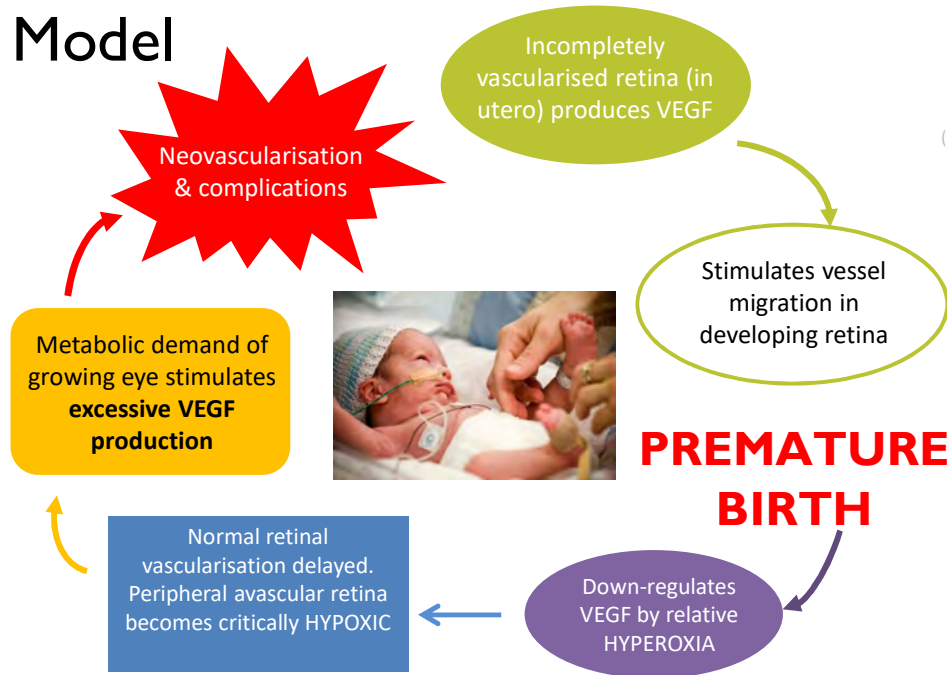
## Vascularisation of Normal Developing Eye IN UTERO



Adapted from: Fleck and McIntosh. Early Human Development (2008) 84, 83–88

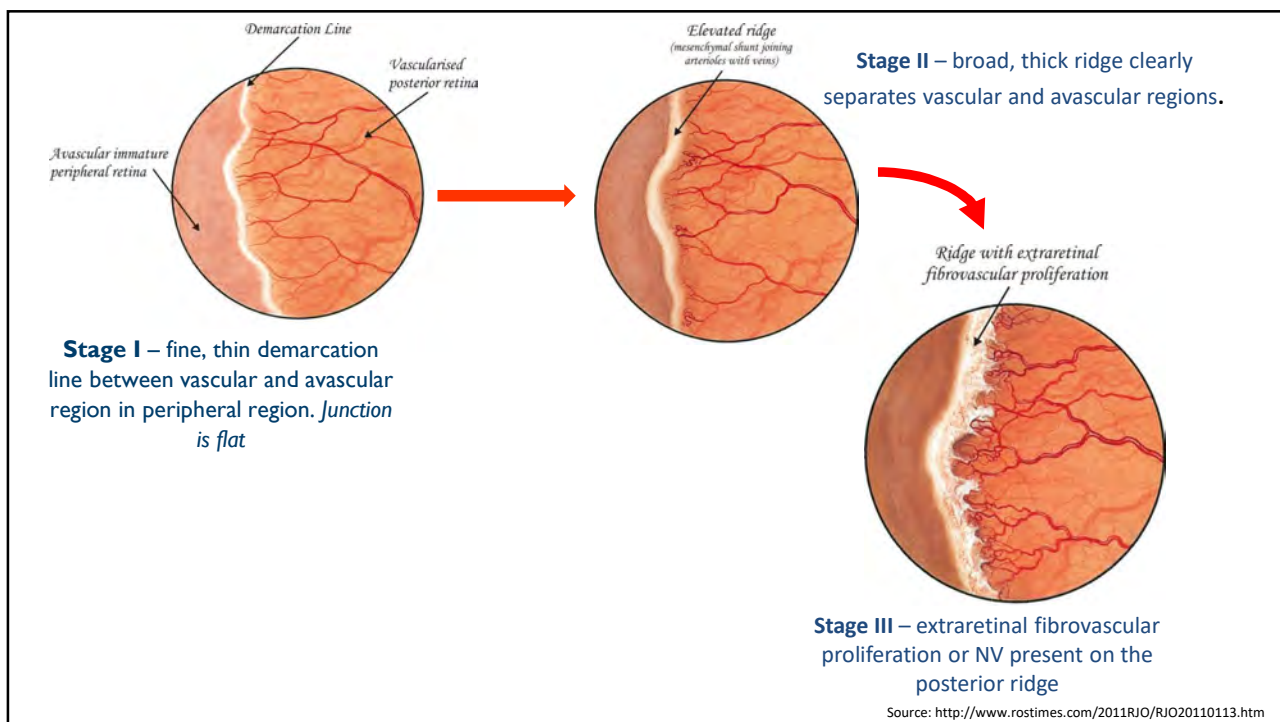
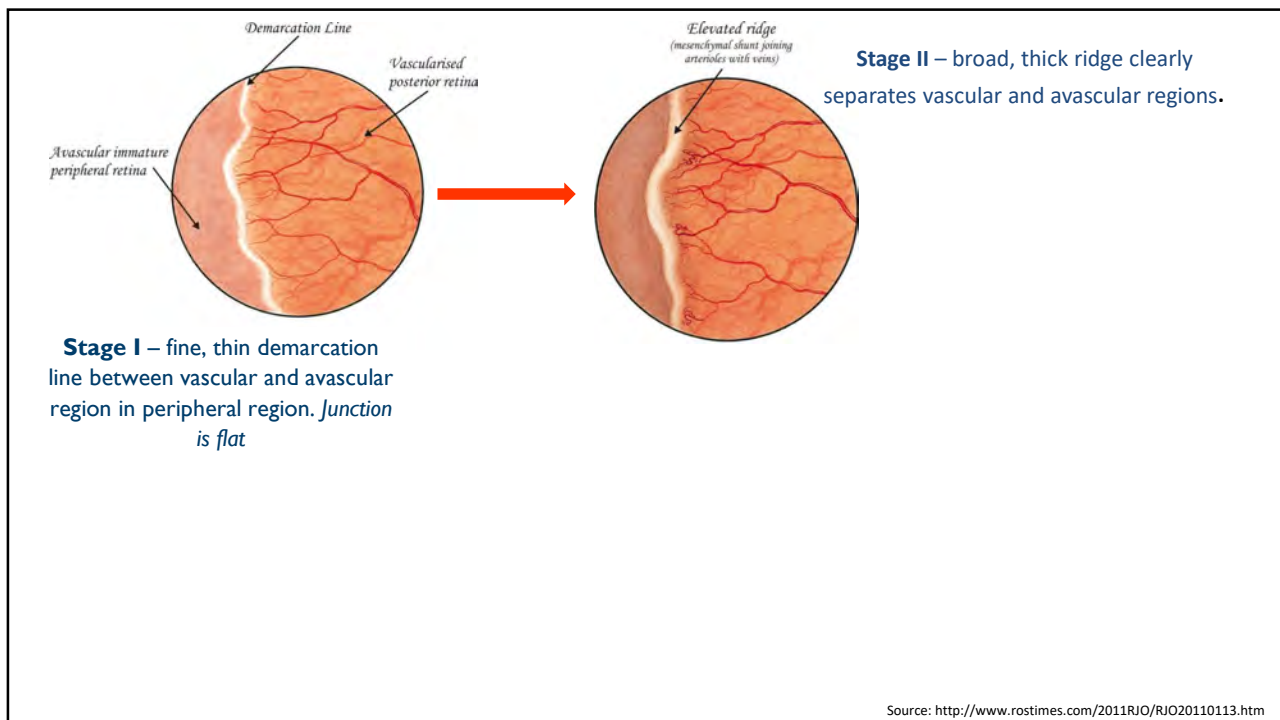
# ROP Model

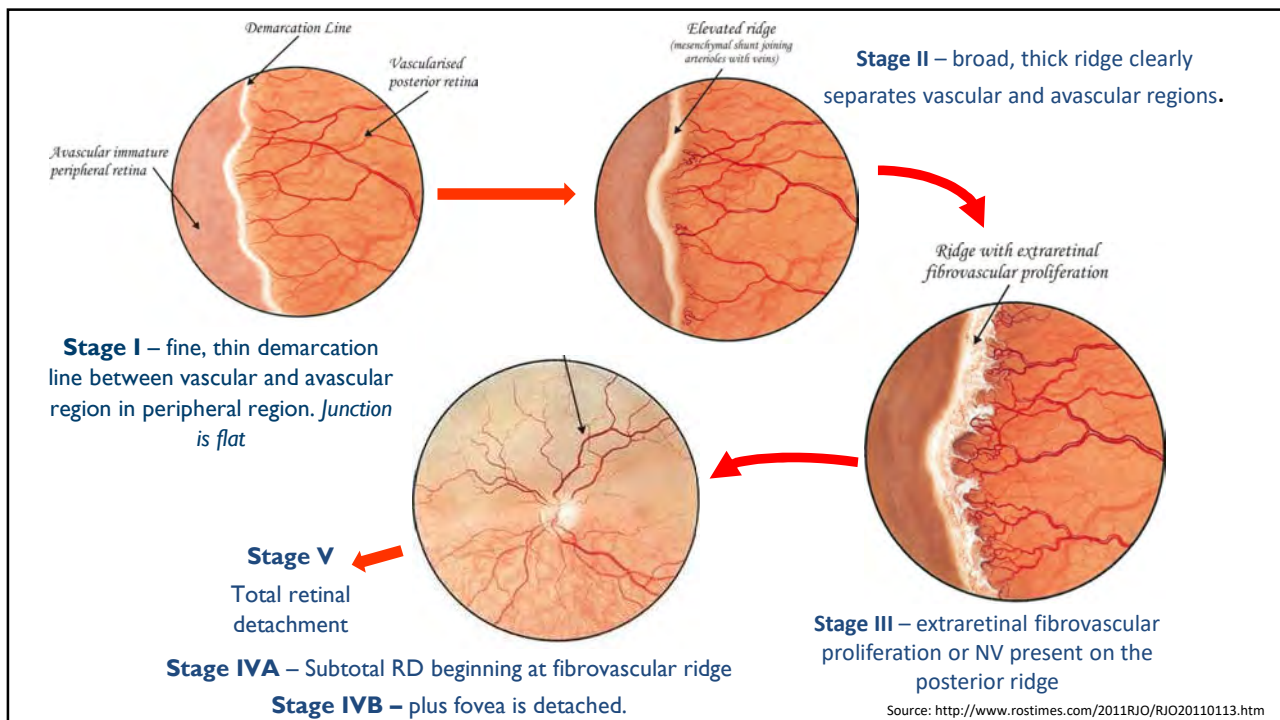
Adapted from:  
Fleck and  
McIntosh. Early  
Human  
Development  
(2008) 84, 83–88



**Stage I** – fine, thin demarcation line between vascular and avascular region in peripheral region. *Junction is flat*

## Stages of ROP





## Stages of Cicatricial Disease



- **Stage 1** – Peripheral retinal pigmentary disturbance/haze at vitreous base
- **Stage 2** – Temporal vitreoretinal fibrosis, straightening of the vascular arcades, dragging of the macula and disc, possibly pseudoexotropia
- **Stage 3** – More severe peripheral fibrosis with contracture & a falciform retinal fold
- **Stage 4** – Incomplete ring of retrolental fibrovascular tissue with partial RD
- **Stage 5** – Complete ring of retrolental fibrovascular tissue with a total RD



Falciform  
Retinal Fold



## ROP: Take Home Points



- ROP is increasing in incidence due to younger babies surviving
- Optometrists most likely to see the **cicatricial sequelae**, strabismus, refractive error and nystagmus



Source: <https://sahlgrenska.gu.se/english/research/news-events/news-article/web-method-can-prevent-blindness-in-premature-babies-.cid1262643>

## Conclusion

- Imaging has redefined the way we diagnosed retinal disease but interpretation takes time
- New technologies are frequently emerging and it is a challenge to keep up with the literature
- Despite the challenges, our future as optometrists is sure to be truly interesting and rewarding



Einstein discovers that time is actually money



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# Thank you!

Any questions or comments?  
email: [pkatalinic@cfeh.com.au](mailto:pkatalinic@cfeh.com.au)

