Pearls in OCT Interpretation

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Disclosures

- Jeremy Hwang is a consultant for Allergan, but did not receive any commercial support from Allergan in the preparation of this course.
- David Jeng and Lyndon Lee have no financial disclosures related to the topics in this lecture
- The content and format of this course is presented without commercial bias and does not claim superiority of any product or service.

Course Objectives

To be comfortable with:

- the basics of OCTs
- the utility of an anterior segment OCT
- the analysis of an RNFL OCT
- the retinal layers in a macular OCT
- Upcoming technologies

Outline

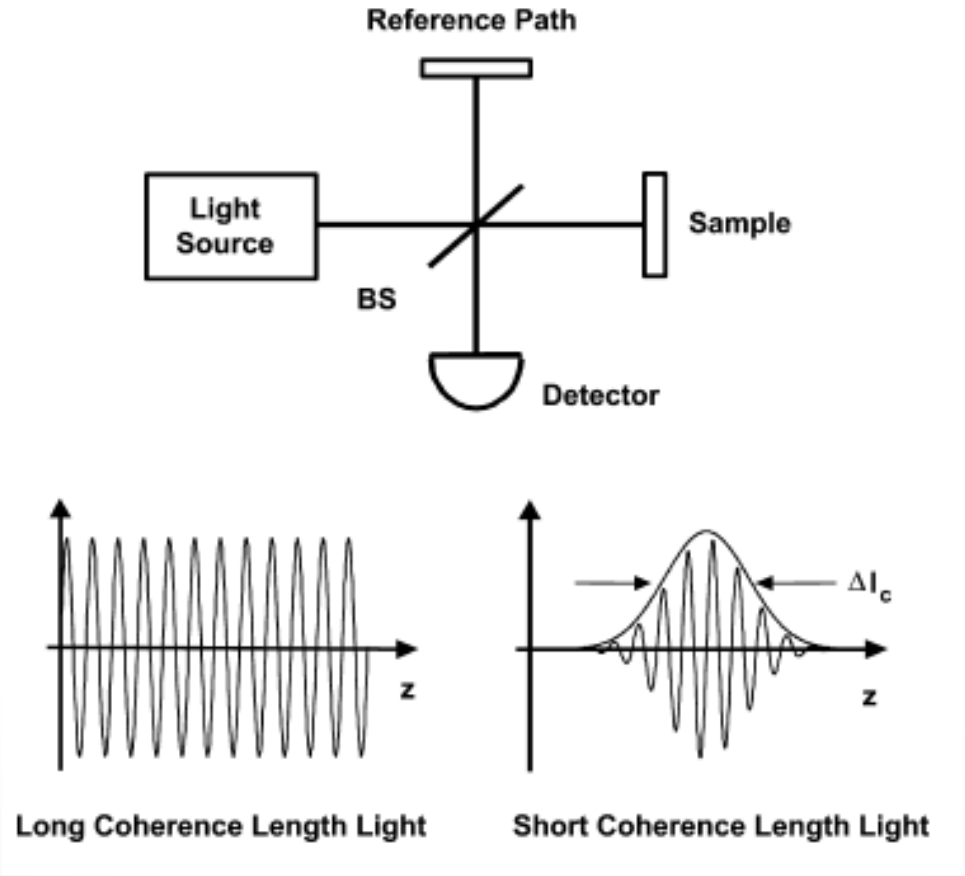
- Background and History
- Anterior Segment
- Optic Nerve
- Macula
- New and Coming Applications

What is OCT?

- "A method of using low-coherence interferometry to determine the echo time delay and magnitude of backscattered light reflected off an object of interest." (Schuman JS 2008)

How it Works

Michelson Interferometer

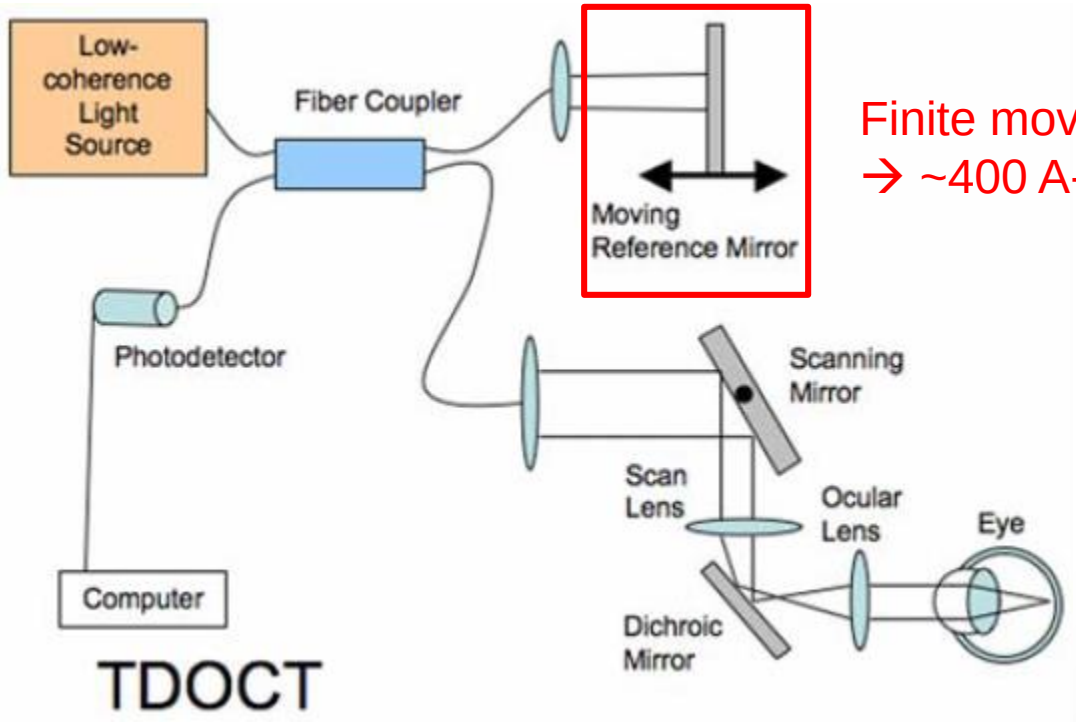


Fujimoto et al, 2000

History

- Time Domain
- Fourier or Spectral Domain

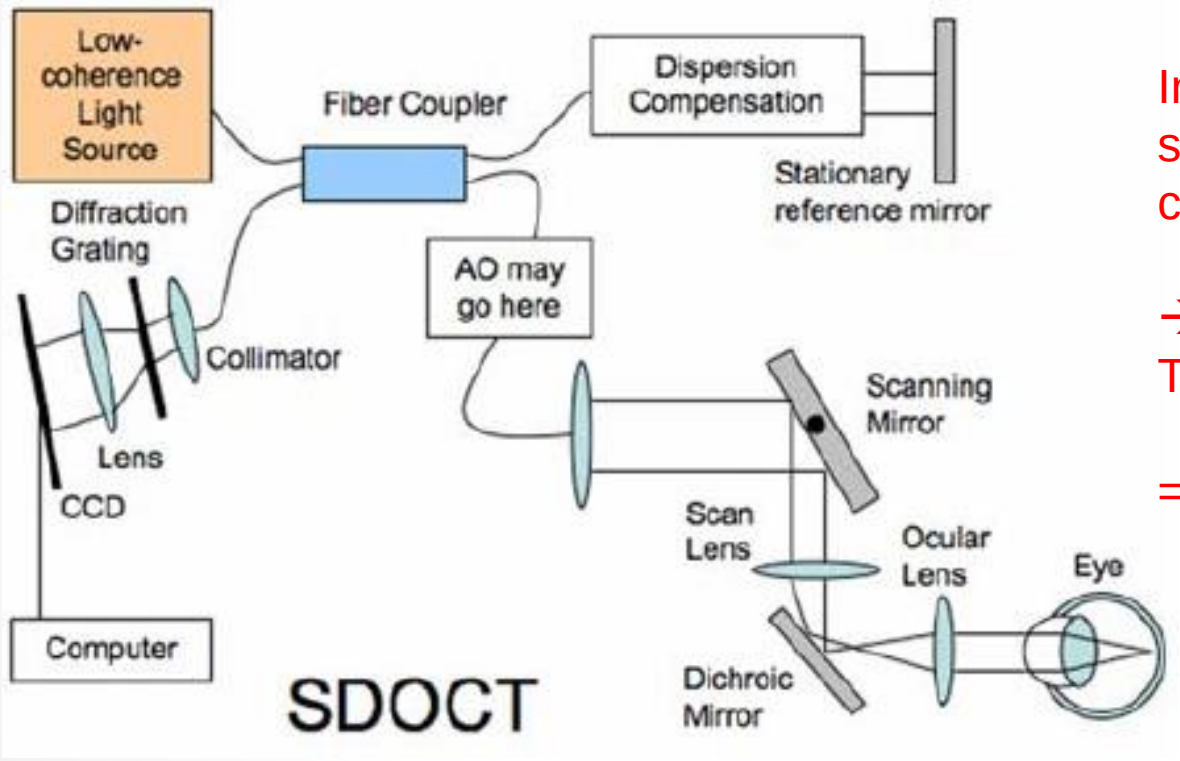
Time-Domain OCT



Finite movement speed
→ ~400 A-scans/second

Schuman, 2008

Spectral-Domain OCT



Interference pattern split into frequency components

→ 40-100x faster than TD-OCT

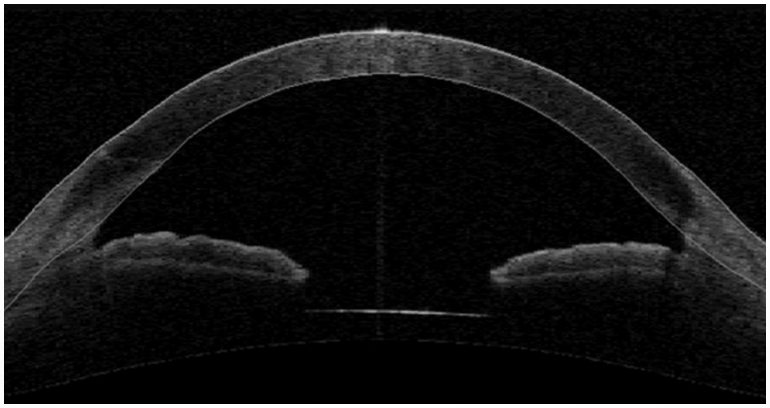
= less motion artifact

Schuman, 2008

Anterior Segment OCT

- Cross-sectional images of the angle, cornea, and anterior chamber structures

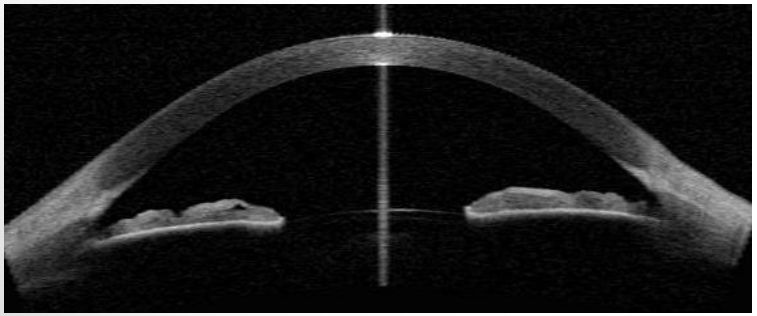
- Assessing narrow or suspicious angles
- Evaluating corneal pathology
- Managing blebs and Descemet's membrane surgeries



1310 nm vs 830 nm

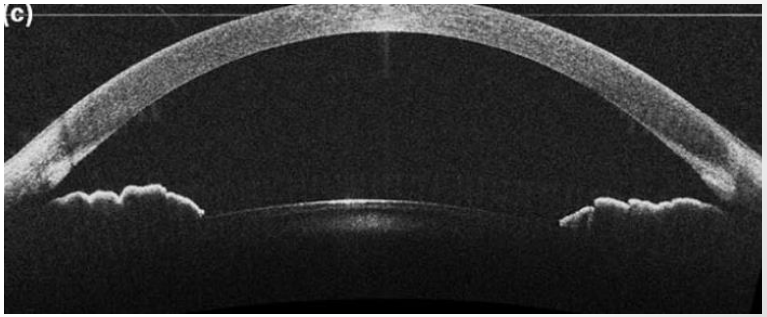
1310 nm

- Dedicated system
- Time-domain
- Longer wavelength allows for greater depth of imaging

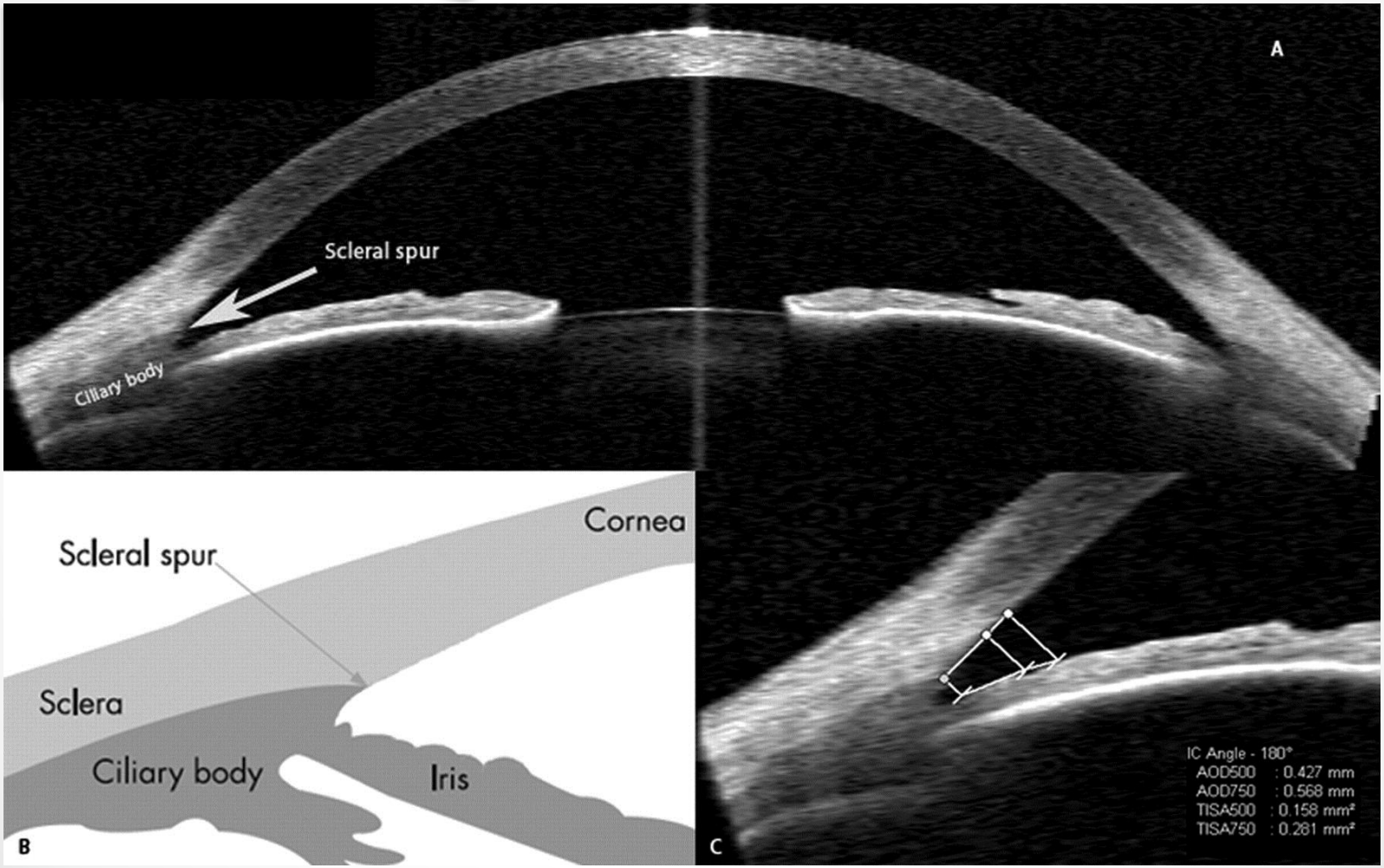


830 nm

- Converted from retinal scanner
- Spectral domain
- Higher resolution but imaging depth is limited

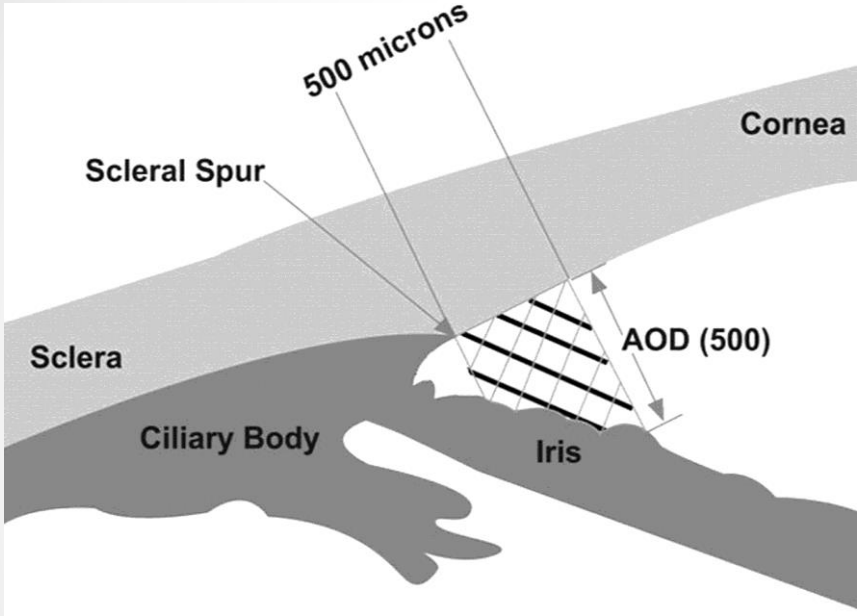


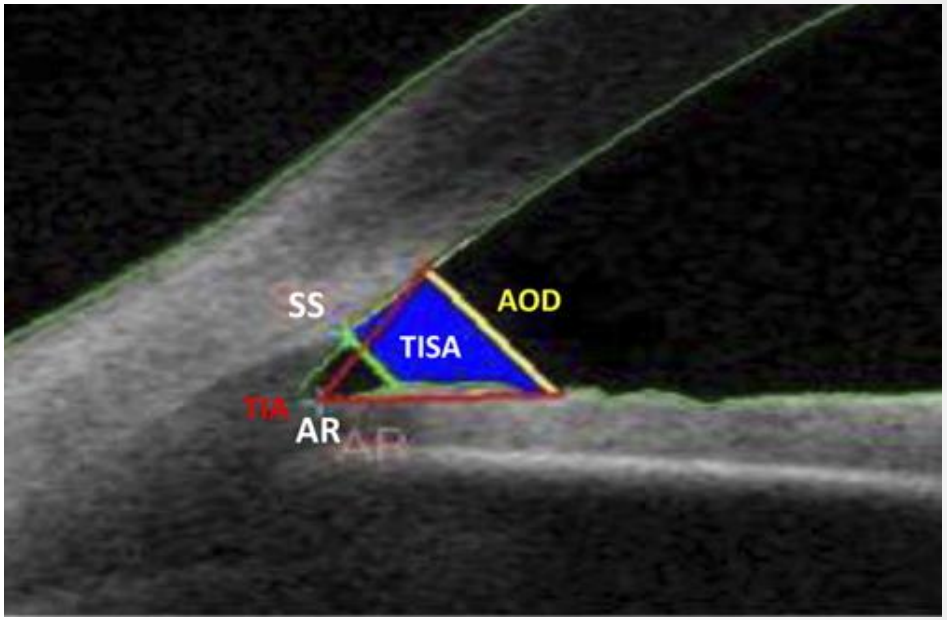
Interpretation – Qualitative



- Tan, A. et al. Reproducibility of anterior chamber angle measurements with anterior segment optical coherence tomography. Glaucoma; April 2011

Interpretation – Quantitative





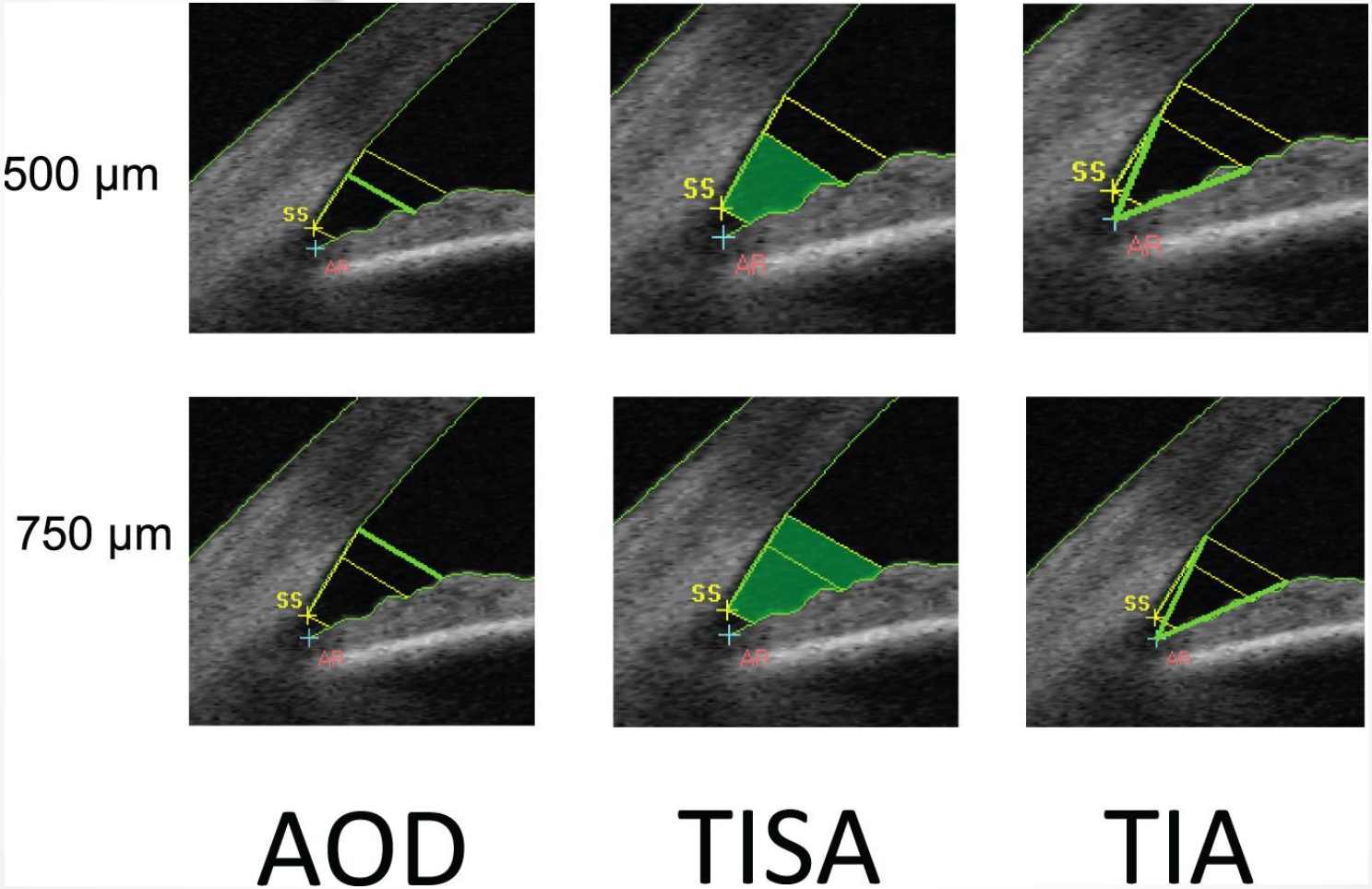
AOD: Angle opening distance

TISA: Trabecular-iris space area

TIA: Trabecular-iris angle

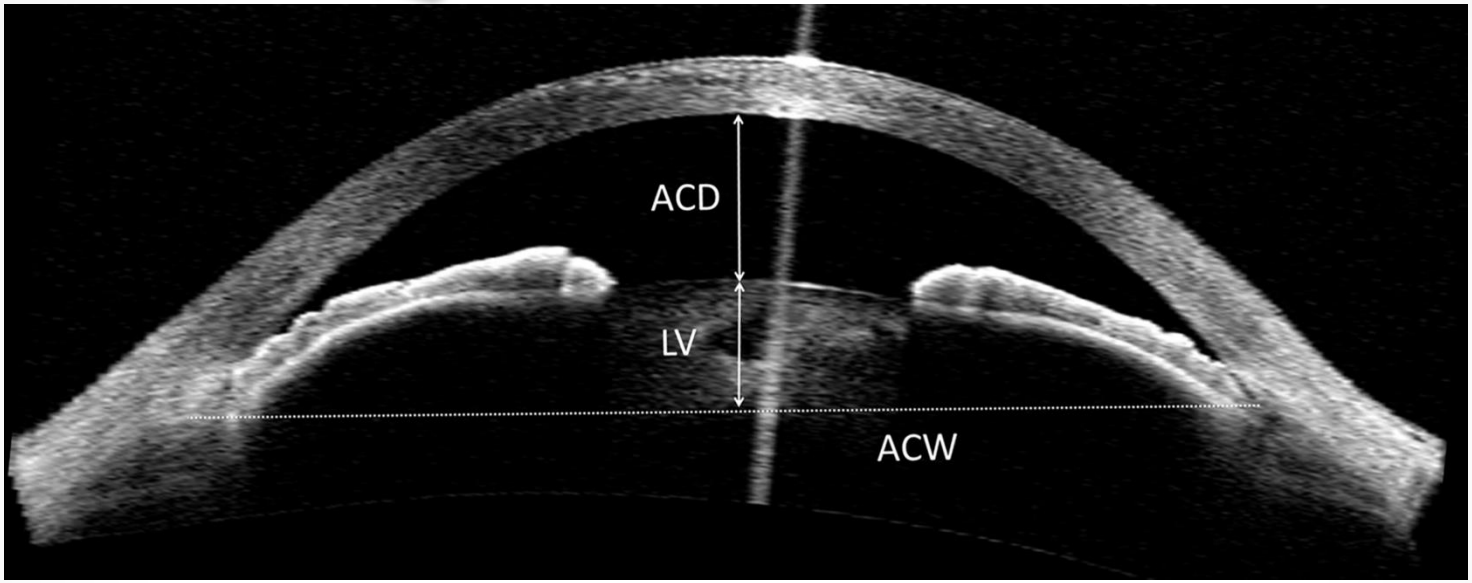
- Measured at 500 um or 750 um anterior to scleral spur
- Scleral spur must be identified manually
- “Normal” values vary by refractive state, ethnicity, quadrant analyzed

Interpretation – Quantitative



Sanchez-Parra, L. et al. Diurnal IOP and the relationship with SS OCT-derived anterior chamber dimensions in angle closure: The IMPACT study. IOVS; May 2015

Interpretation – Quantitative



ACD: Anterior chamber depth

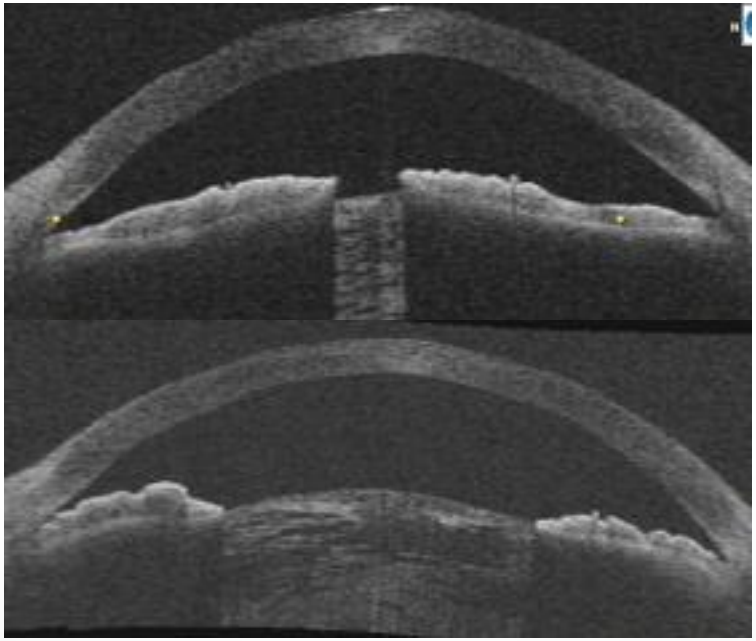
ACW: Anterior chamber width

LV: Lens vault

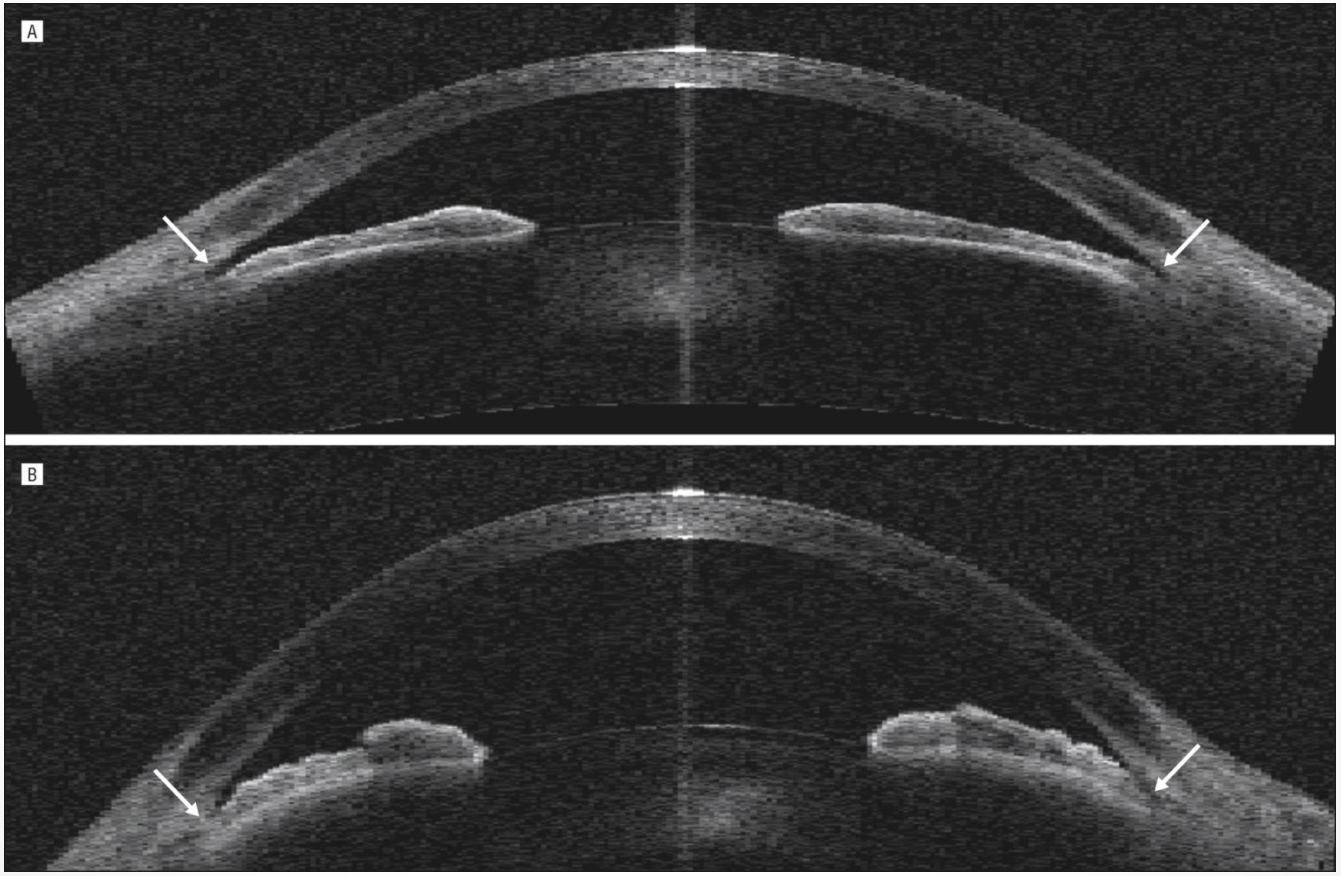
- Shallow anterior chamber depth
- Increased lens vaulting
- Decreased anterior chamber width
- Greater iris thickness and curvature

Glaucoma – Angle assessment

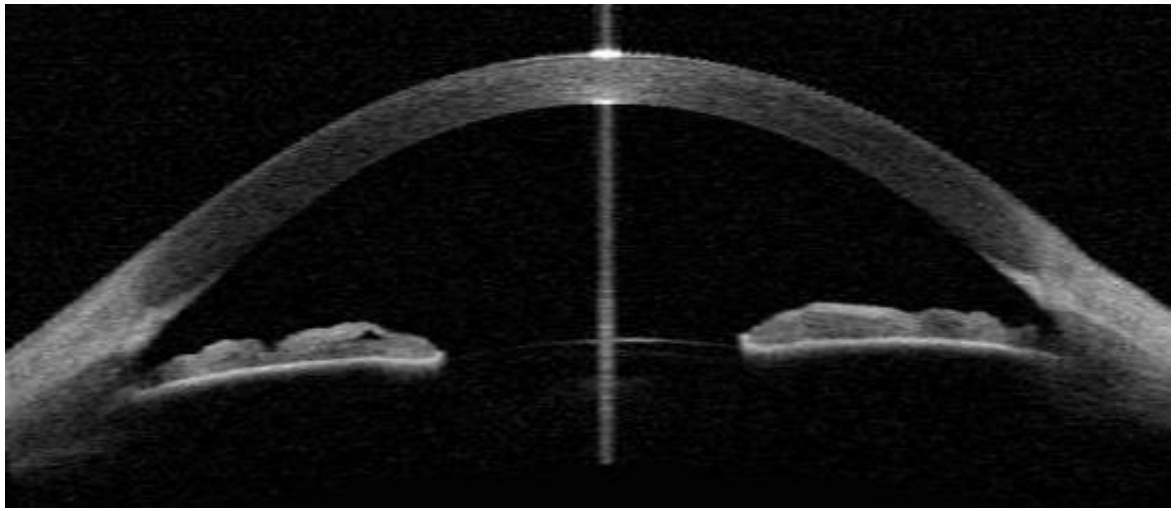
- Useful when gonioscopy is not feasible due to corneal pathology or lack of patient cooperation
- Able to image the angle in the dark when occludable angles are more likely to be narrow or even closed

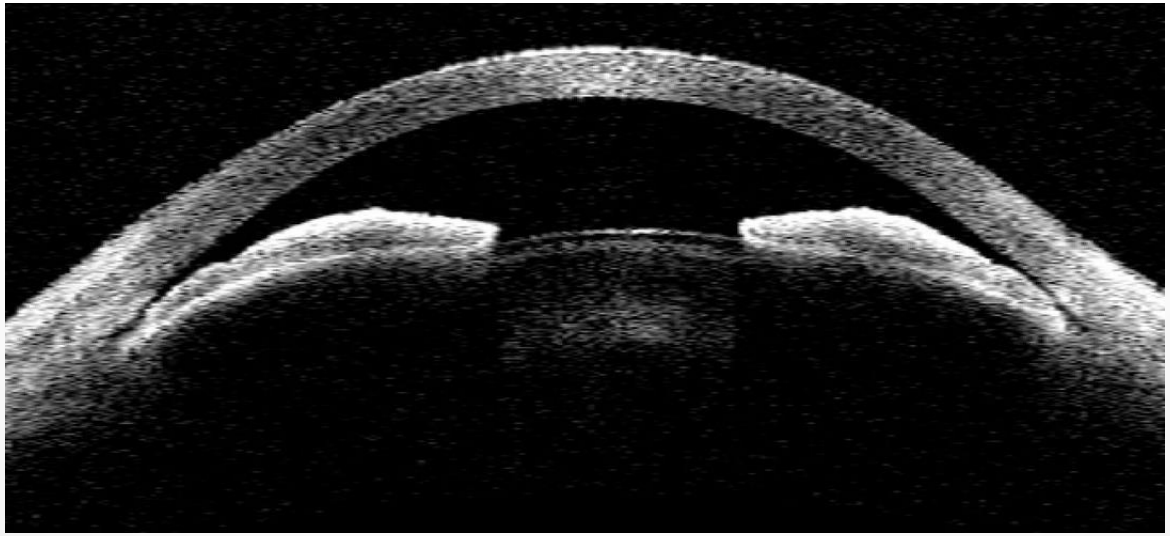


Glaucoma – Narrow angle

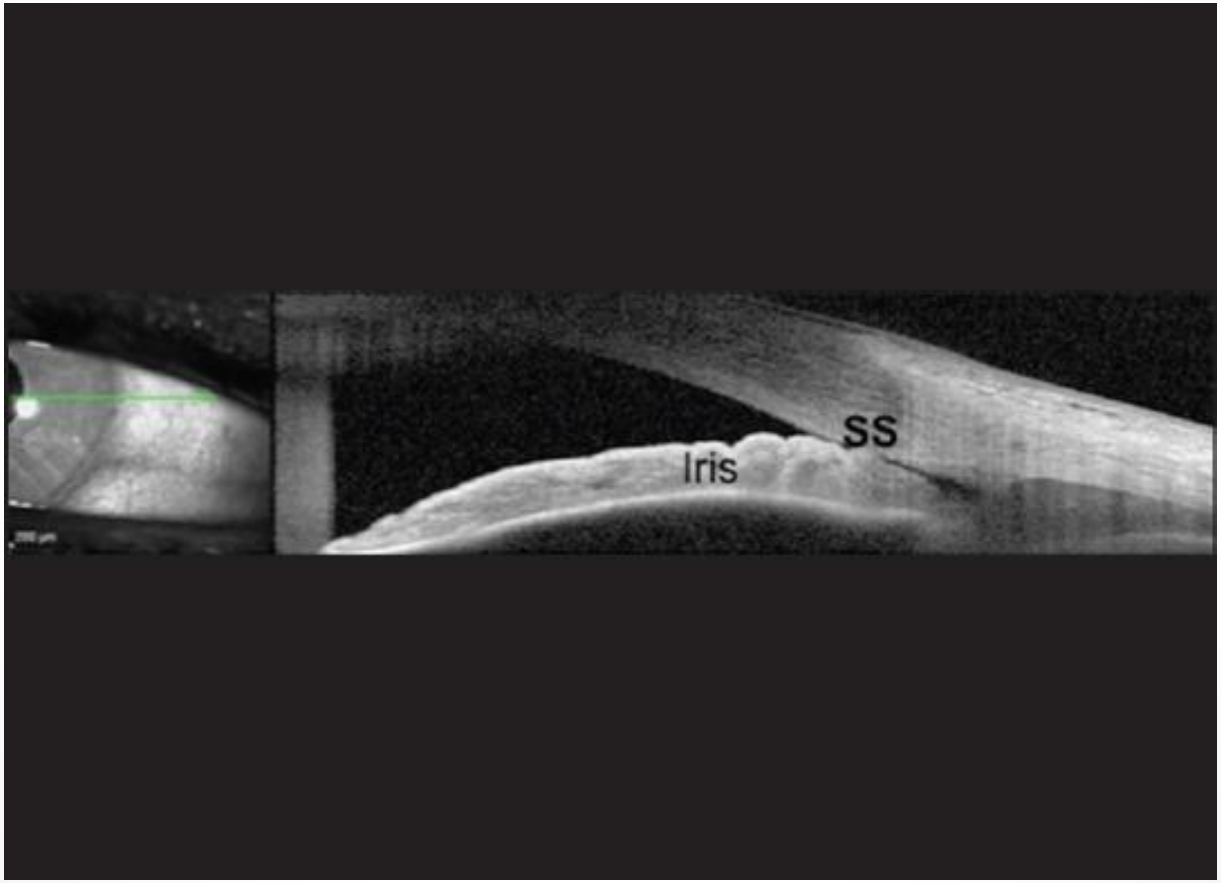


Glaucoma – Narrow angle



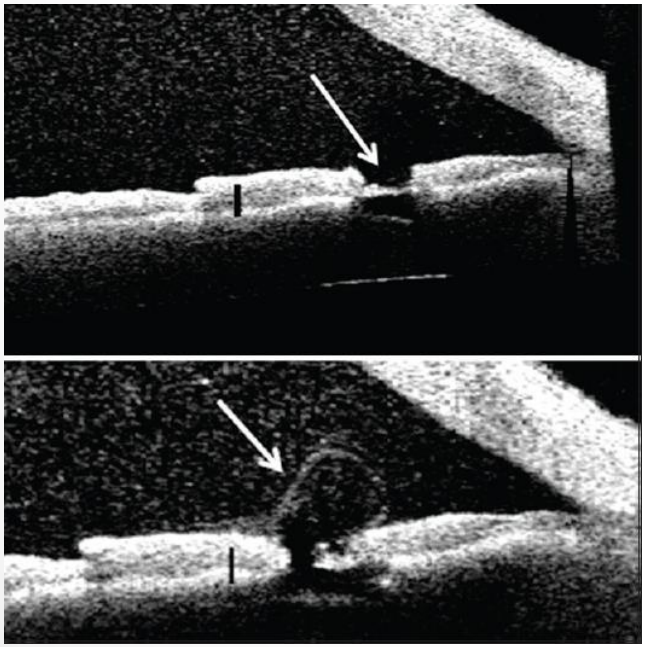


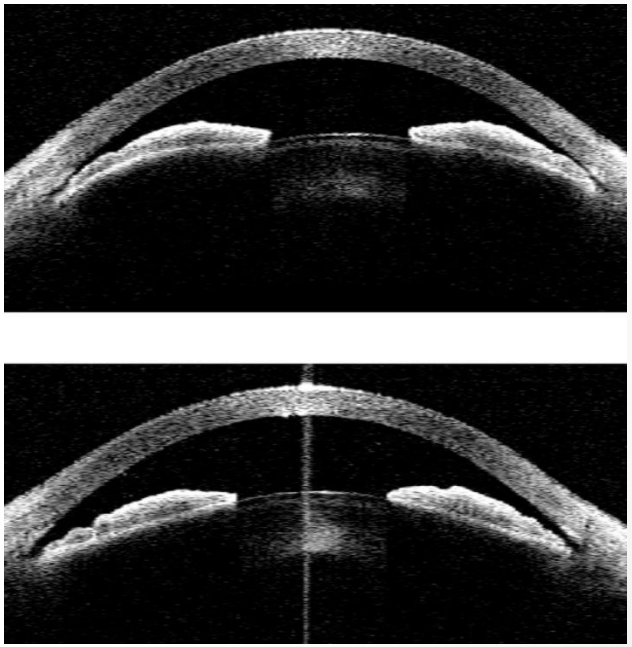
Glaucoma – Closed angle



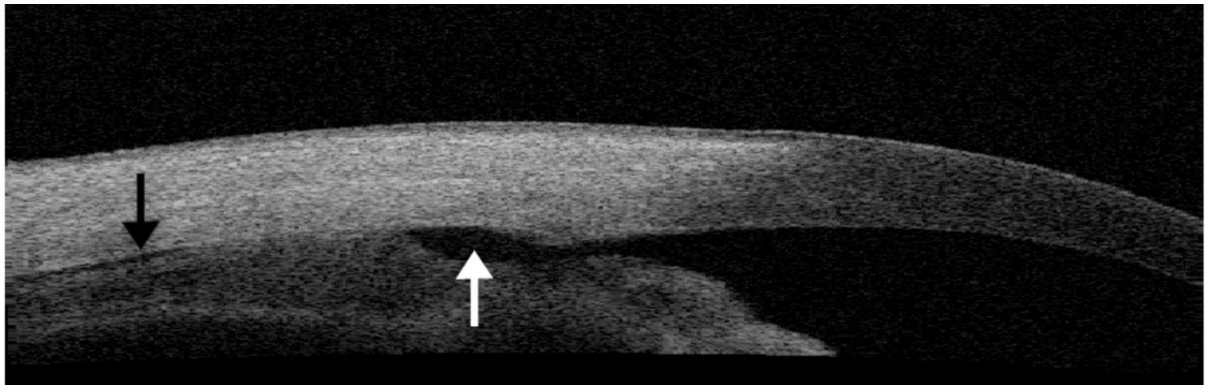
After laser iridotomy

- Determine patency of laser peripheral iridotomy (LPI)
- Evaluate success of LPI (iris plane should flatten)



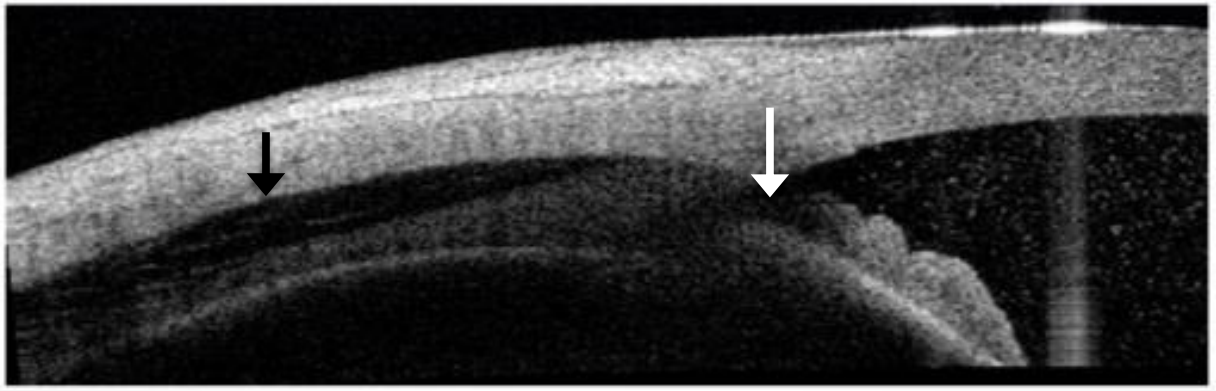


Cyclodialysis cleft



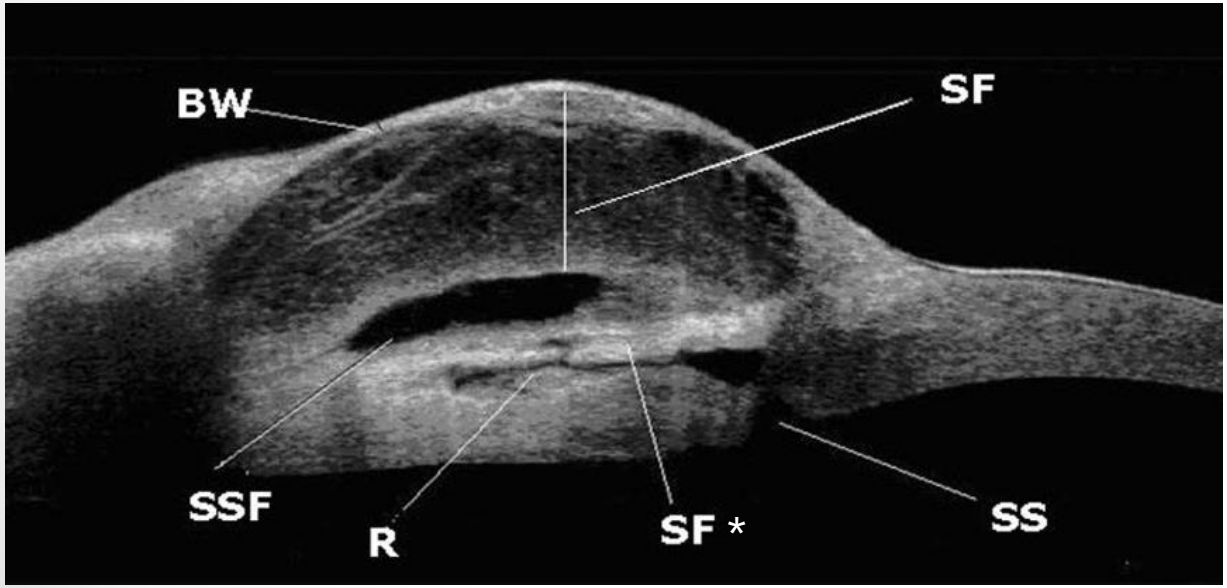
Suprachoroidal fluid

Separation of ciliary body from sclera



Bleb assessment

- Imaging at 2 weeks can predict bleb functionality at 6 months

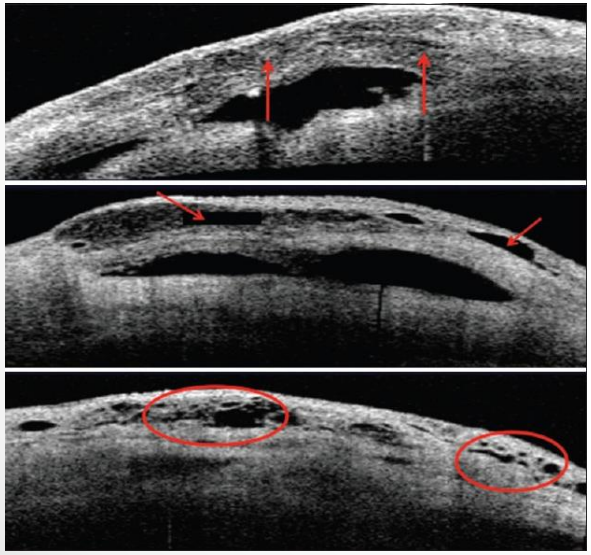


- BW = Bleb wall
- SF = Subconjunctival fluid
- SSF = Suprascleral fluid
- R = Route under scleral flap
- SF* = Scleral flap
- SS = Sclerotomy site

Bleb assessment

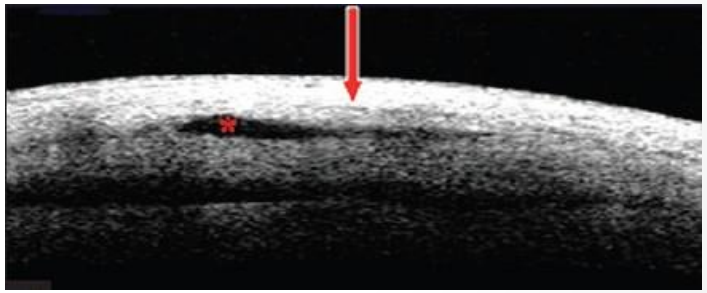
Good bleb function

- Multiform bleb wall reflectivity
- Large internal fluid-filled cavity
- Extensive hyporeflective area
- Thinner, hyporeflective bleb walls
- More microcysts



Poor bleb function

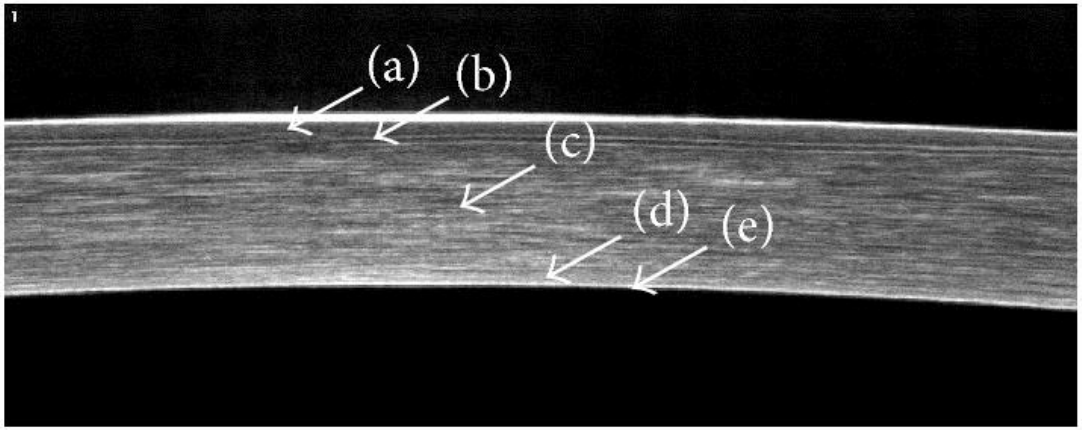
- Uniform reflectivity of bleb
- Ostium occlusion
- Apposition of conjunctiva-episclera to sclera



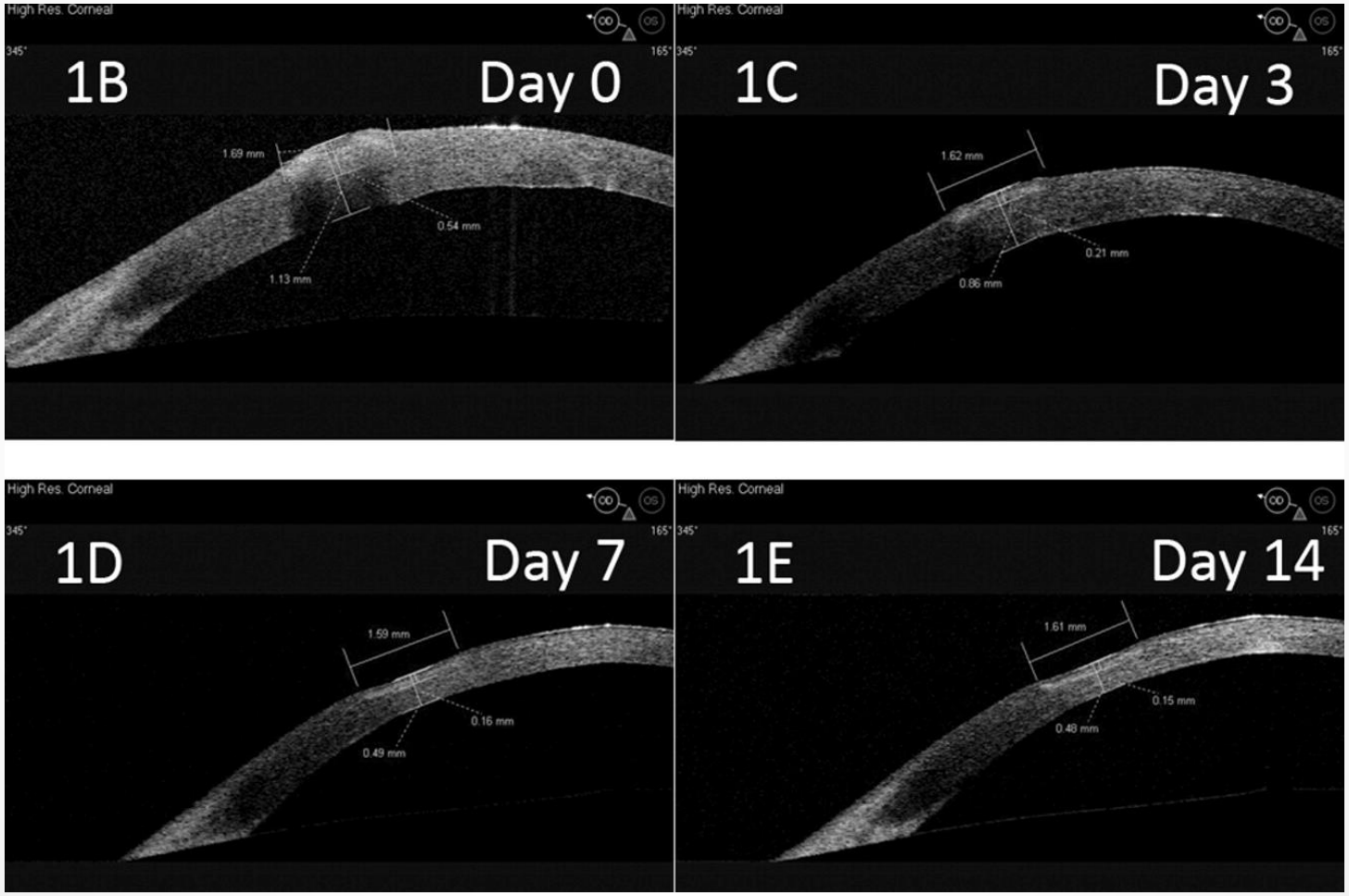
Khamar MB et al. Morphology of functioning trabeculectomy blebs using anterior segment optical coherence tomography.

Corneal imaging

- Useful adjunct in evaluating corneal infiltrates, corneal dystrophies, and managing Descemet's membrane surgeries

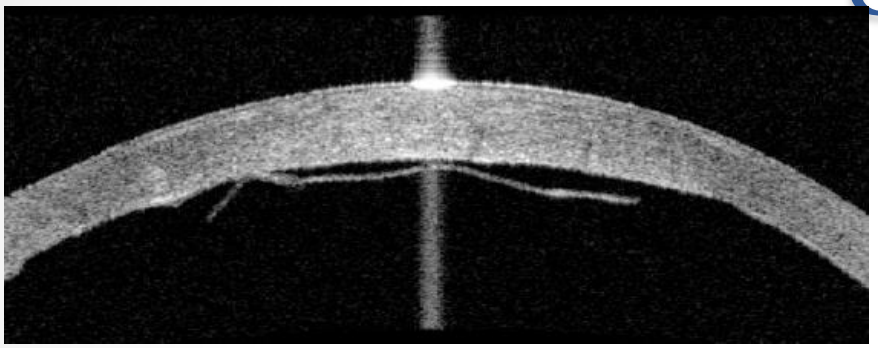


Microbial keratitis

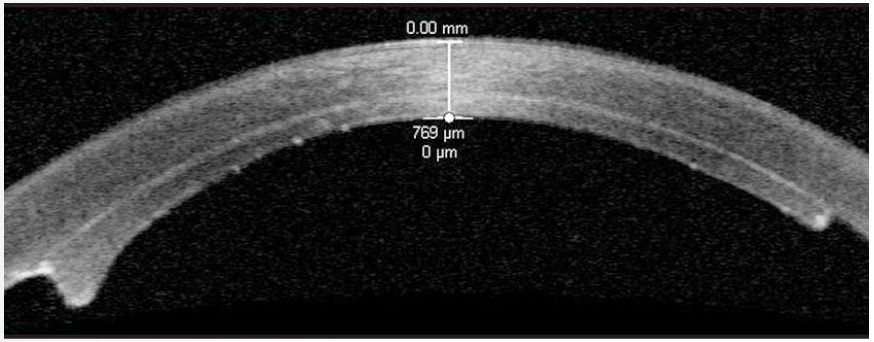


Konstantopoulis, A et al. In vivo quantification of bacterial keratitis with optical coherence tomography. Cornea; Feb 2011

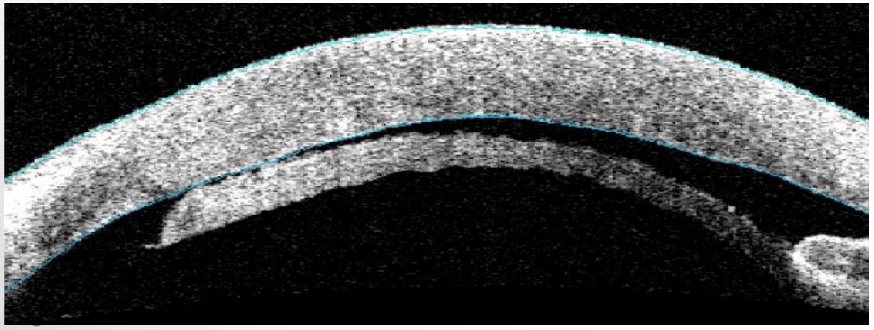
Descemet's membrane imaging



Descemet's membrane detachment after cataract surgery



Adherent graft after Descemet's stripping endothelial keratoplasty (DSEK)

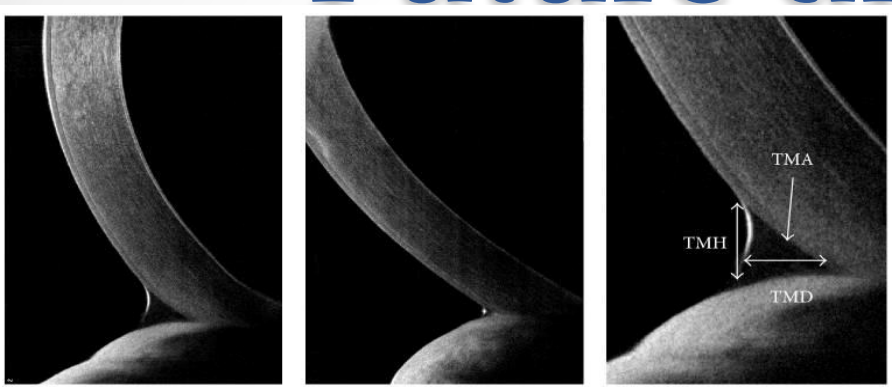


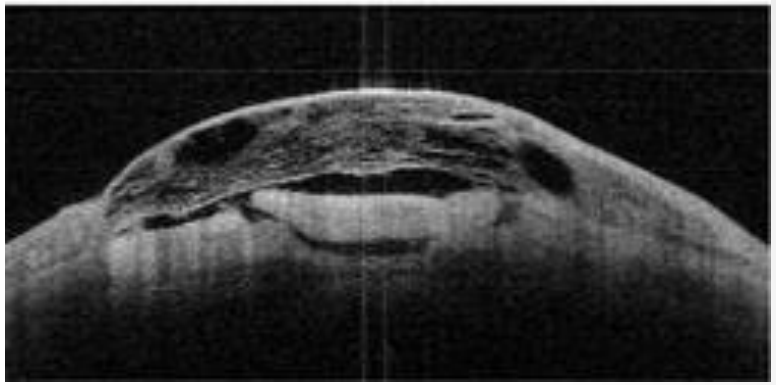
Graft detachment after DSEK

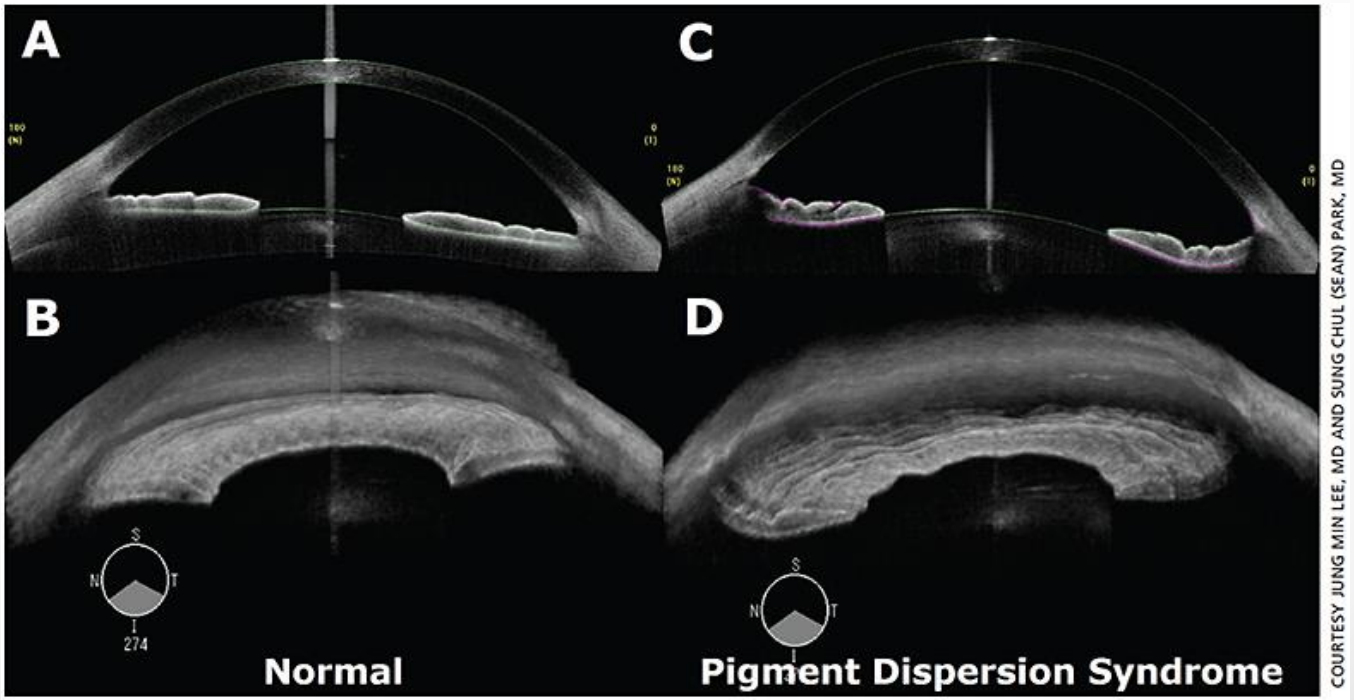
Limitations

- Incomplete imaging beyond the sclera or iris pigment epithelium make AS-OCT less useful in diagnosing posterior mechanisms of angle closure (iridociliary lesions, plateau iris)
- Inability to visualize the trabecular pigment or narrow bands of peripheral anterior synechiae
- Quantitative measurements for angle assessment not routinely used
    - Difficulty in identifying the scleral spur (15-28%)
    - Wide natural variation in angle anatomy within the same eye and between eyes

Future directions







Questions?

Optic Nerve

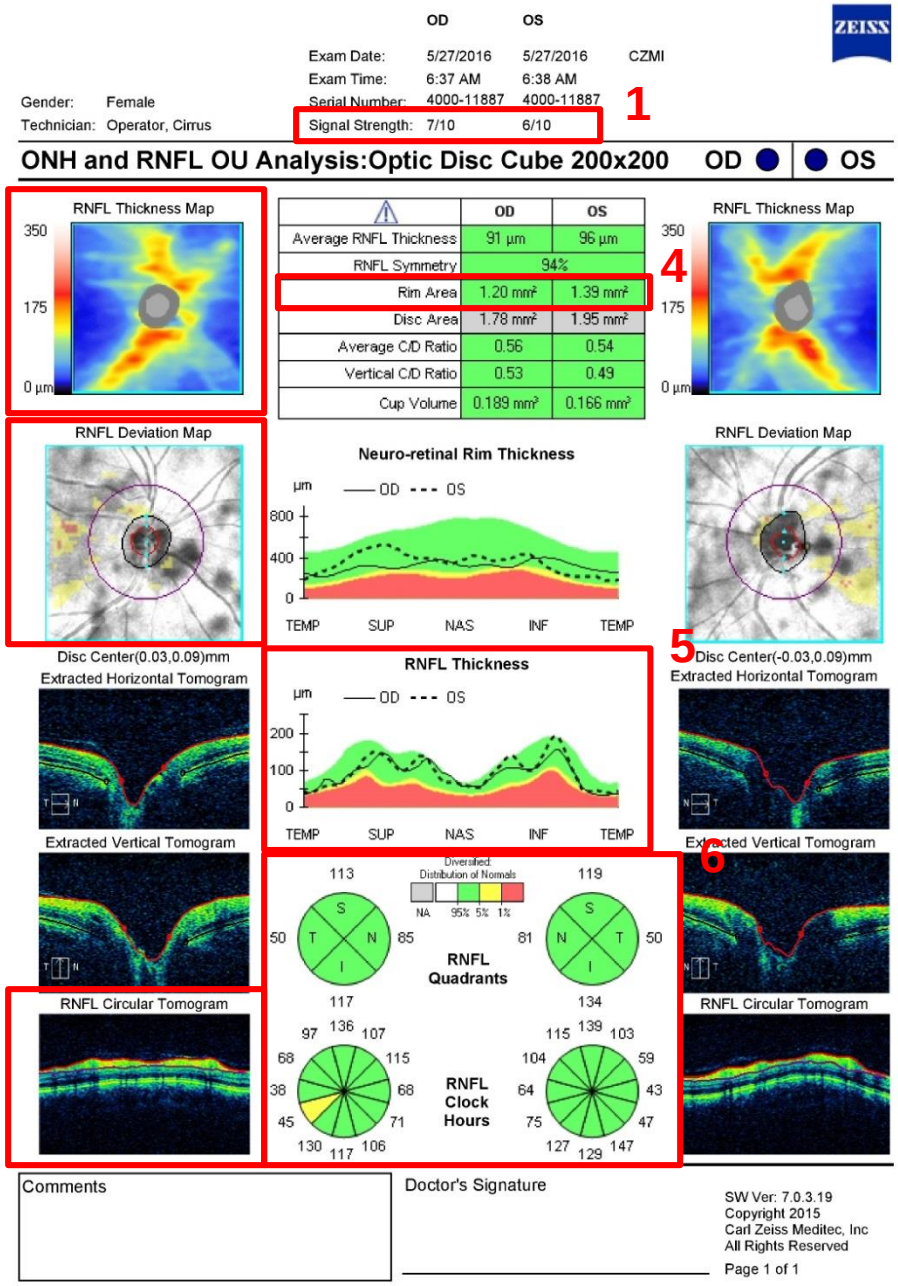
- Retinal Nerve Fiber Layer OCT

OCT - RNFL

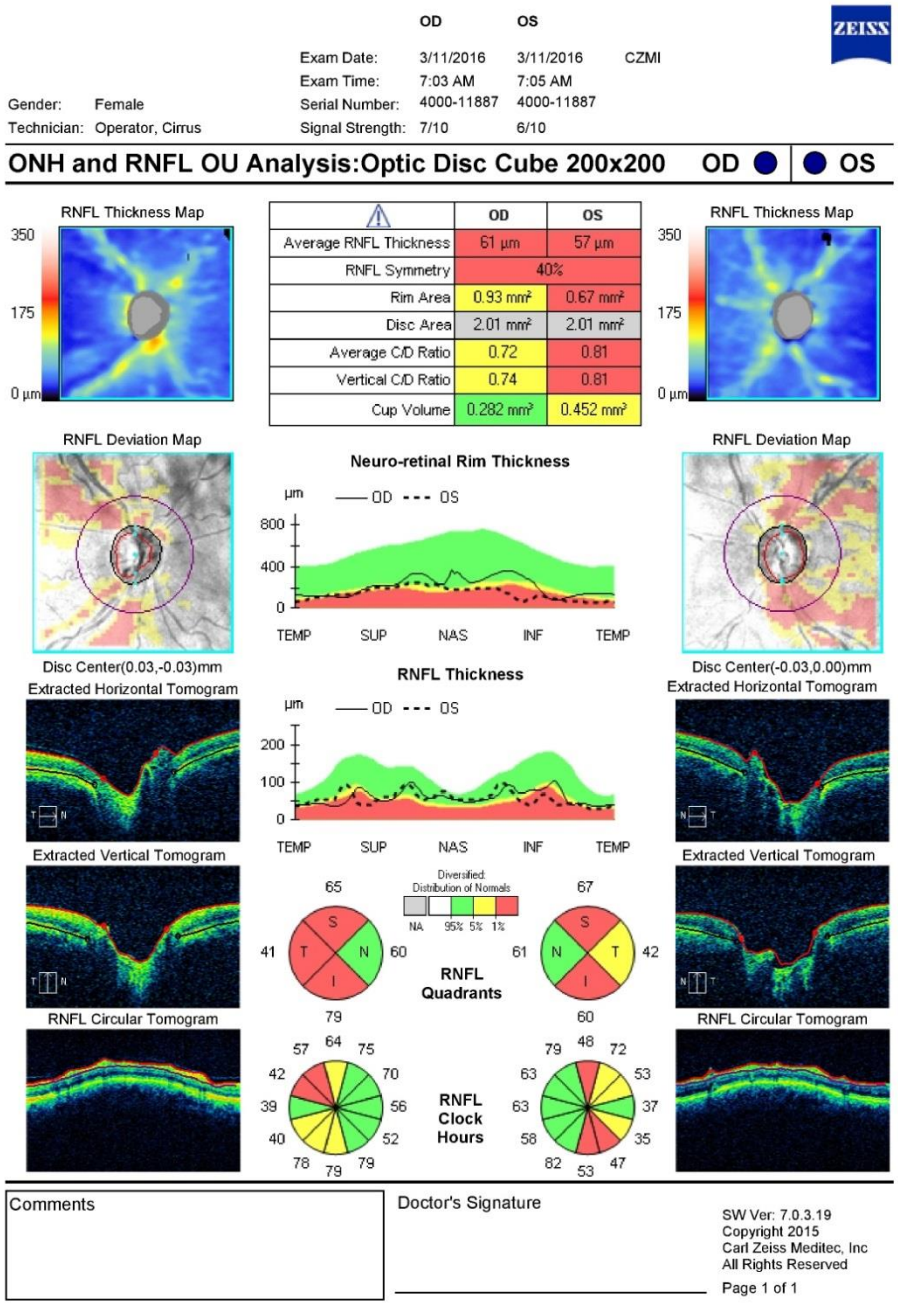
- RNFL is measured in the peripapillary region by performing a circular scan centered around the optic disc (3.4 mm diameter)

- Compared with age-matched controls
  - Green – 5th-95th percentile
  - Yellow – 1st -5th percentile
  - Red – below 1st percentile

- Multiple manufacturers – Zeiss, Heidelberg, Optovue



1. Signal strength
2. 2-D thickness map
3. 2-D deviation map
4. Rim area
5. RNFL thickness (scroll)
6. RNFL thickness (clock)
7. Segmentation



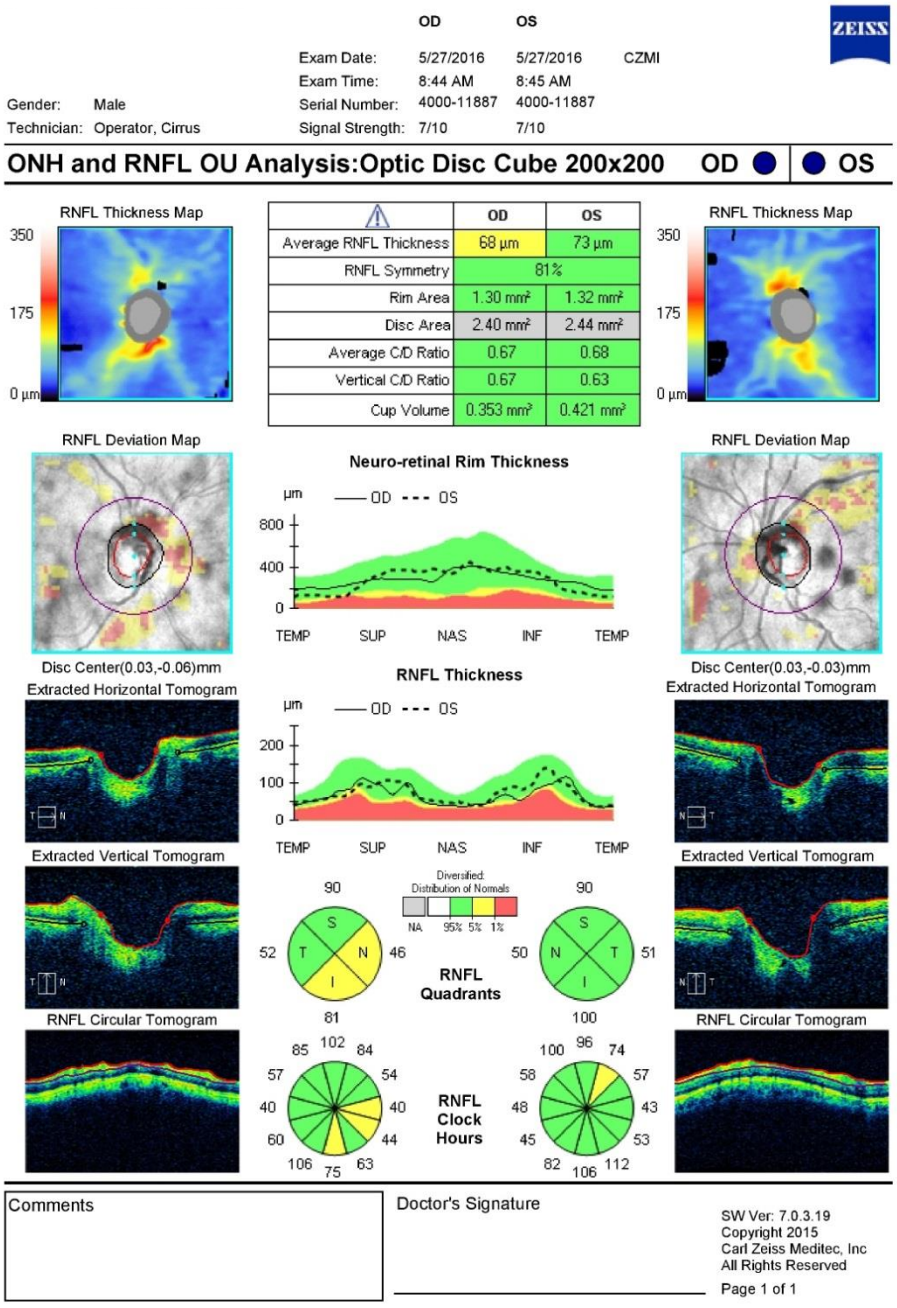
Case #1

68 yo AAF

Va 20/30 OU
IOP 11 OD, 16 OS

On 4 glaucoma meds

Glaucoma OS>OD



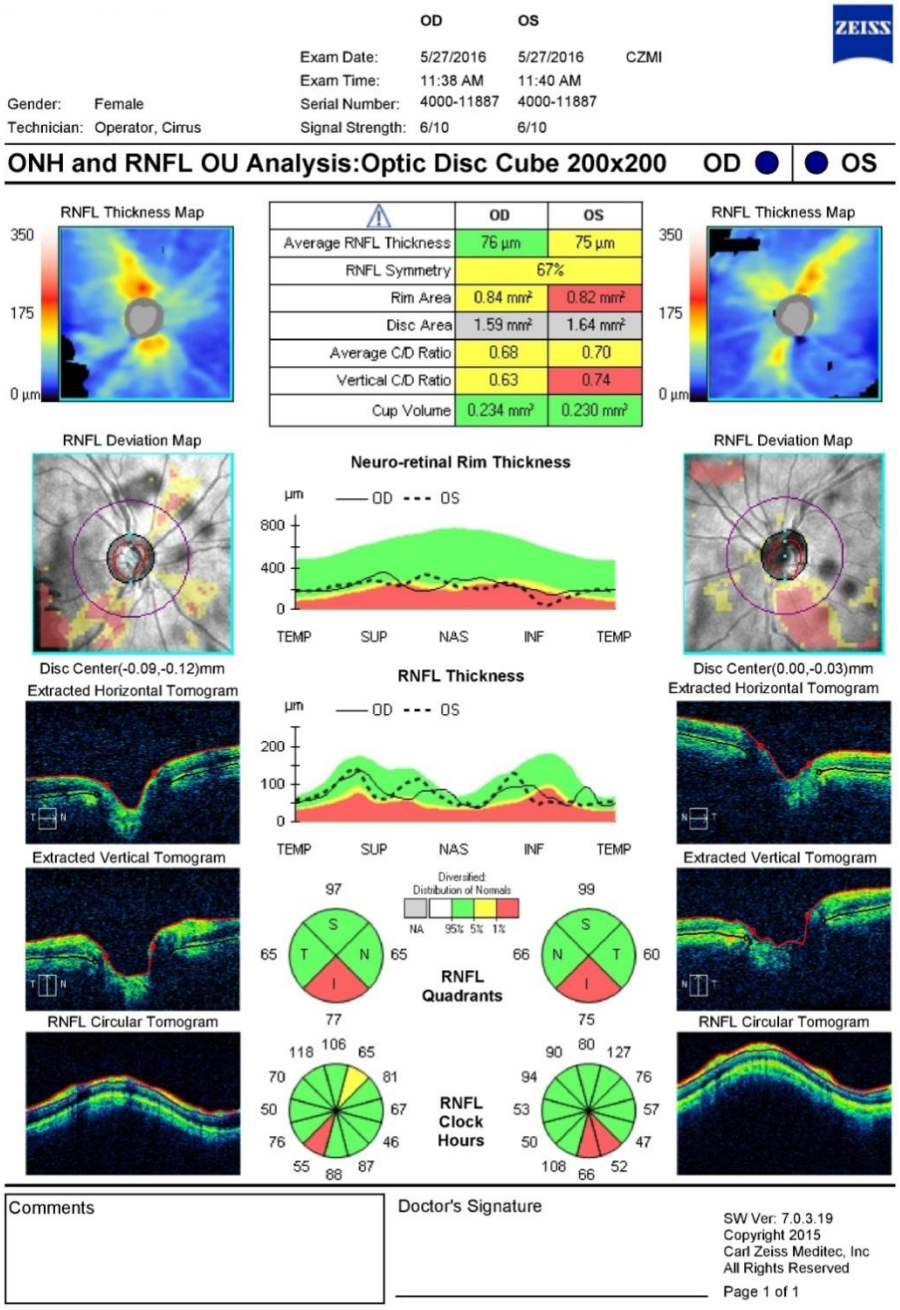
Case #2

84 yo WM

Va 20/40, 20/30
IOP 10 OU

On Brimonidine OU

Glaucoma Suspect



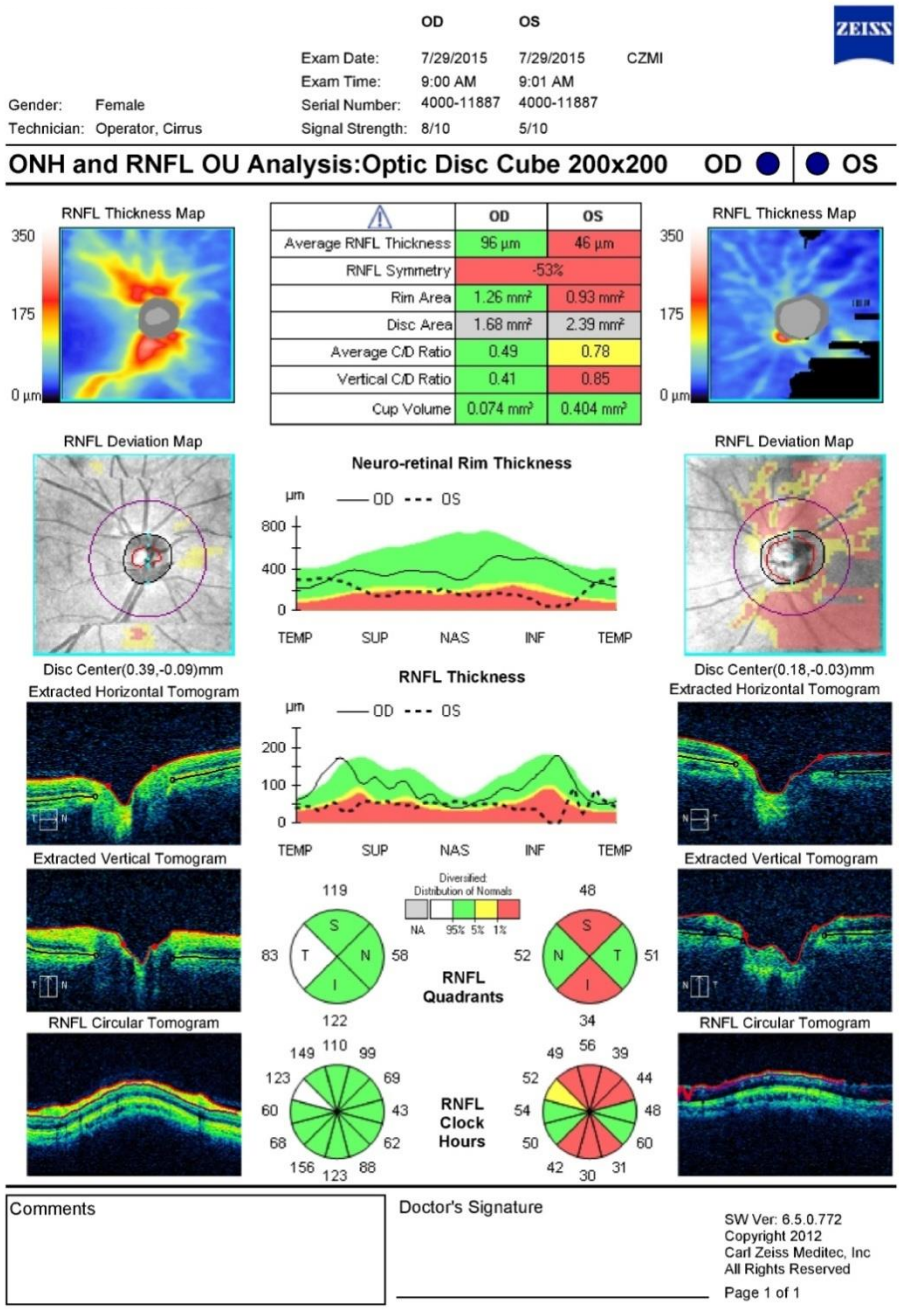
Case #3

68 yo HF

Va 20/30, 20/20
IOP 16 OU

On Azopt and Travatan OU

Focal inferior notching
Glaucoma OU



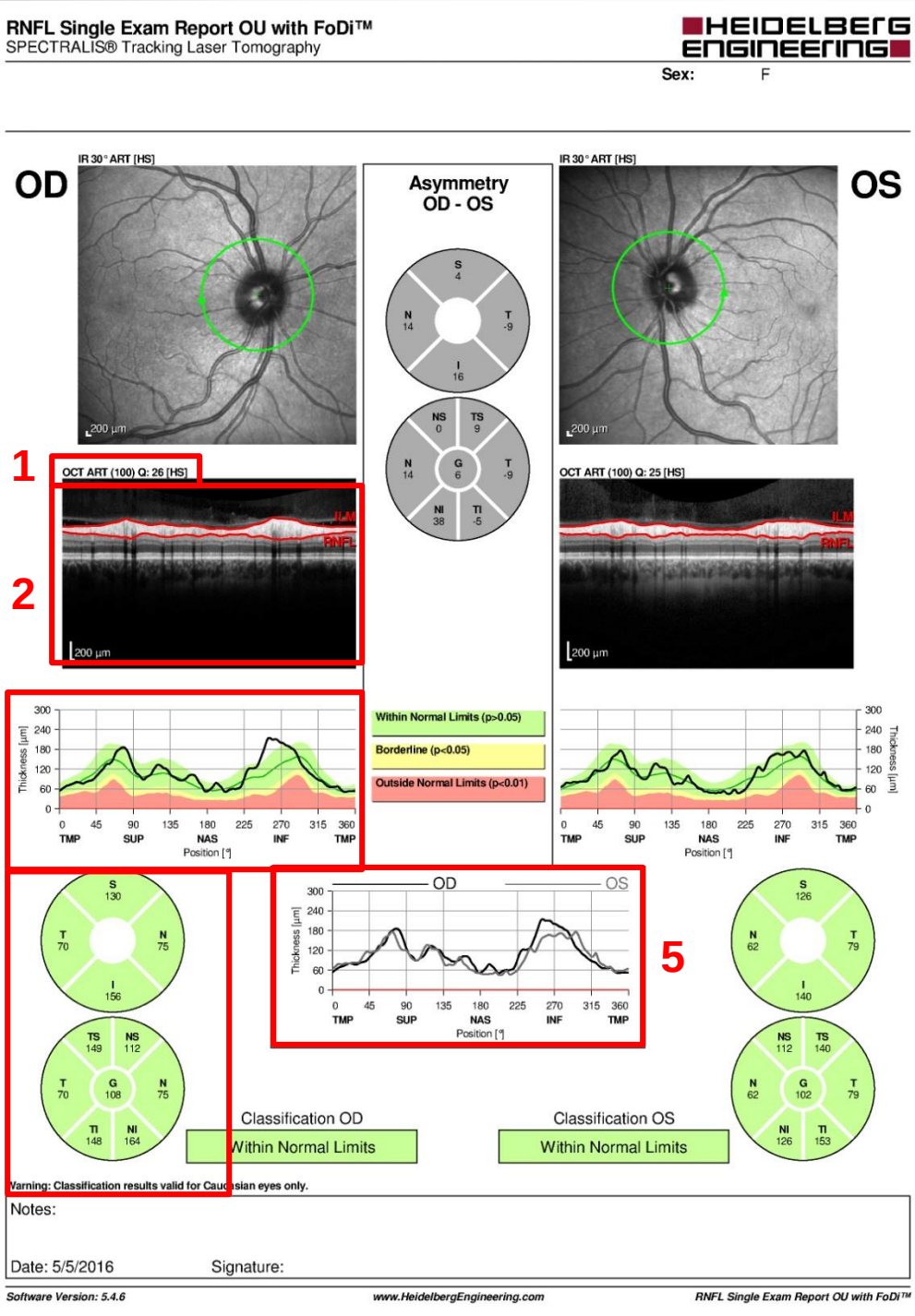
Case #4

64 yo AF

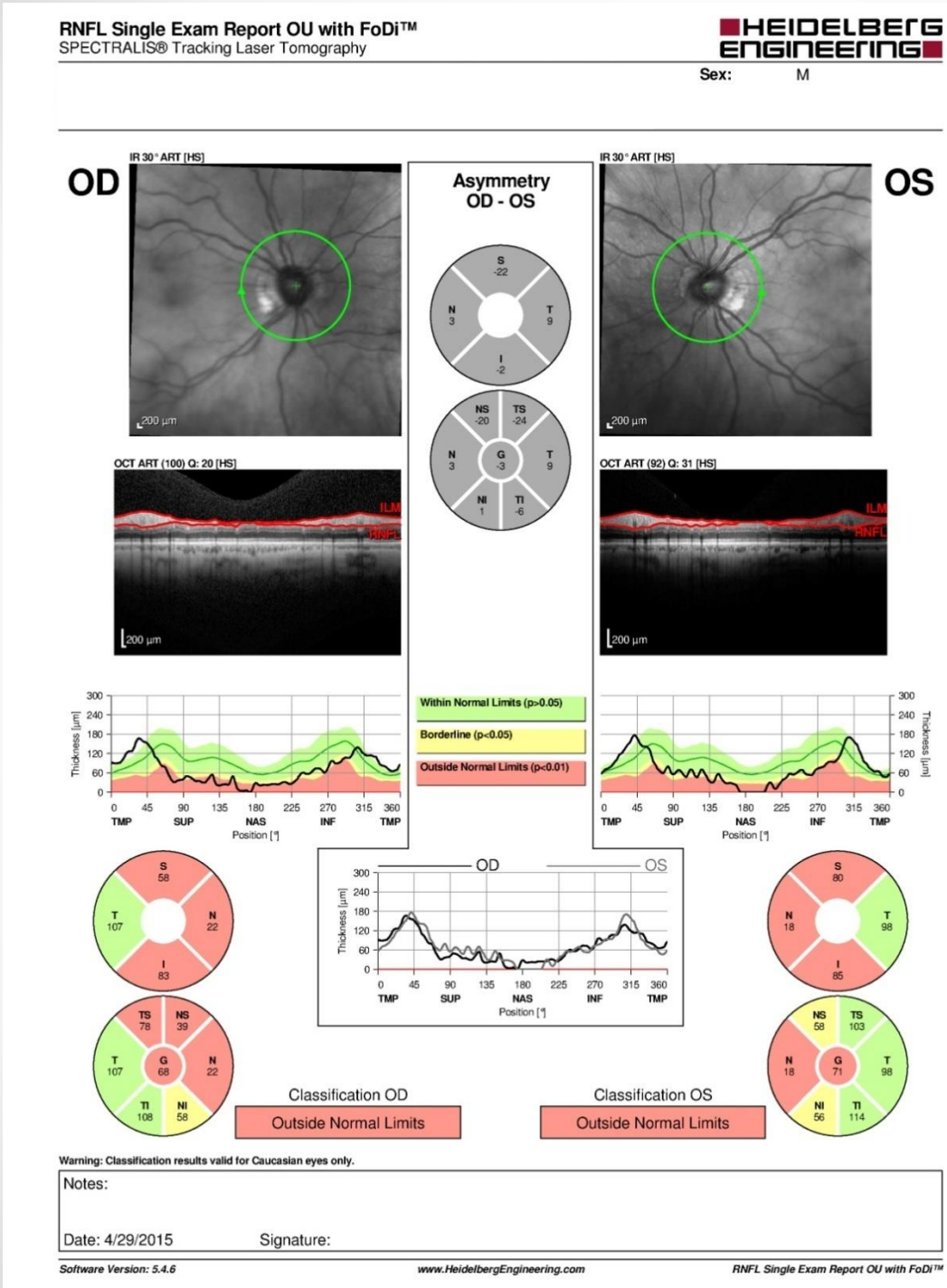
Va 20/30, 20/50
IOP 12 OU

h/o Trabeculectomy OS

Unilateral glaucoma
Consider secondary causes



1. Signal quality
2. Segmentation
3. RNFL thickness (scroll)
4. RNFL thickness (clock)
5. OD-OS asymmetry



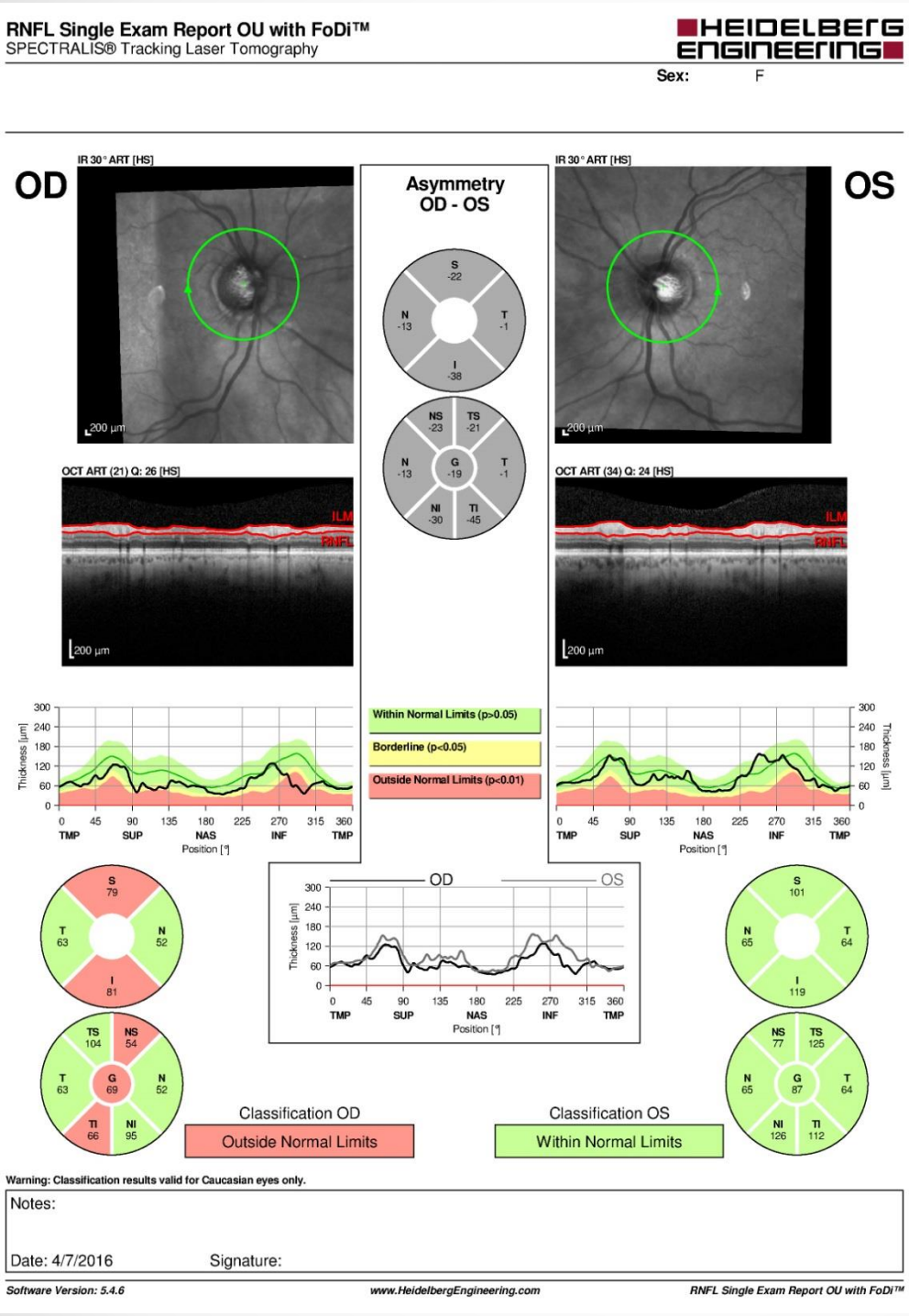
Case #5

75 yo WM

Va 20/25, 20/20
IOP 22, 17

No glaucoma meds

Glaucoma suspect
Shifted NFL



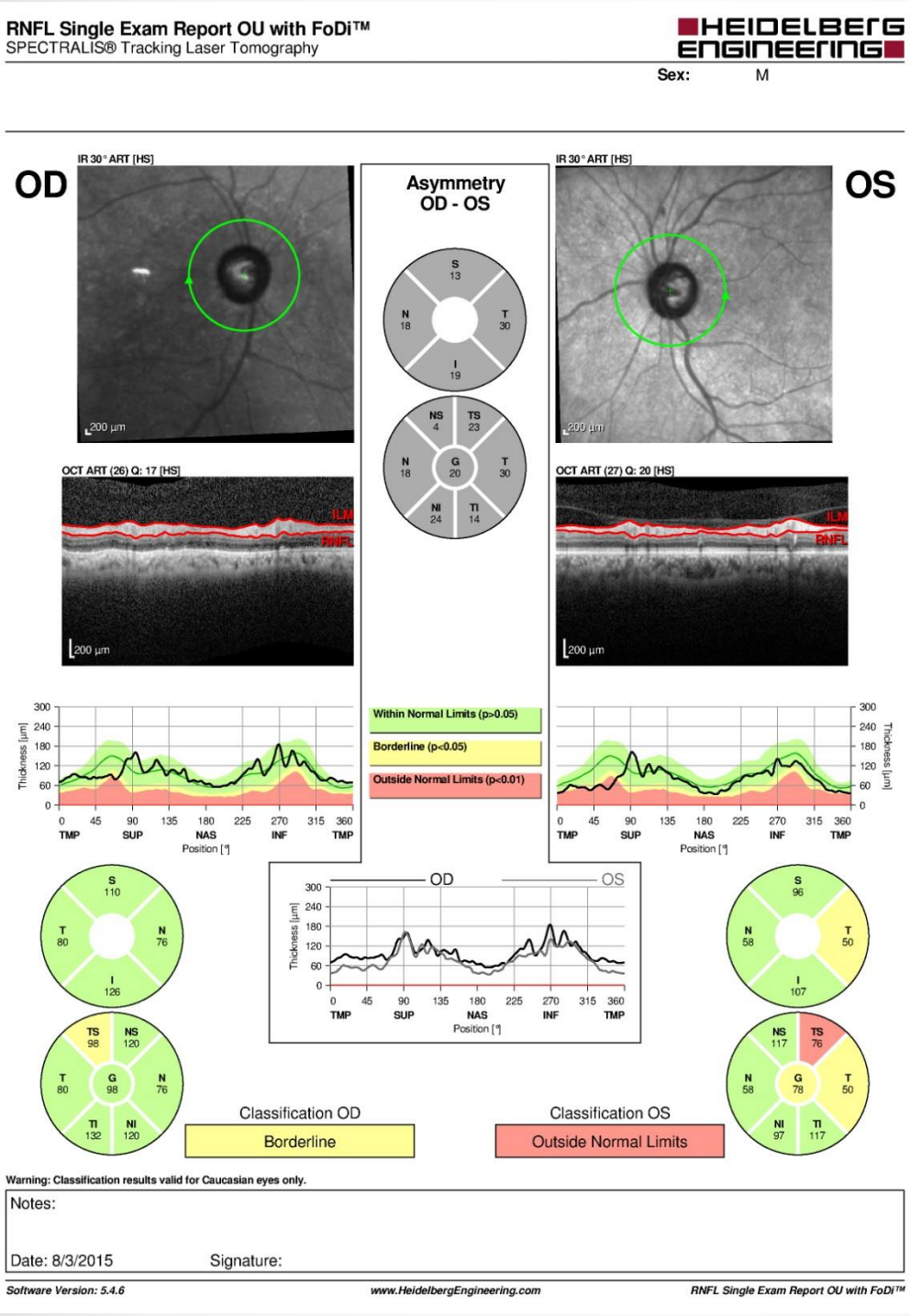
Case #6

77 yo WF

Va 20/25, 20/25
IOP 11, 18

s/p trabeculecomy OD
On 2 meds OS

Asymmetric glaucoma



Case #7

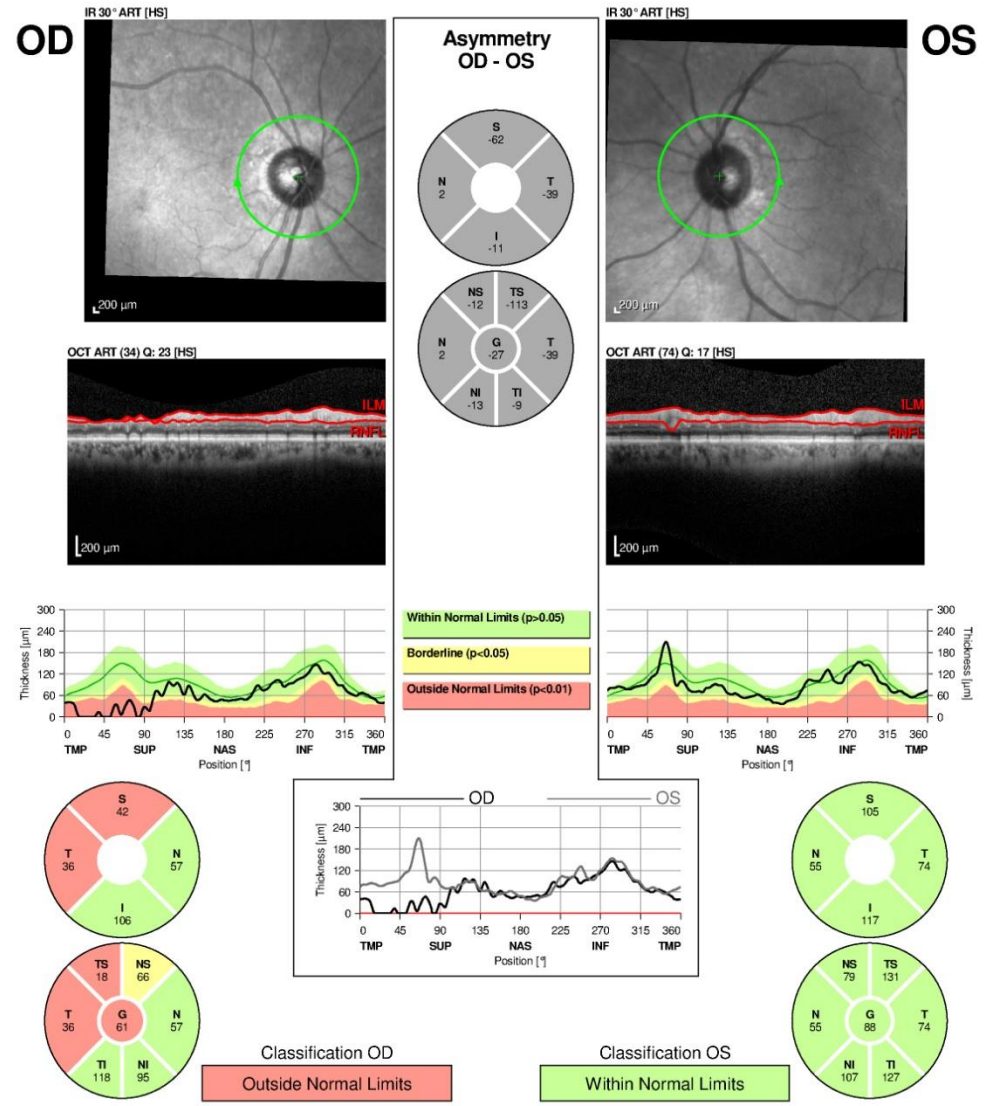
74 yo AAM

Va 20/100, 20/40
IOP 12, 15

Corneal scar OD
Cataract OS

No glaucoma meds

Superior NFL thinning OU



Case #8

86 yo AAF

Va 20/30 OU
IOP 14 OU

h/o SLT OU
On Lumigan OU

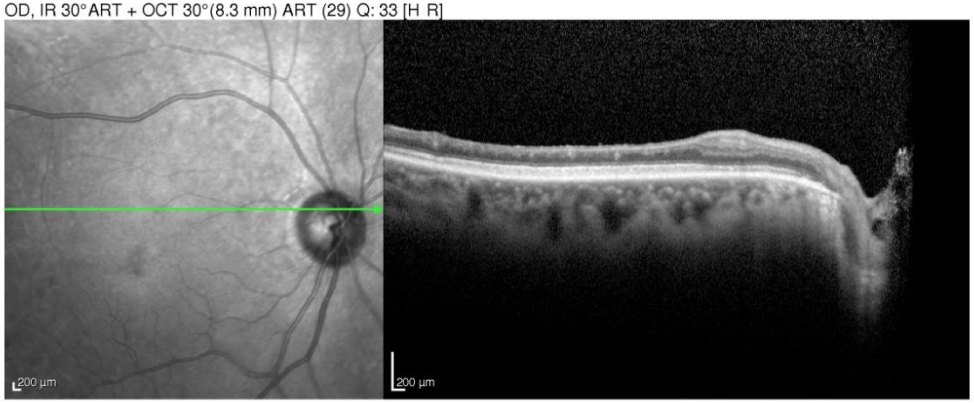
Overview Report
SPECTRALIS® Tracking Laser Tomography

HEIDELBERG ENGINEERING

Sex: F

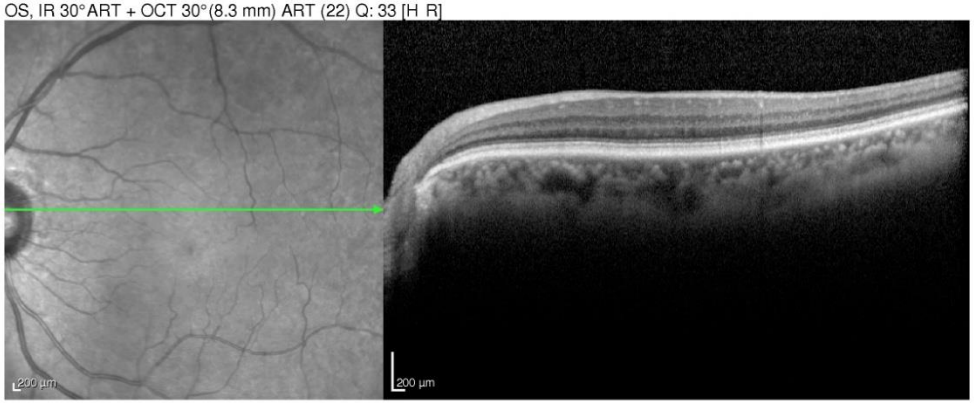
Case #8

OD, IR 30°ART + OCT 30°(8.3 mm) ART (29) Q: 33 [H R]



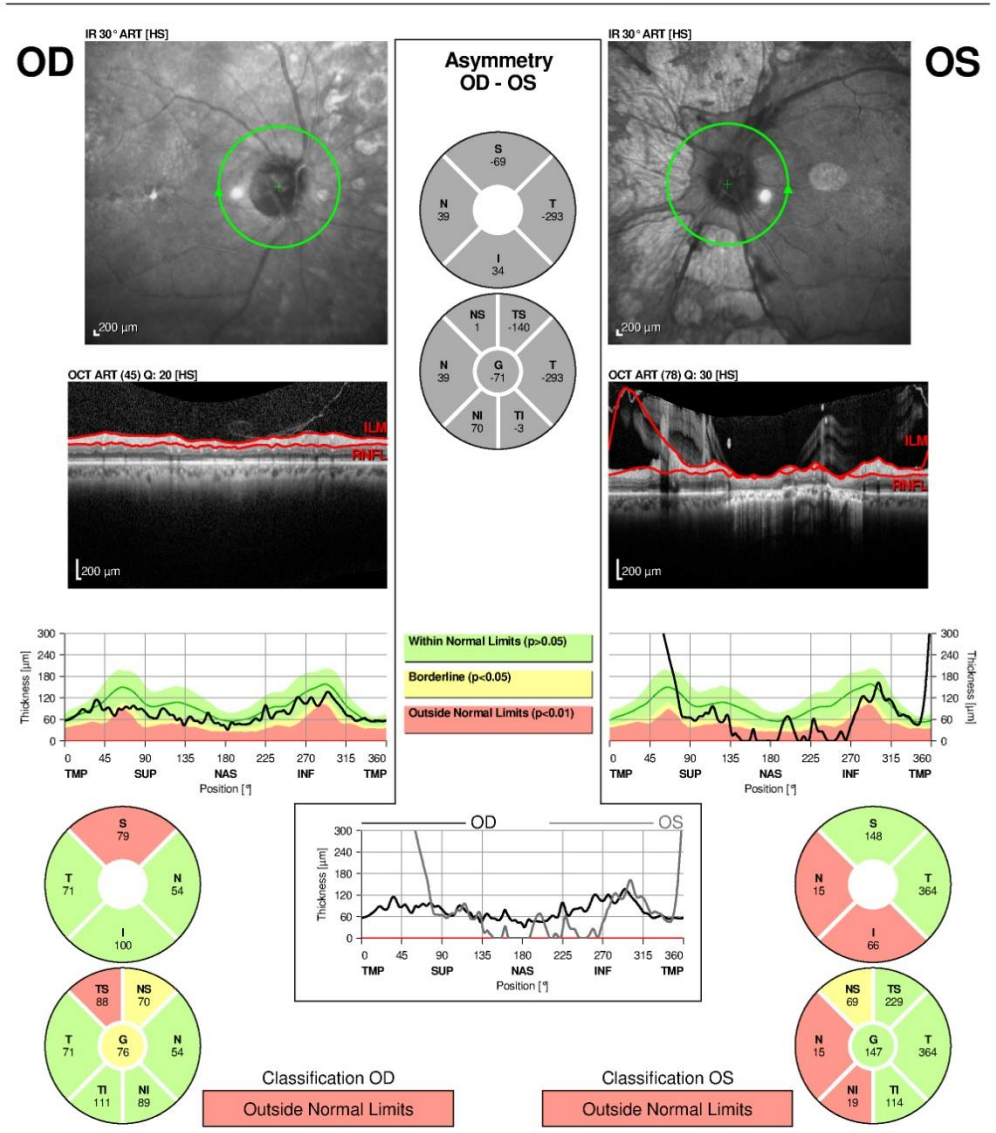
History of BRAO → NOT glaucoma!

OS, IR 30°ART + OCT 30°(8.3 mm) ART (22) Q: 33 [H R]



Notes:

Date: 2/1/2012 Signature:



Case #9

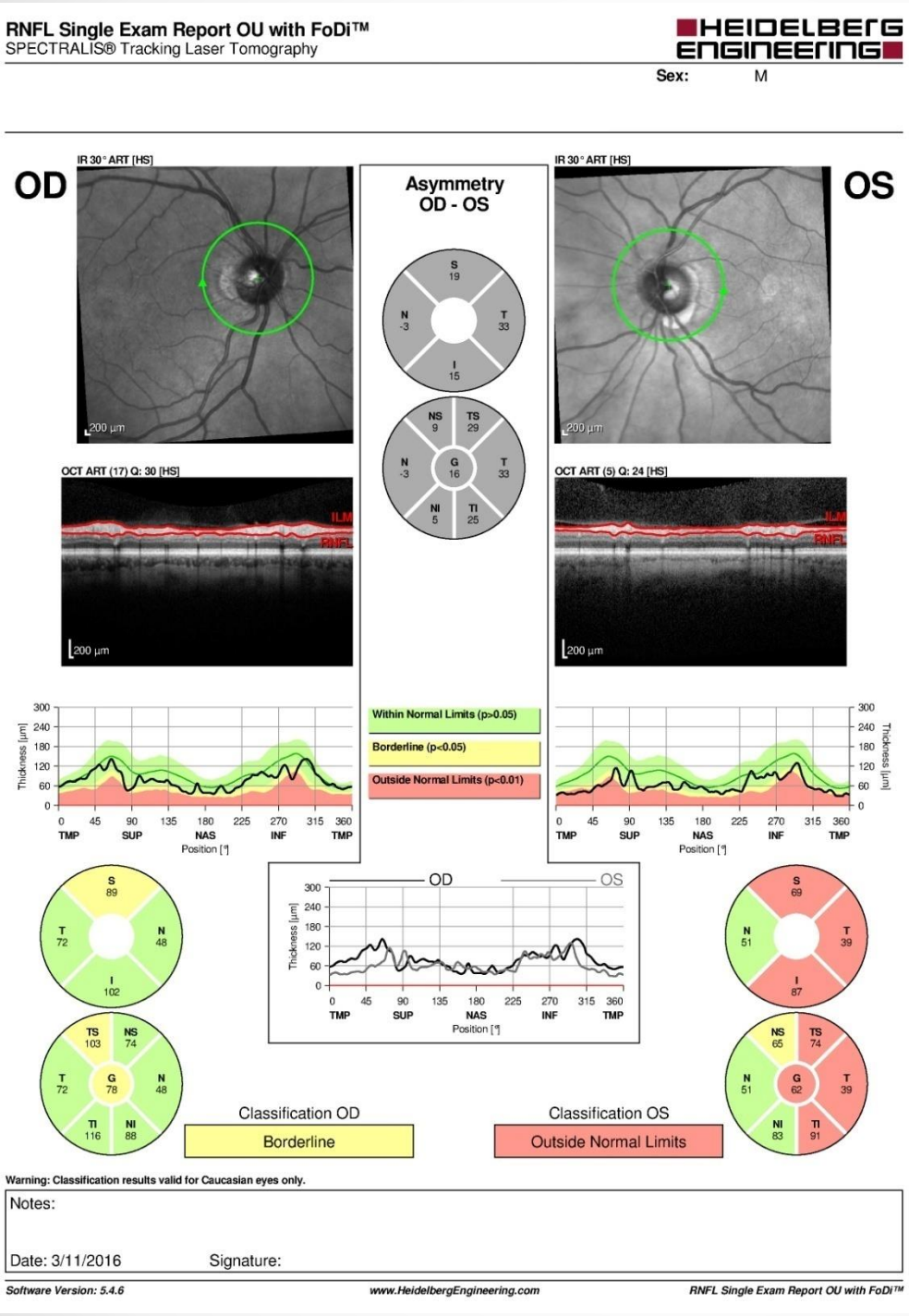
58 yo AAF

Va 20/60, 20/25
IOP 19, 13

h/o corneal transplant OD
h/o PDR s/p PRP OU

On 4 glaucoma meds OU

Glaucoma suspect
PRP artifact



Case #10

68 yo HM

Va 20/25, 20/40
IOP 16 OU

No glaucoma meds

Case #10

Disc pallor → optic neuropathy
Not glaucoma!

OCT-RNFL Pearls

- An OCT scan is only as good as the clinician who's interpreting it
- Glaucoma is a **progressive** disease, so **repeat, repeat, repeat** the testing until you are sure
- Don't forget to look at the whole eye!

Questions?

Macula

- Normal Macula (histologic vs OCT)
- Pathologic findings
- Artifacts

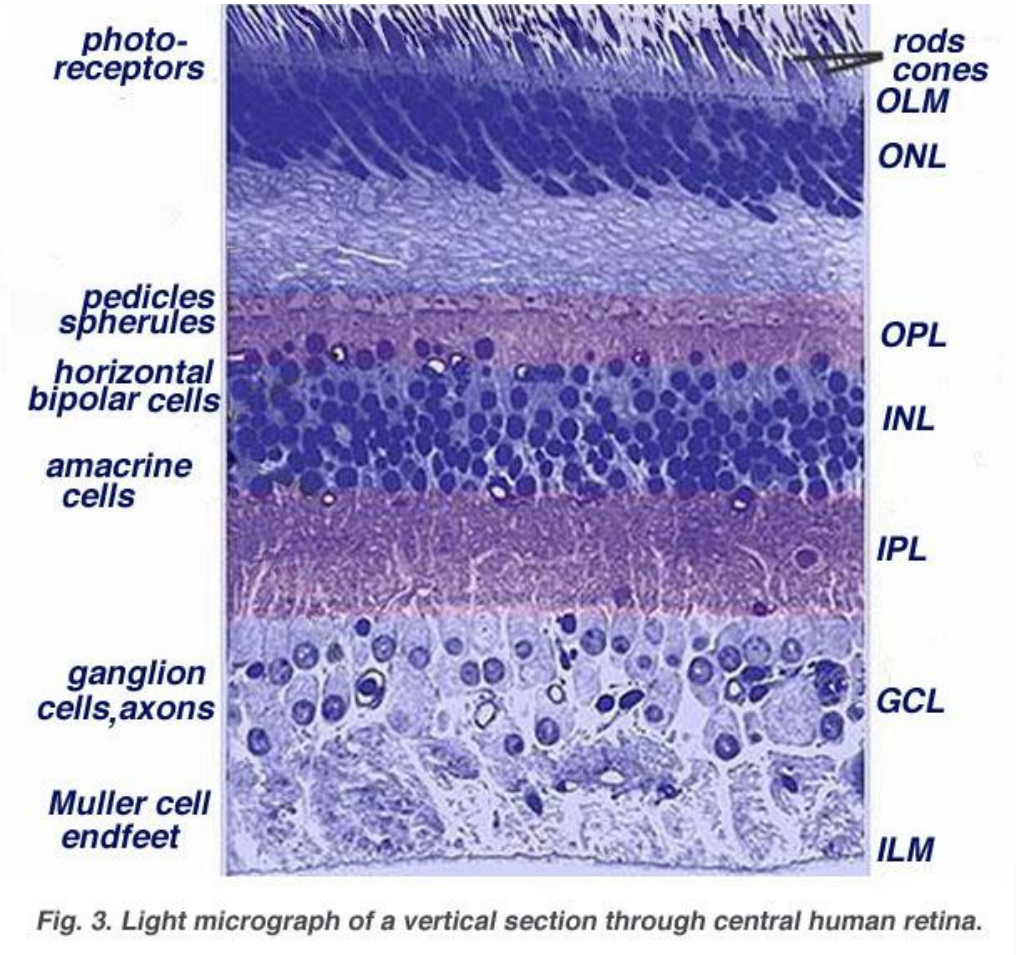


Fig. 3. Light micrograph of a vertical section through central human retina.

http://webvision.med.utah.edu/book/part-i-foundations/simple-anatomy-of-the-re

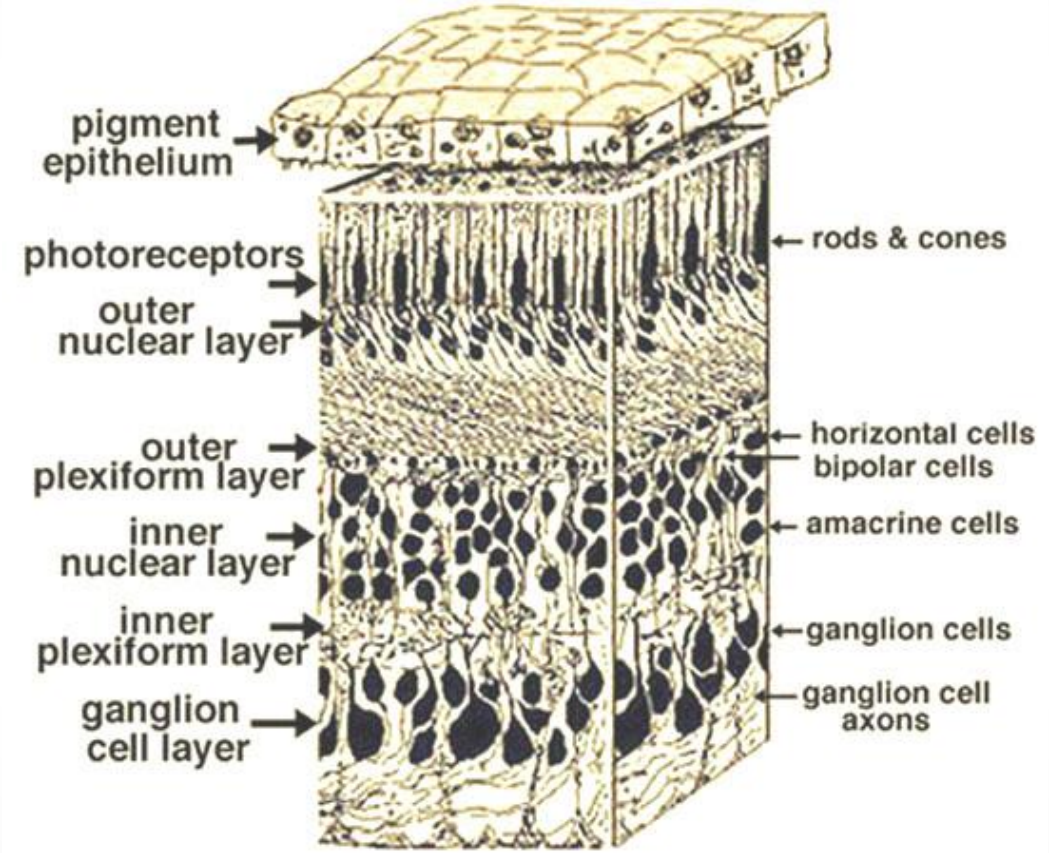
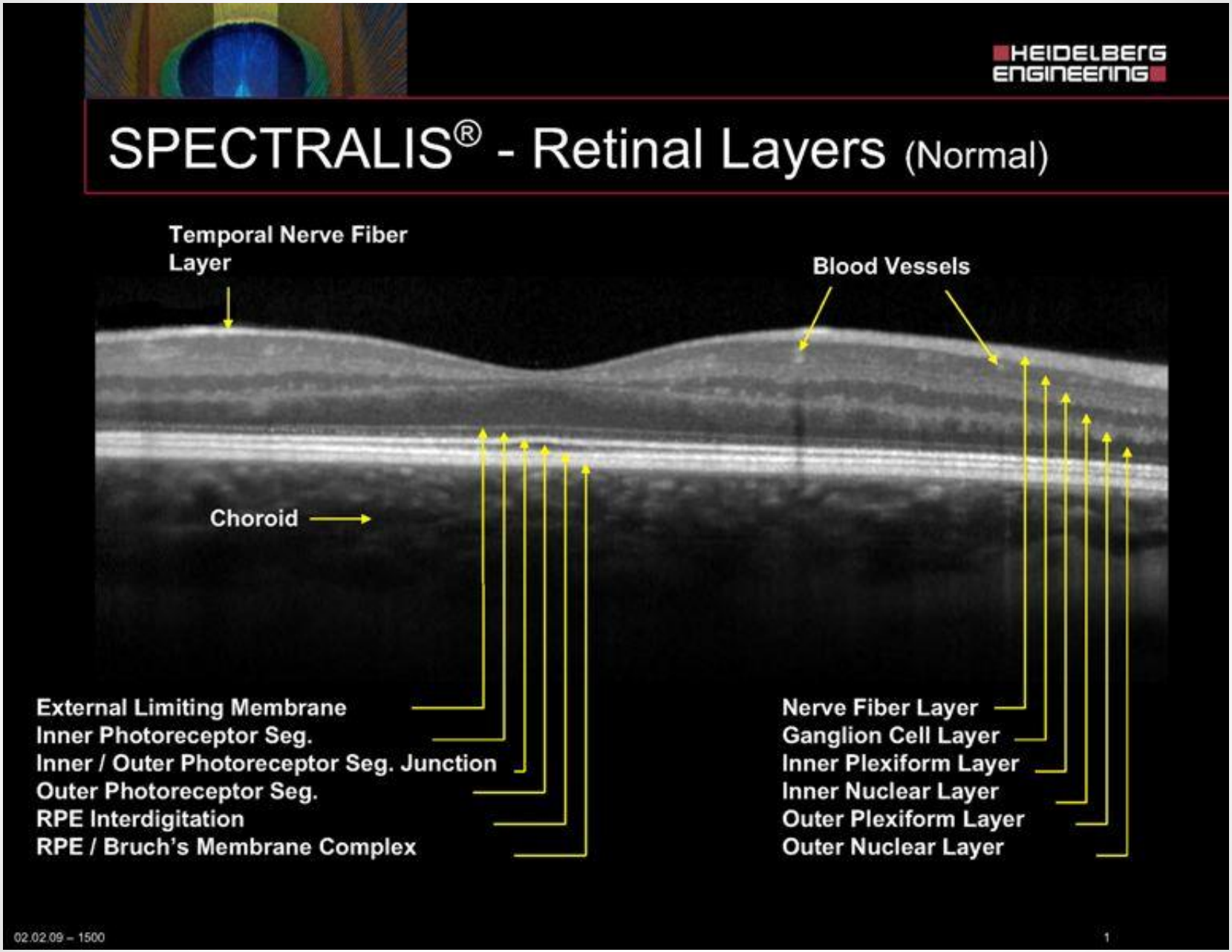


Fig. 4. 3-D block of a portion of human retina.

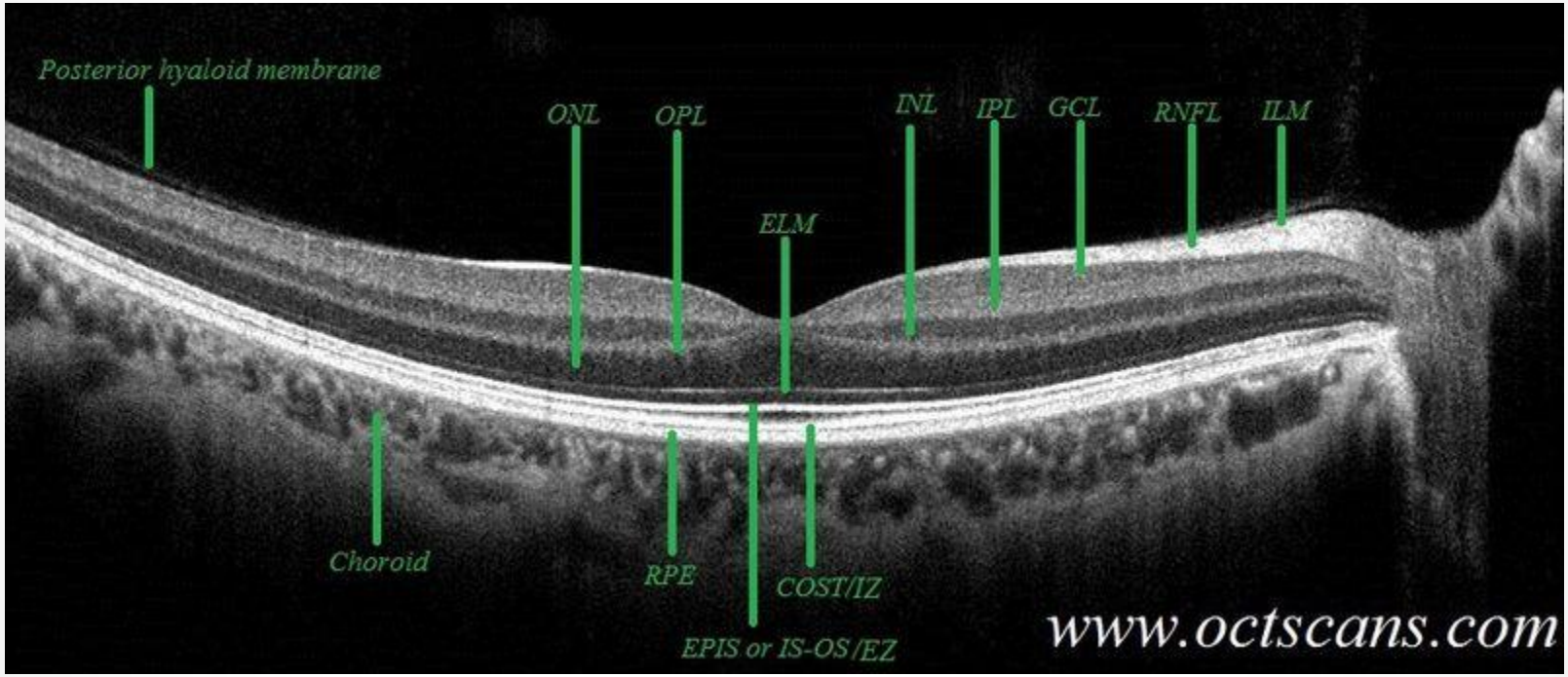
http://webvision.med.utah.edu/book/part-i-foundations/simple-anatomy-of-the-retin

Normal Macular Scan

- layers
- CMT
- Foveal contour
- Vessels

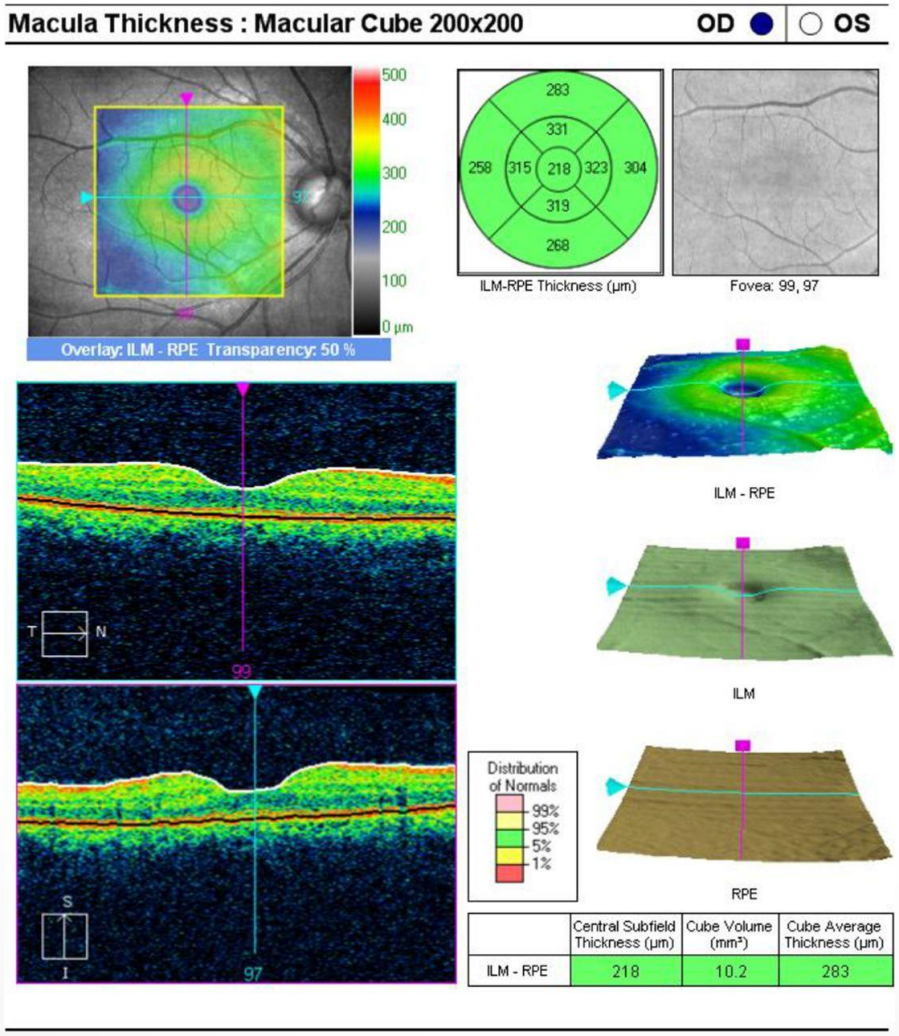

HEIDELBERG ENGINEERING
SPECTRALIS® - Retinal Layers (Normal)
Temporal Nerve Fiber Layer
Blood Vessels
Choroid
External Limiting Membrane
Inner Photoreceptor Seg.
Inner / Outer Photoreceptor Seg. Junction
Outer Photoreceptor Seg.
RPE Interdigitation
RPE / Bruch's Membrane Complex
Nerve Fiber Layer
Ganglion Cell Layer
Inner Plexiform Layer
Inner Nuclear Layer
Outer Plexiform Layer
Outer Nuclear Layer
02.02.09 – 1500
1

B Scan Image



http://www.octscans.com/anatomy-review.html

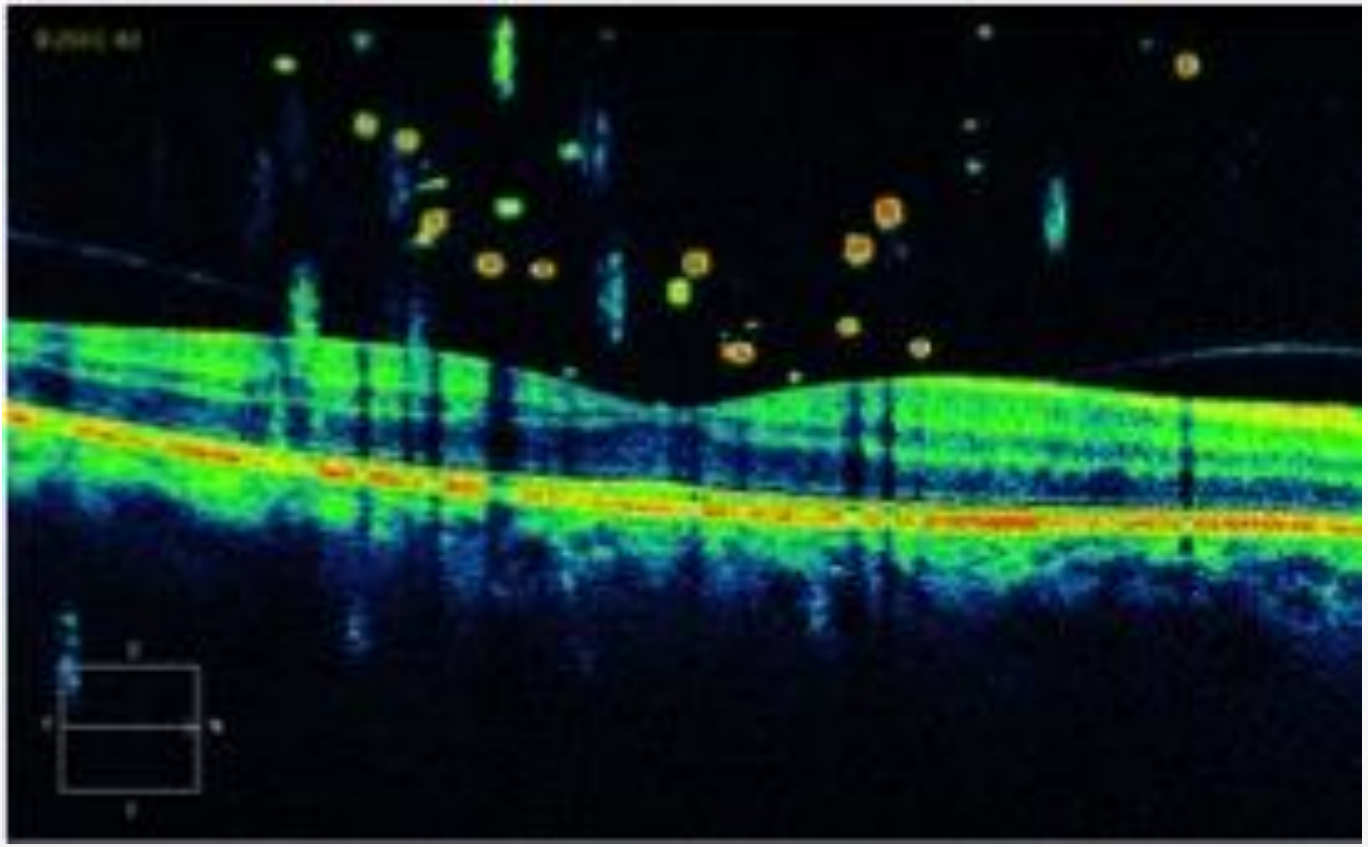
Macula Thickness Map



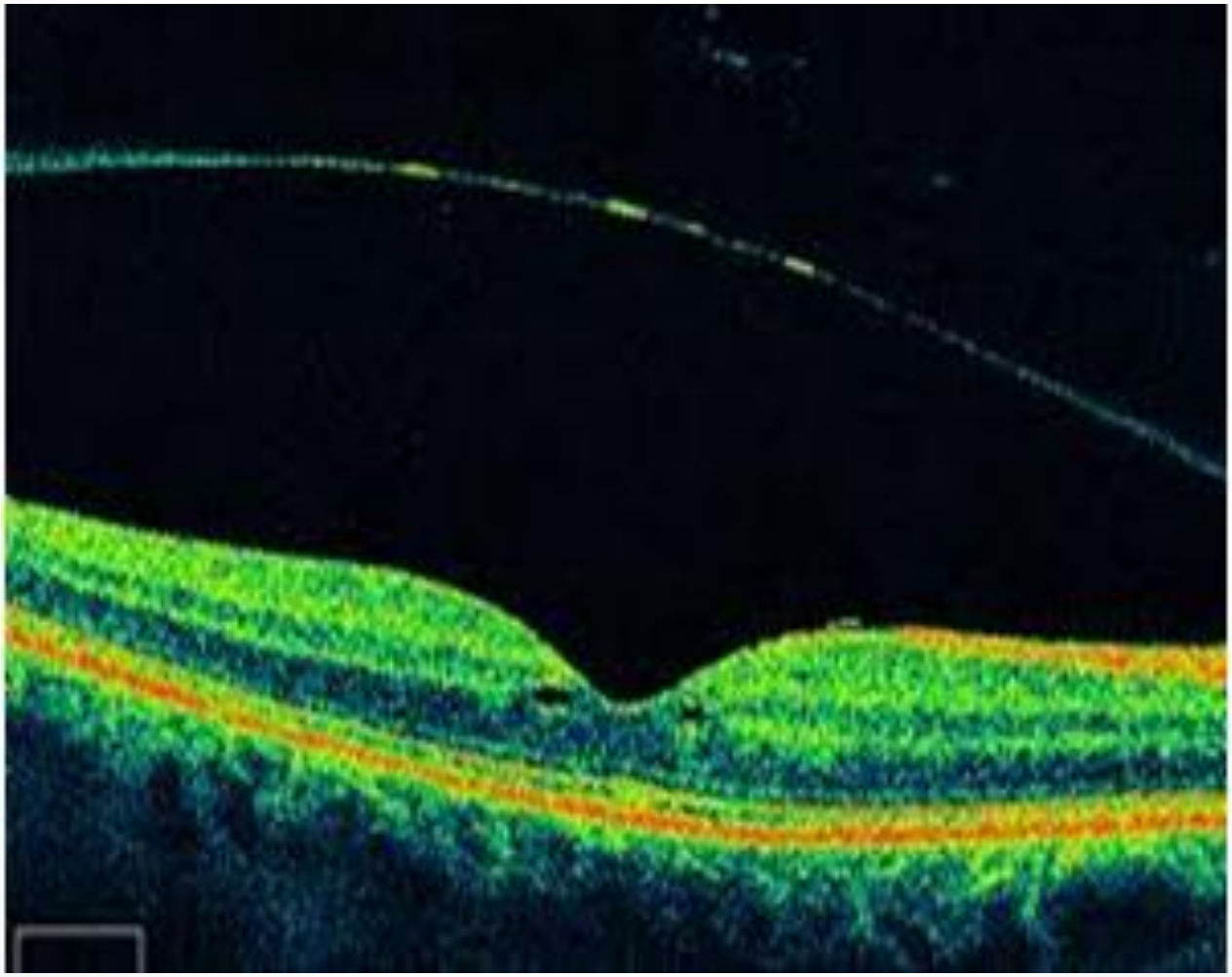
Macular OCT Findings

- Vitreous
- Posterior Hyaloid-Macular interface
- Intraretinal
- RPE
- Choroid

Vitreous Opacities

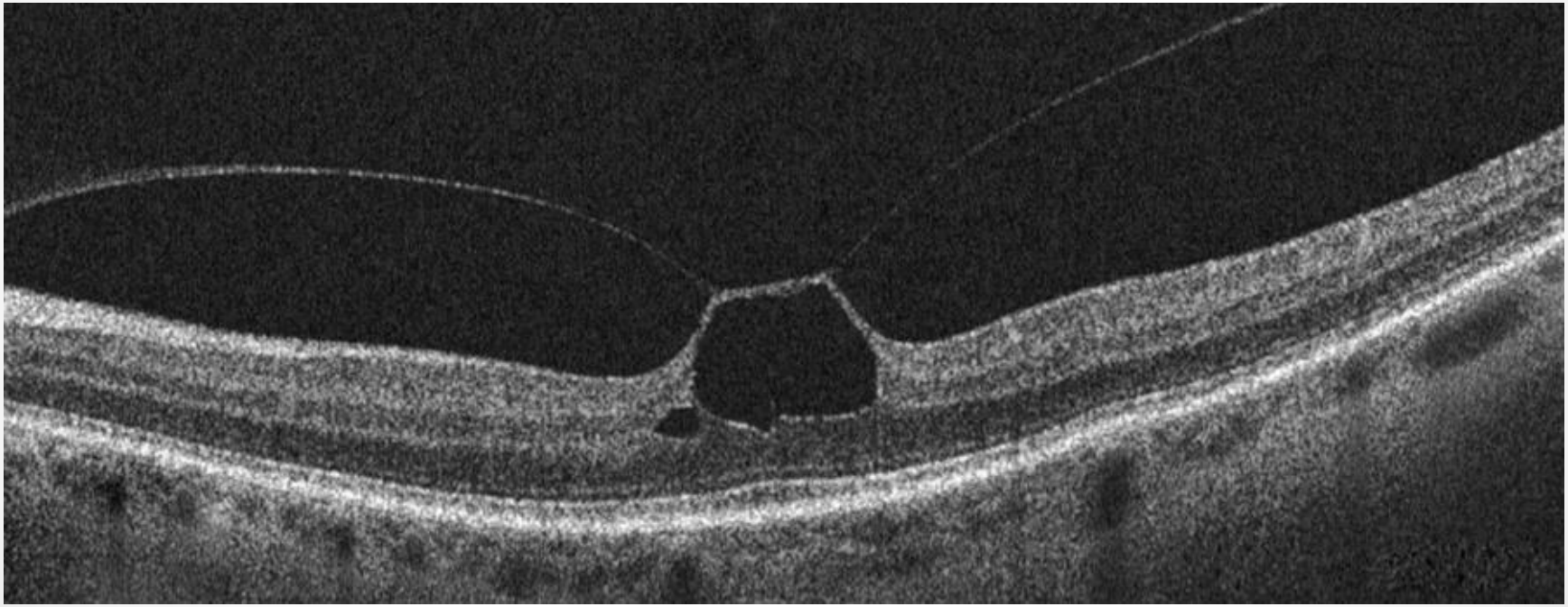


Posterior Vitreous Detachment



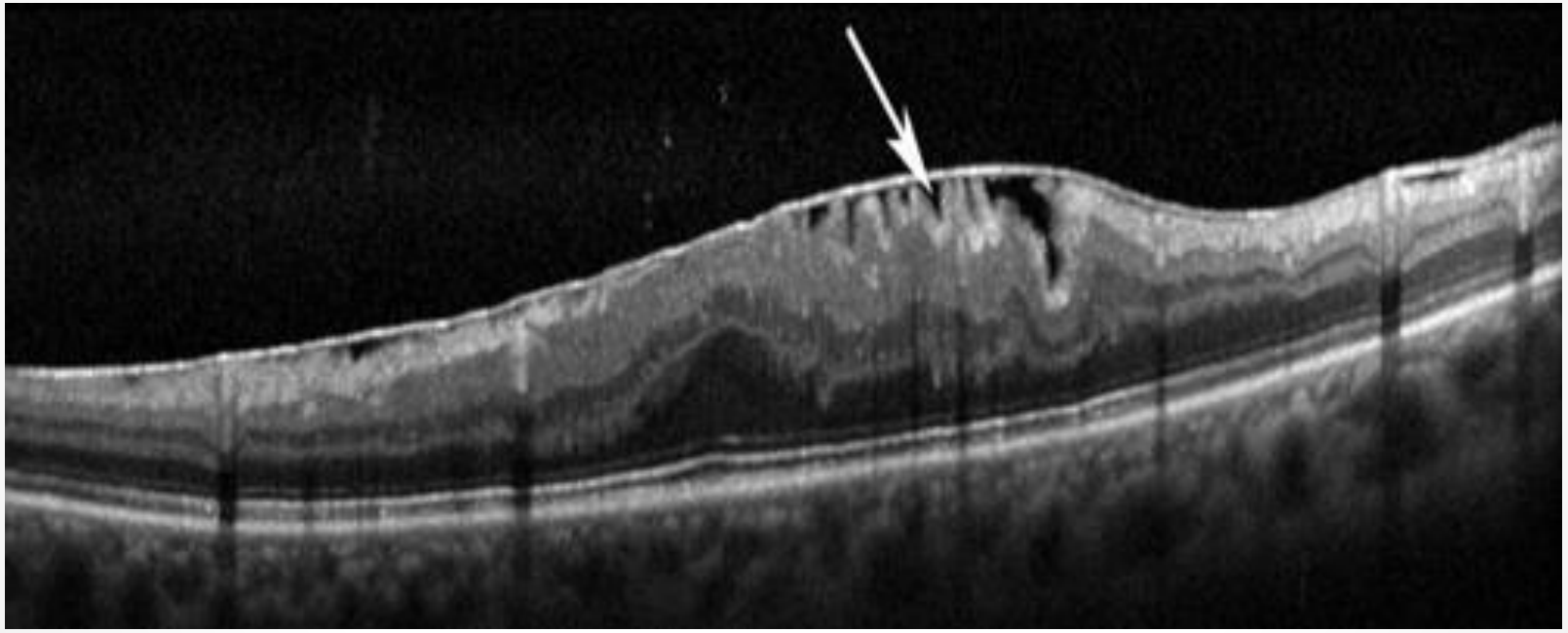
http://www.retinaeye.com/posteriorvitreous.html

Vitreo-Macular Traction

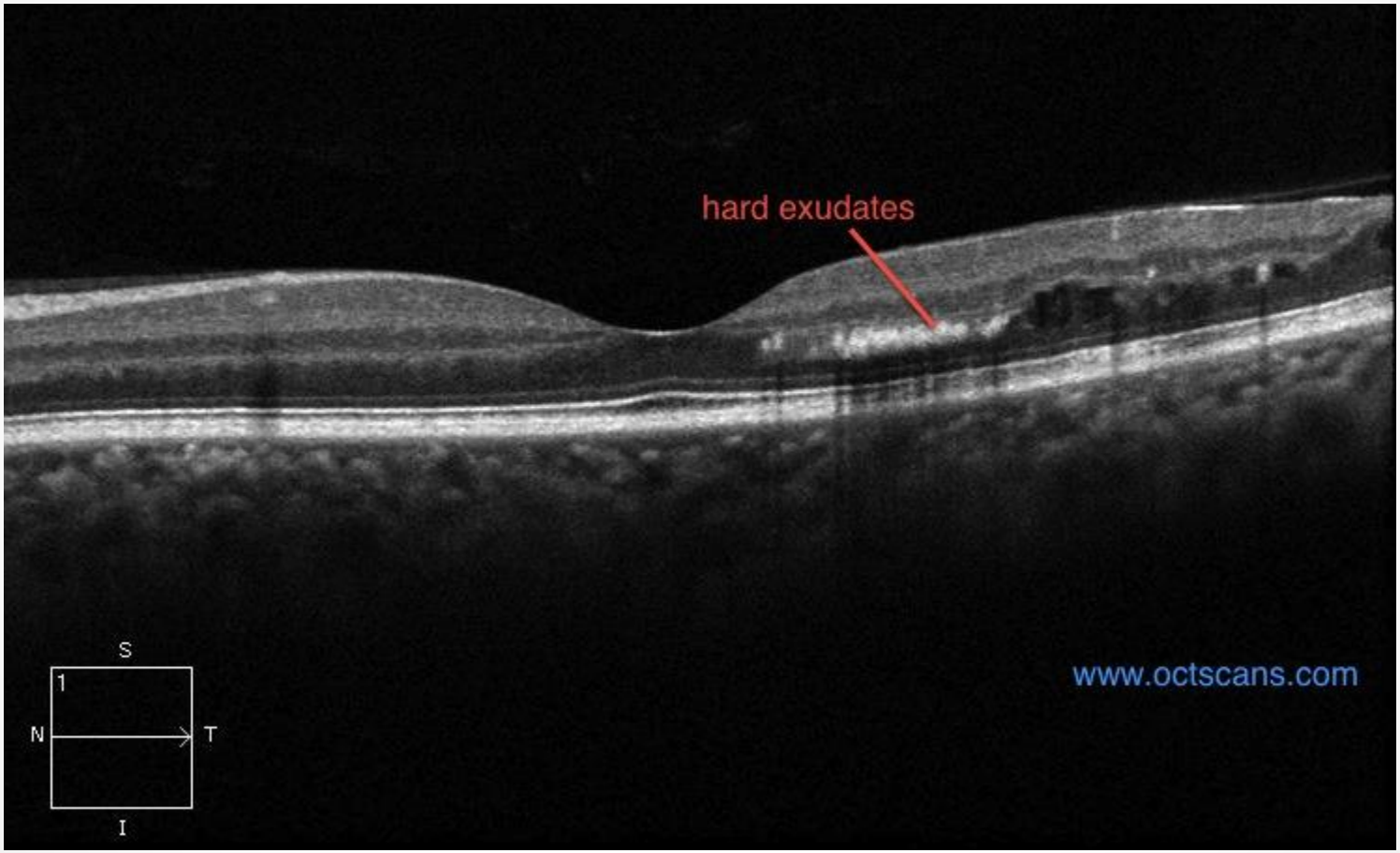


http://jetrea.com/patients/identifying-symptomatic-vma/

Epi-Retinal Membrane

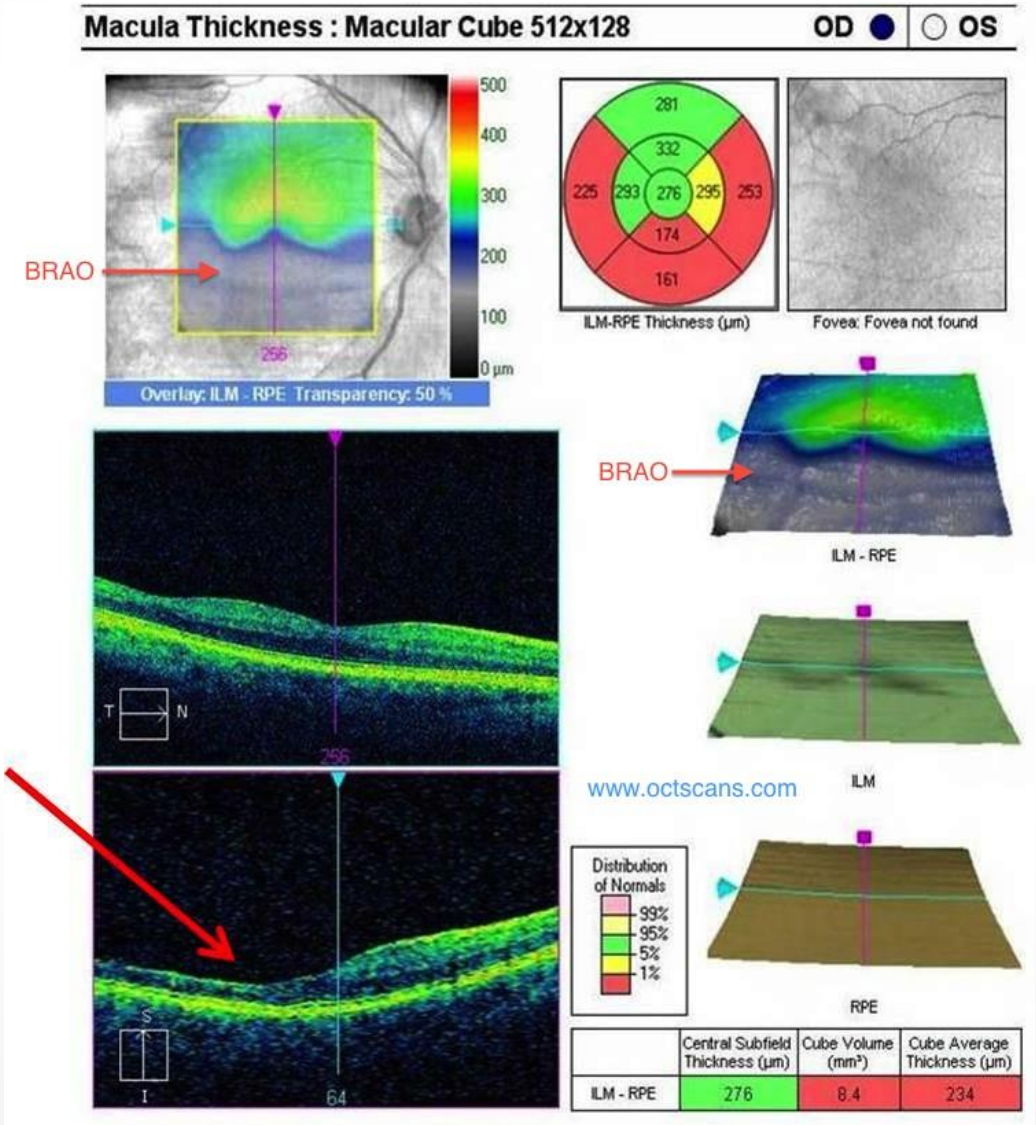


Hard Exudates

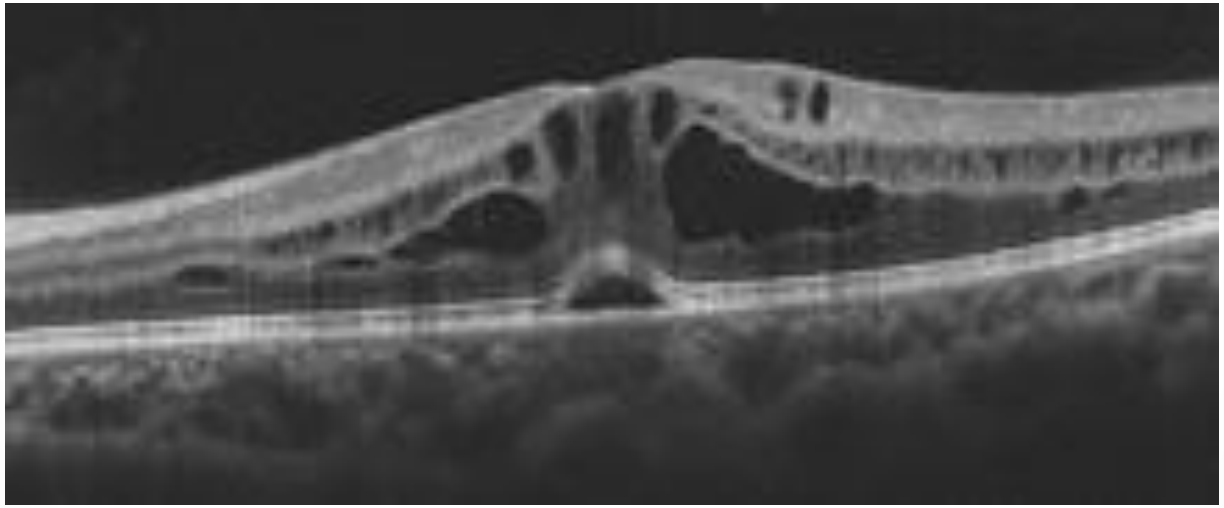


http://www.octscans.com/exudates.html

Branch Retinal Arterial Occlusion

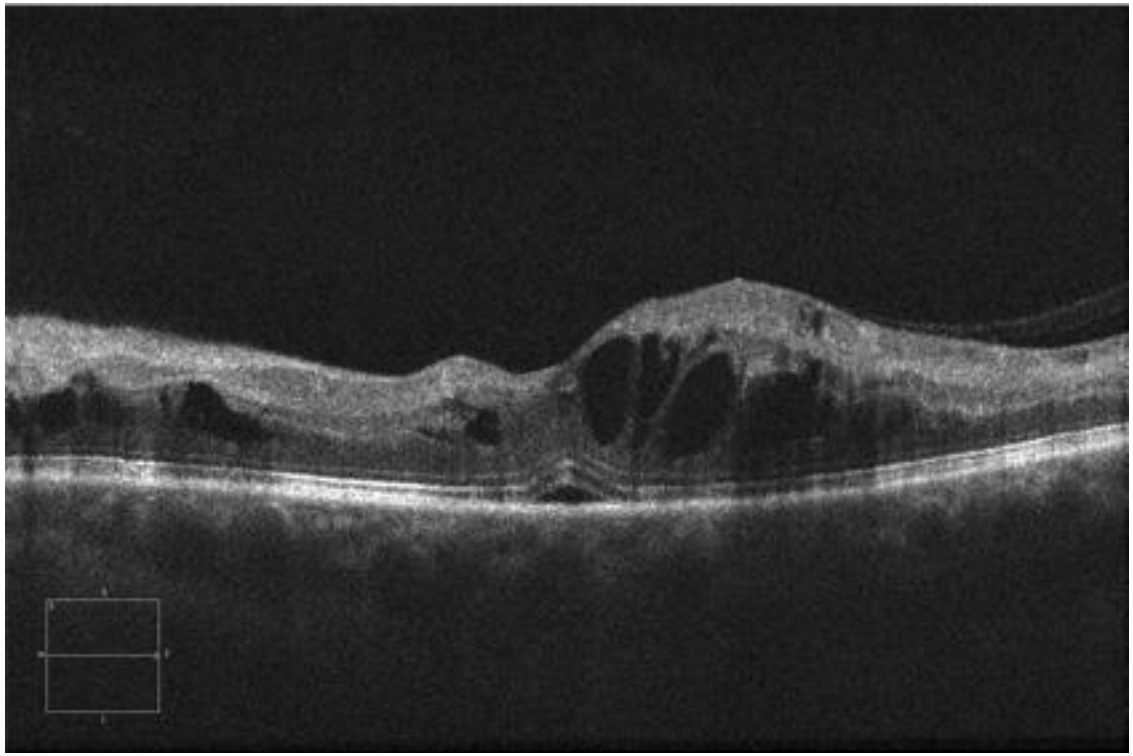


Cystoid Macular Edema



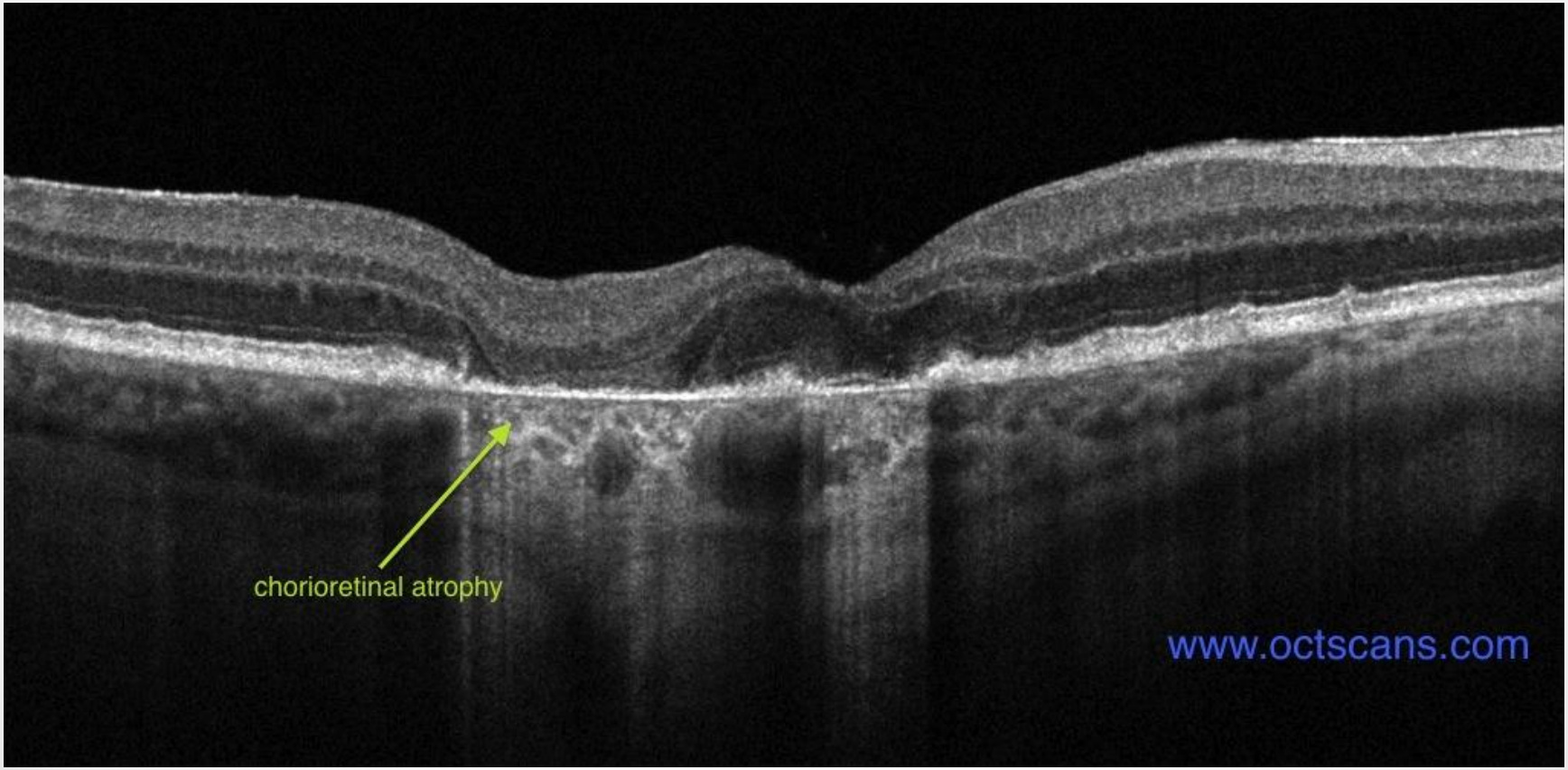
https://www.eyecenters.com/eye-conditions/cystoid-macular-edema-cme.html

Intraretinal Fluid



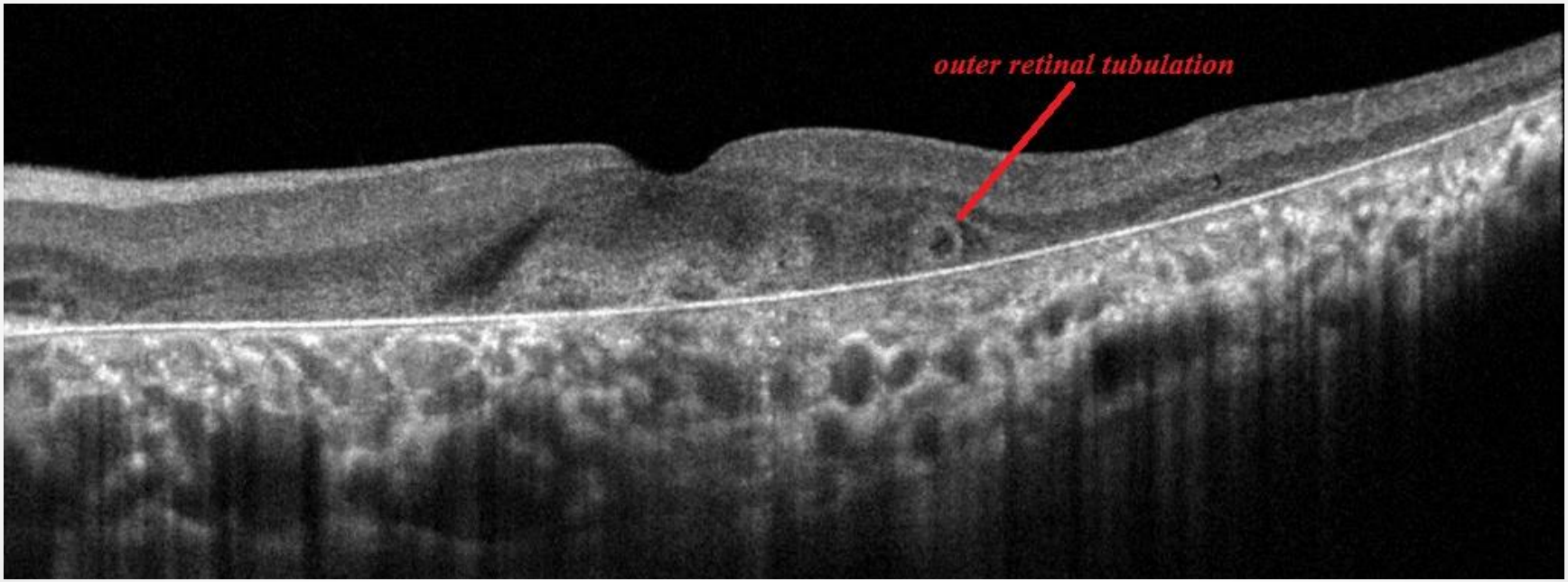
http://www.northerneyesurgeons.com.au/oct-scanning

Outer Retinal Atrophy



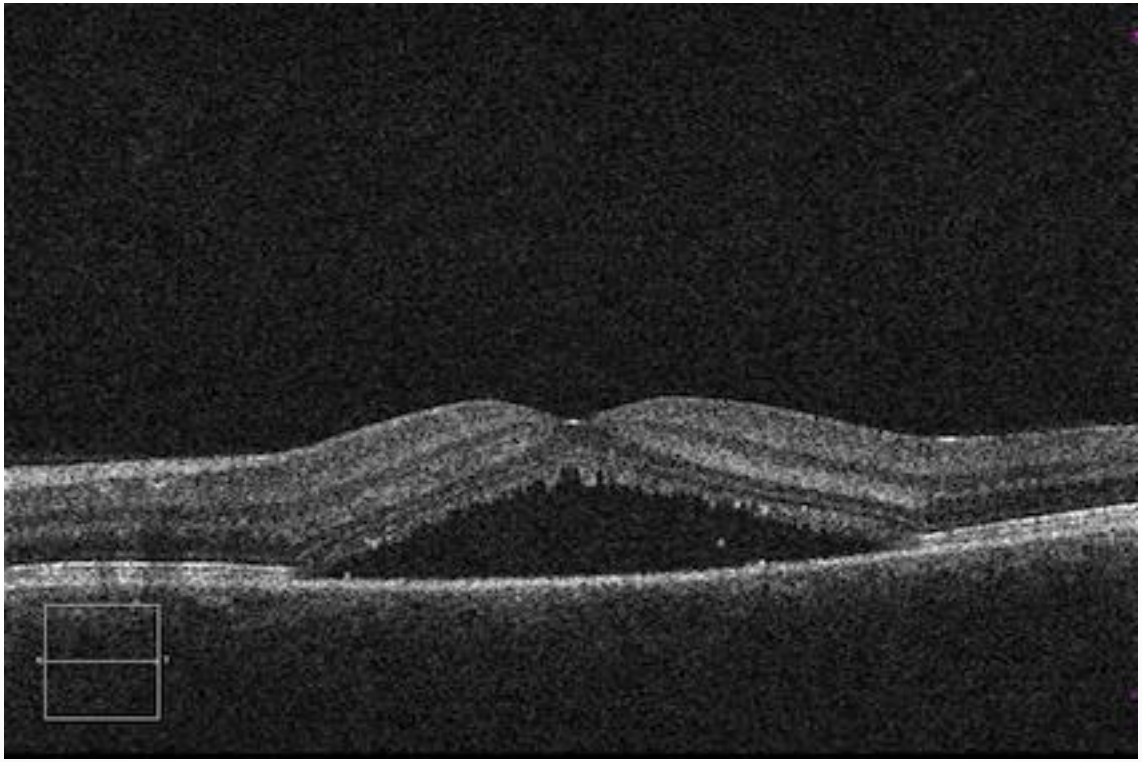
http://www.octscans.com/age-related-macular-degeneration.html

Outer Retinal Tubulation



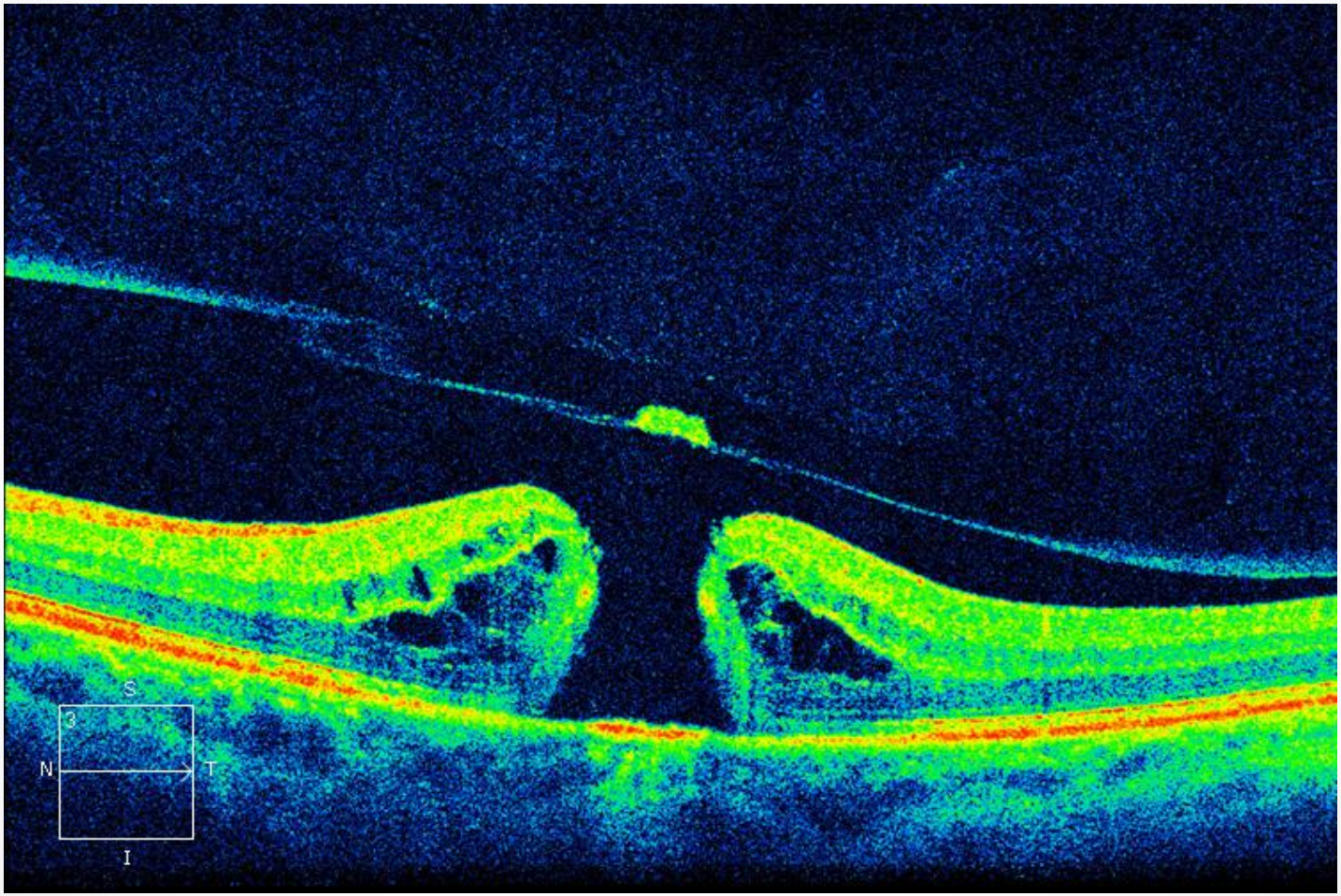
http://www.octscans.com/age-related-macular-degeneration.html

Subretinal Fluid



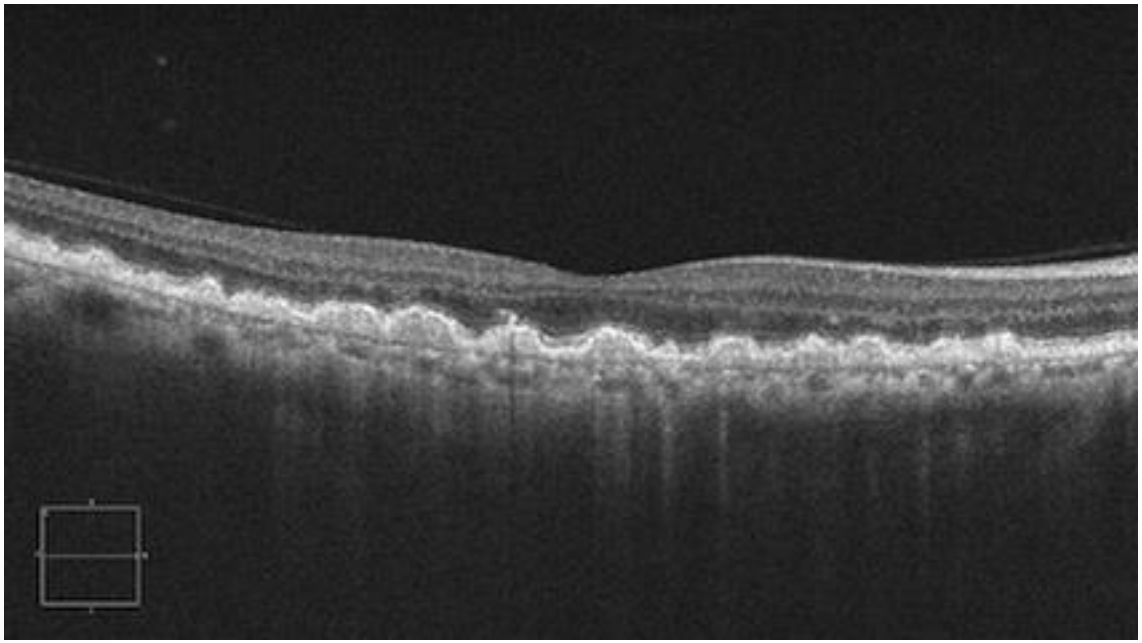
http://www.northerneyesurgeons.com.au/oct-scanning

Macular Hole



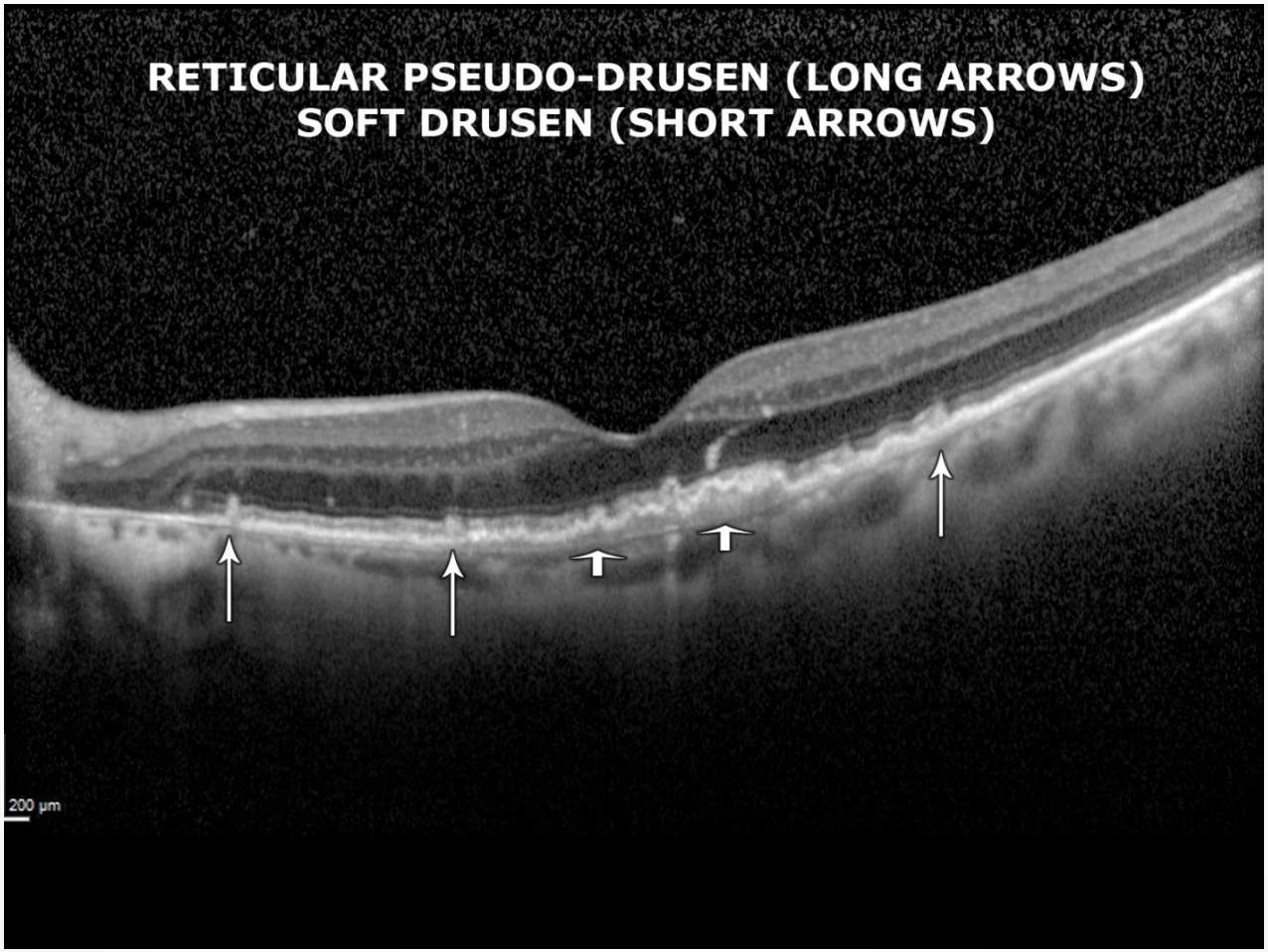
http://retinagallery.com/displayimage.php?pid=5103

Drusen



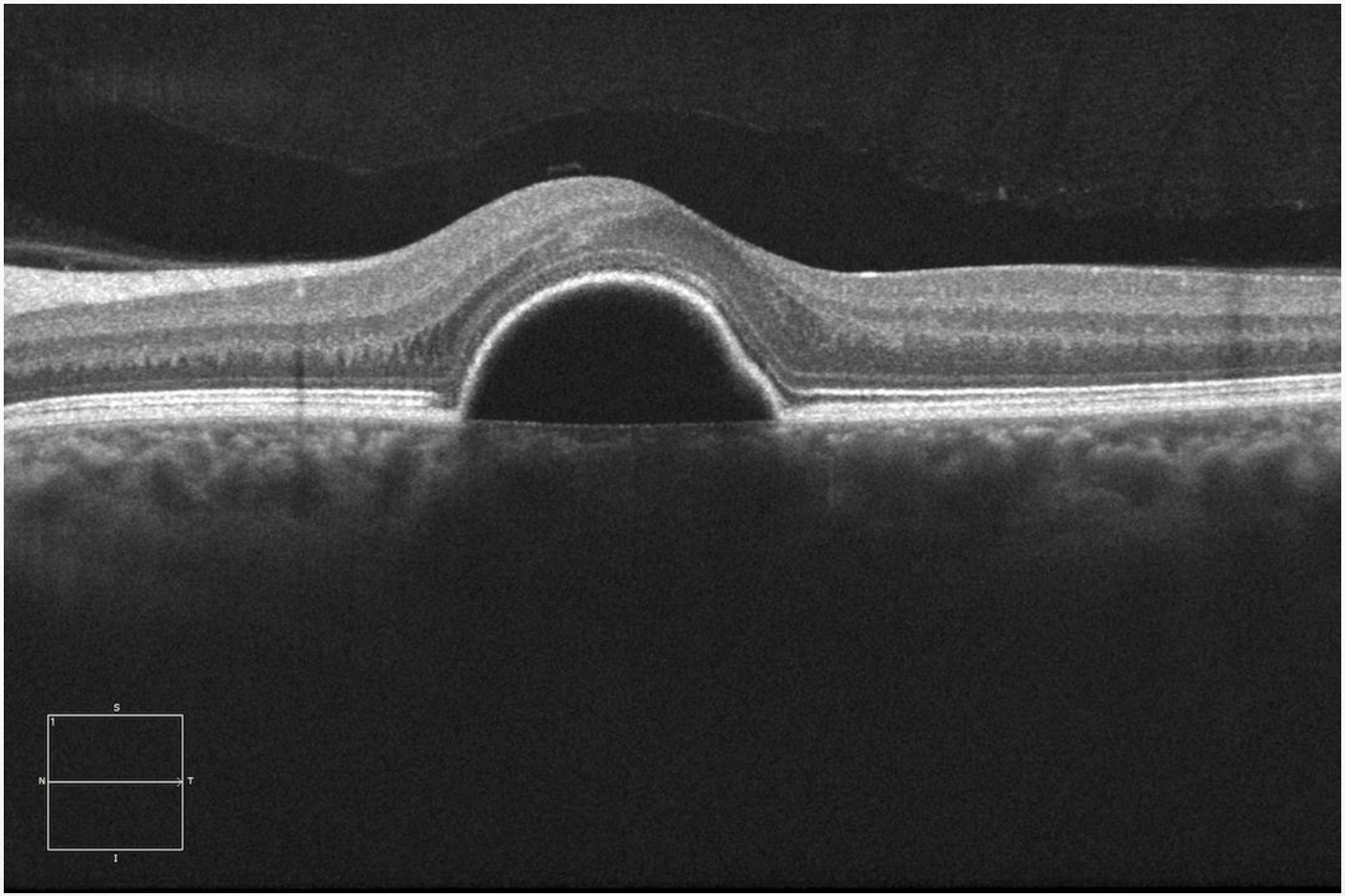
http://www.northerneyesurgeons.com.au/oct-scanning

Reticular Pseudo-Drusen



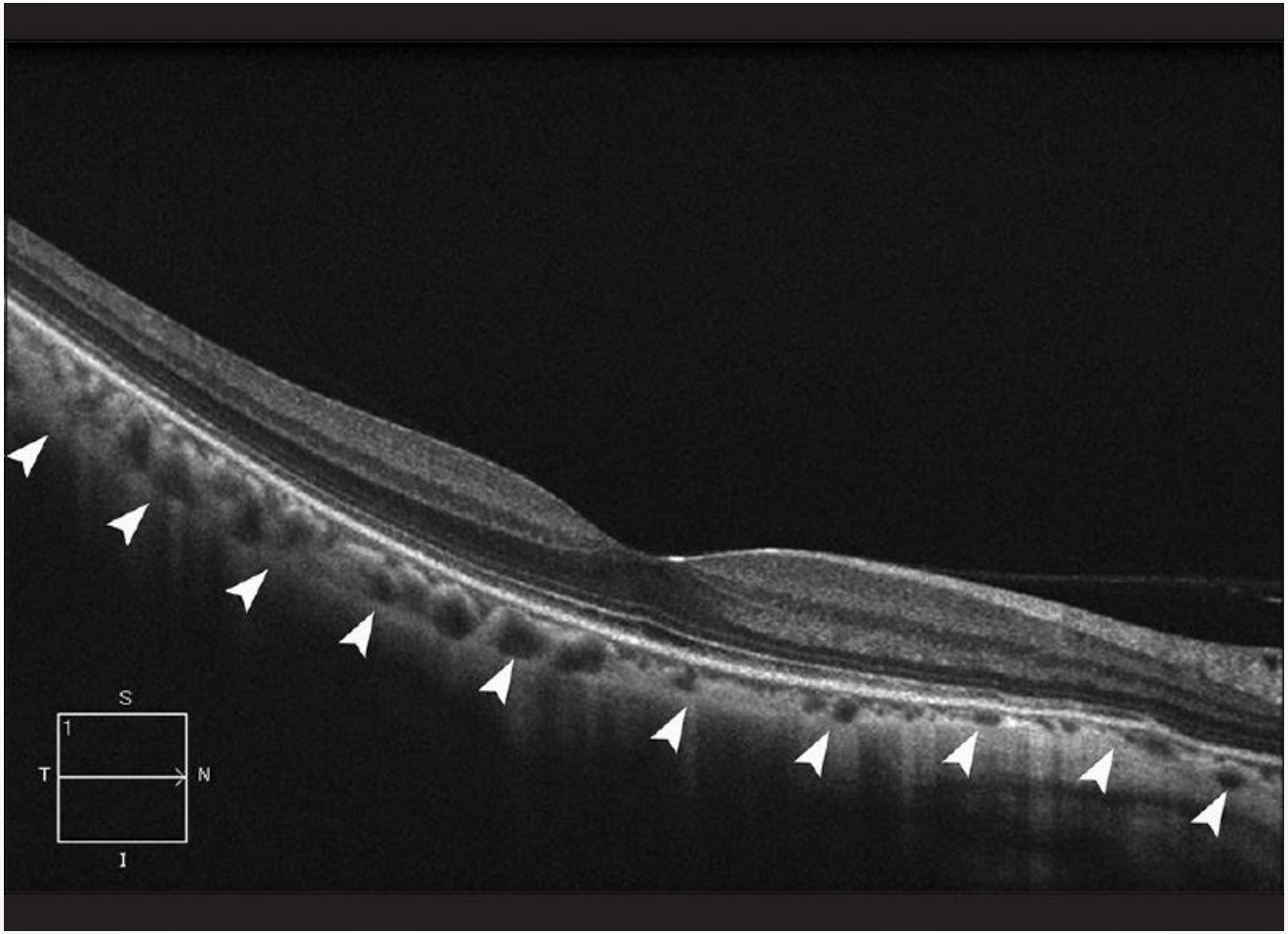
http://retinagallery.com/displayimage.php?pid=4328

RPE Detachment



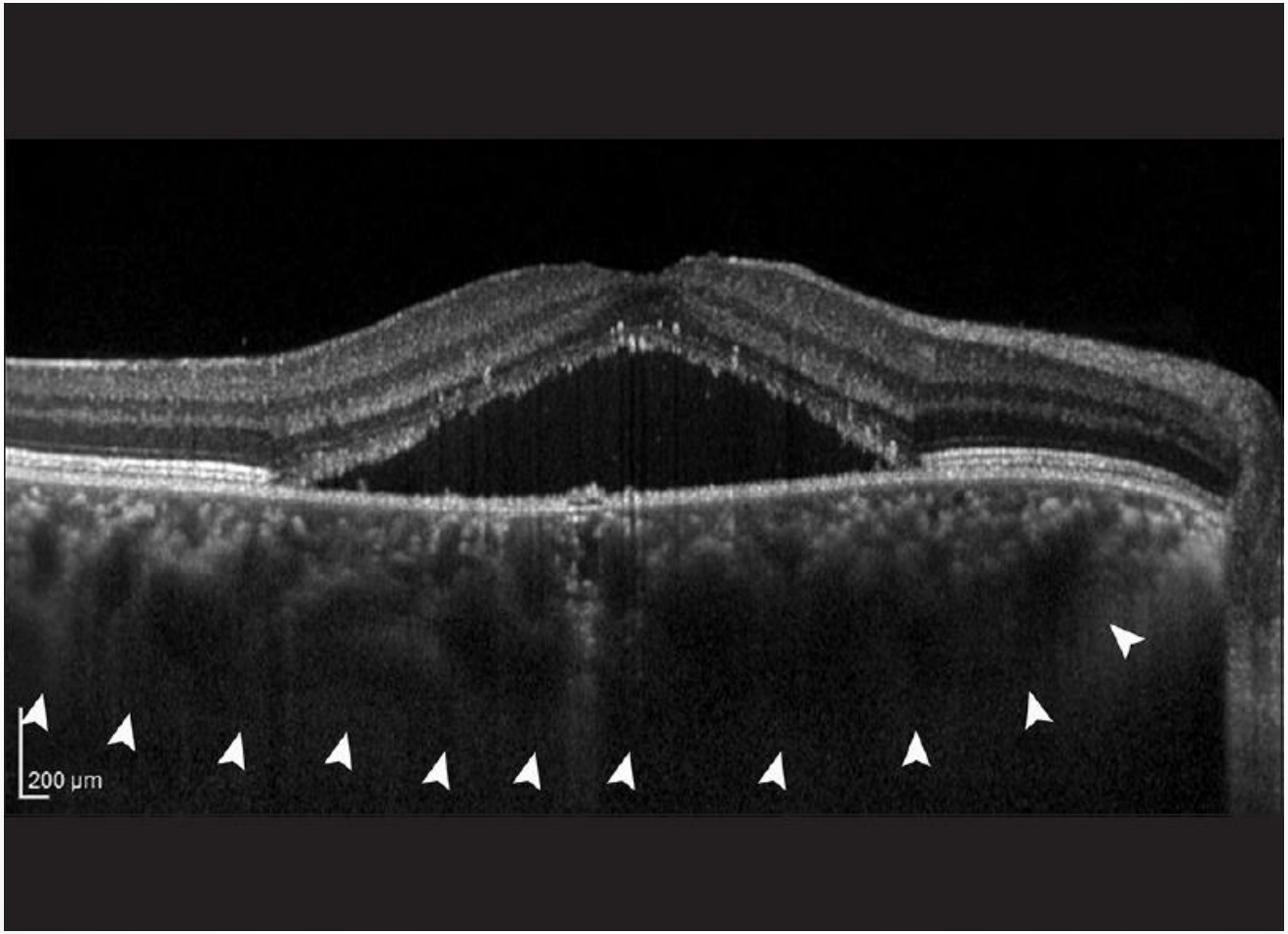
http://www.octmd.org/findings/rpe/ped-serous-large/

Thin Choroid



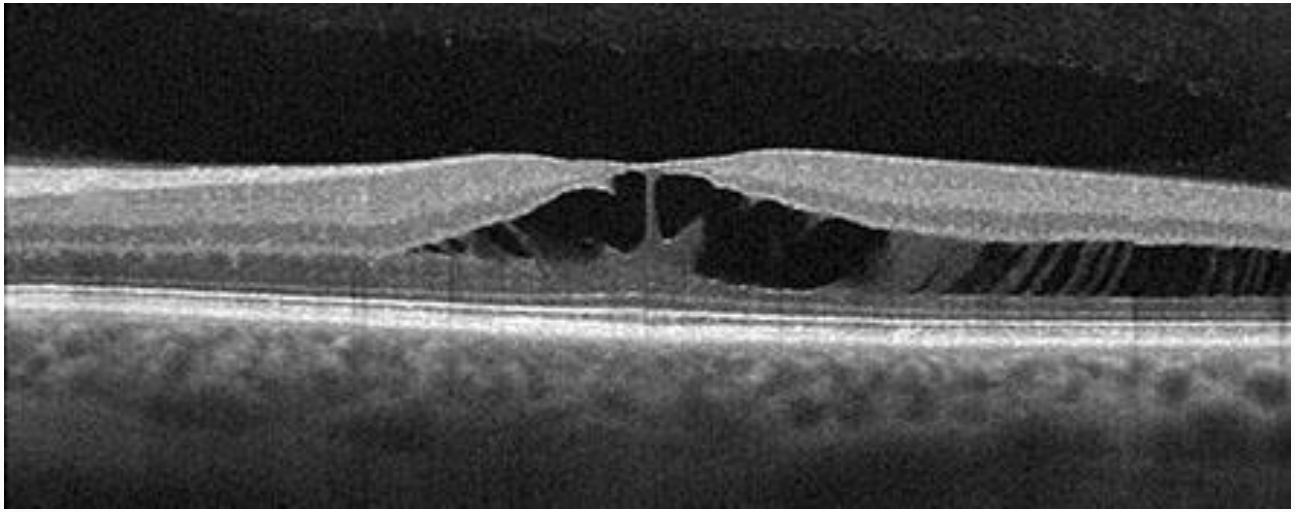
http://www.ijo.in/viewimage.asp?img=IndianJOphthalmol_2015_63_5

Thick Choroid



http://www.ijo.in/viewimage.asp?img=IndianJOphthalmol_2015

Case #1



Case #1

Foveal retinoschisis

Differential Diagnosis?

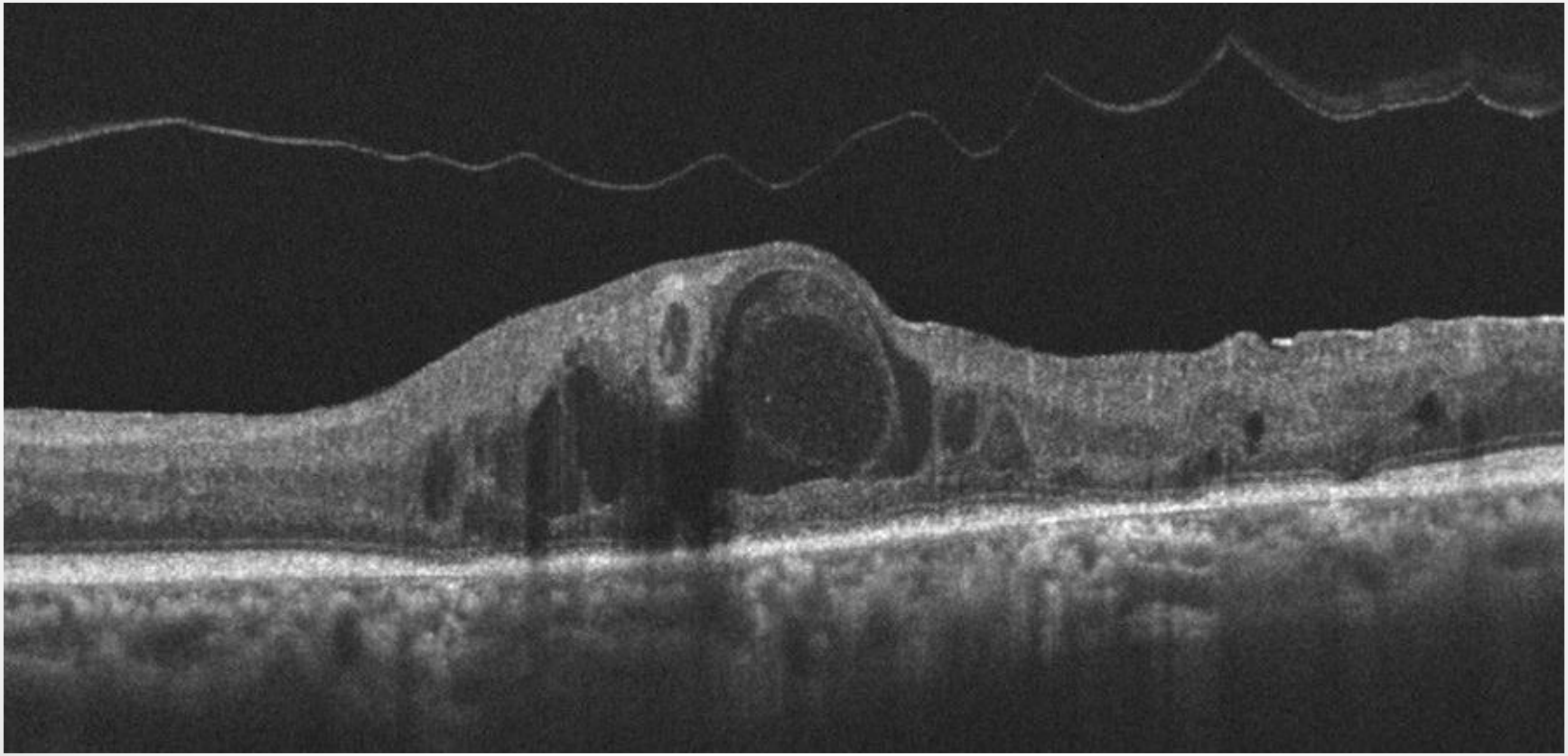
Case #1

Foveal retinoschisis

Differential Diagnosis:

- X-linked juvenile retinoschisis
- Pathologic myopia
- Optic Pit maculopathy
- Glaucoma-related maculopathy
- Non-leaking CME (nicotinic acid maculopathy, RP, Goldman-Favre, taxane maculopathy)
- Stellate non-hereditary idiopathic foveomacular retinoschisis

Case #2

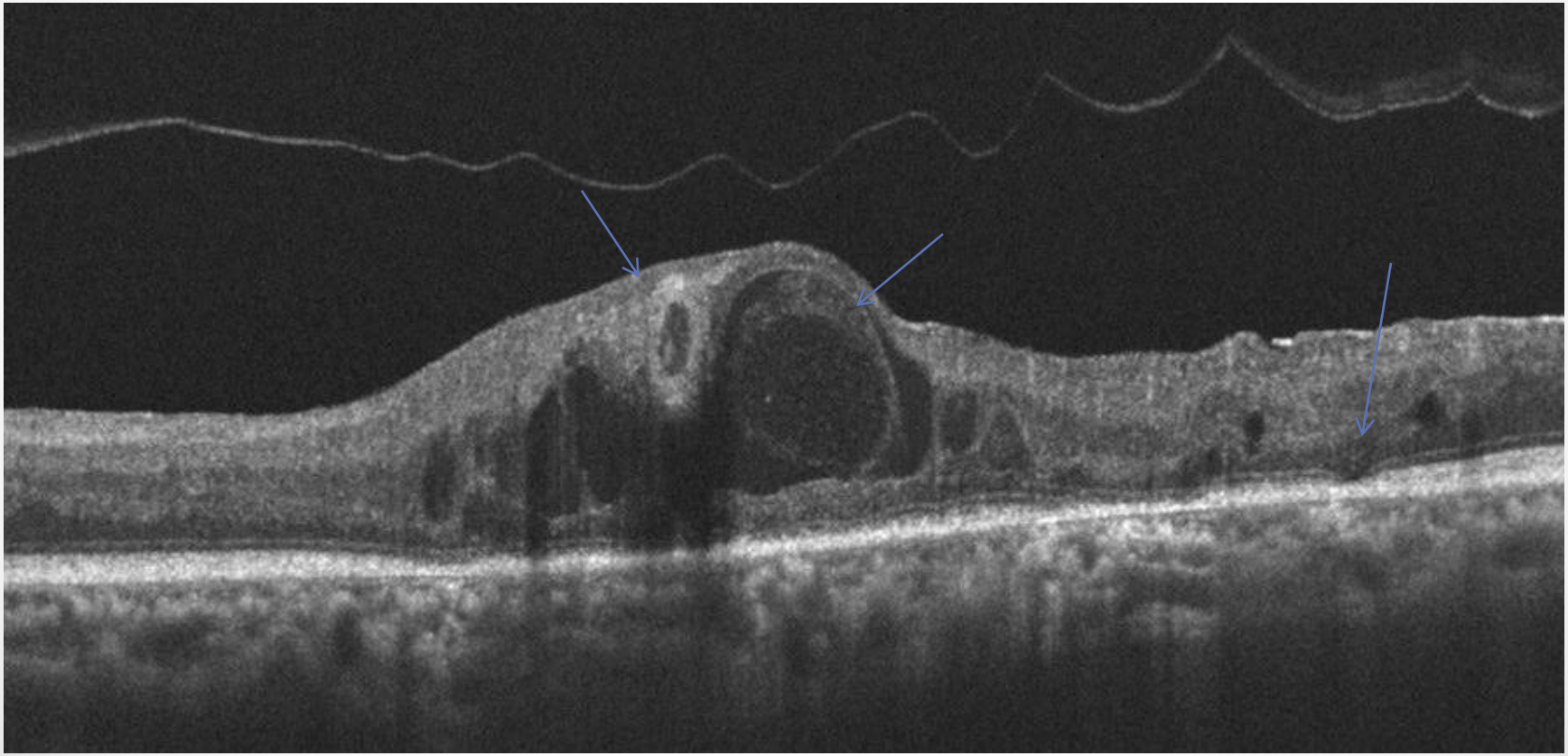


Case #2

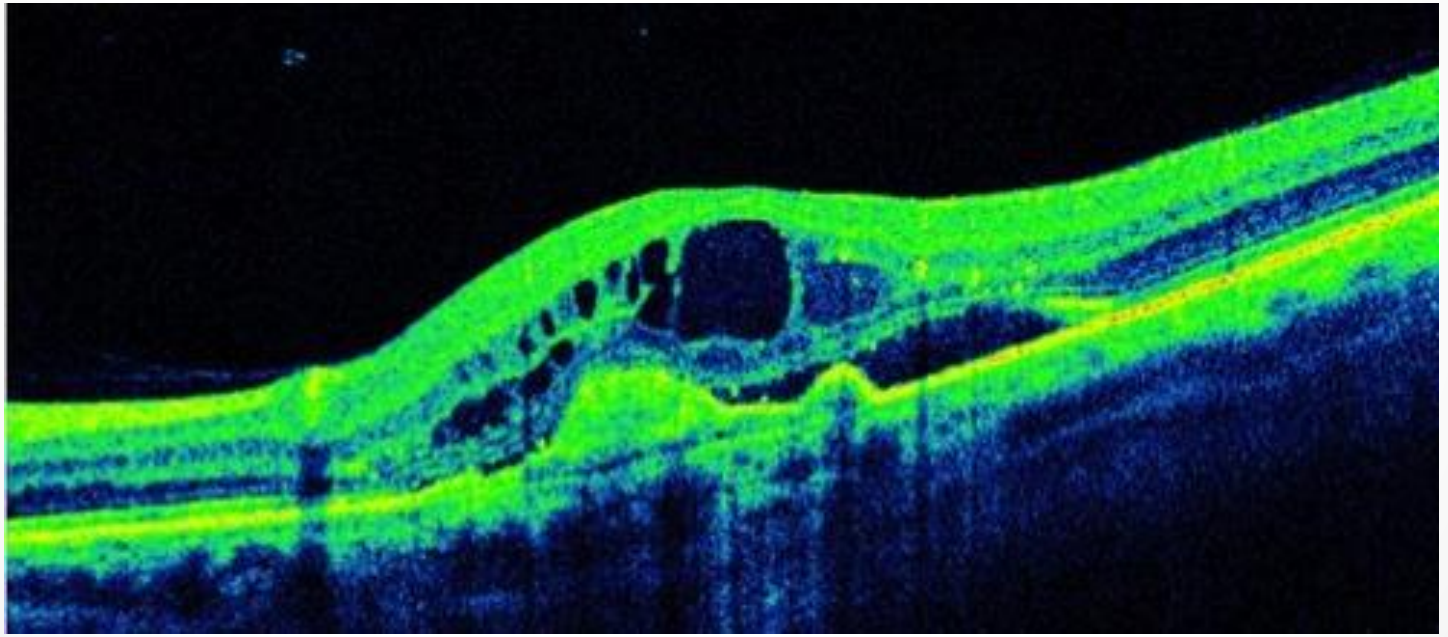
Diabetic Macular Edema

Features?

Case #2



Case #3



Case #3

Choroidal Neovascular Membrane

Diagnosis:
Exudate Age-related Macular Degeneration

Case #4

Case #4

Idiopathic Juxtafovealar Telangiectasis/Macular Telangiectasia/MacTel Type II

Artifacts

- Off-center: Fixation error
- Motion Artifact: eye/head movement
- Degraded image: poor image acquisition from opaque media
- Cut edge: edge of scan is truncated
- Out of Register: scan shifted outside of acquisition gates
- Mirror Artifact: high myopes, longer axial lengths
- Movement: Eye or head, Blink
- Misidentification of Retinal layers (Inner or Outer)
- Shadows
- Blink

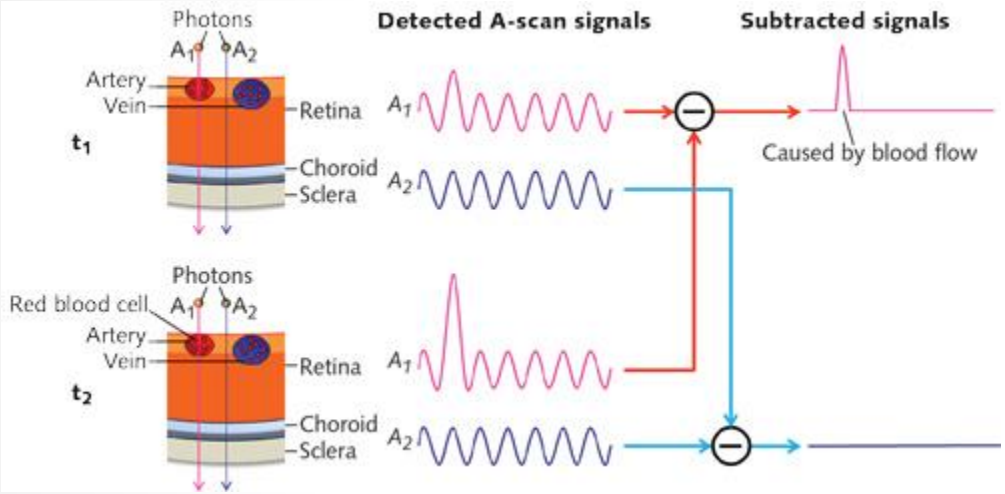
Artifact	Correction
Inner Layer Misidentification	Manual Correction
Outer Layer Misidentification	Manual Correction
Mirror Artifact	Retake scan in area of interest
Degraded Image	Repeat scan after addressing issue
Out of Register	Repeat scan after realigning
Cut edge	Ignore
Off Center	Retake scan or manually correct
Motion Artifact	Retake Scan
Blink Artifact	Retake Scan

Questions?

New and Coming Attractions

- OCT Angiography
- Swept Source OCT

OCT-Angiography



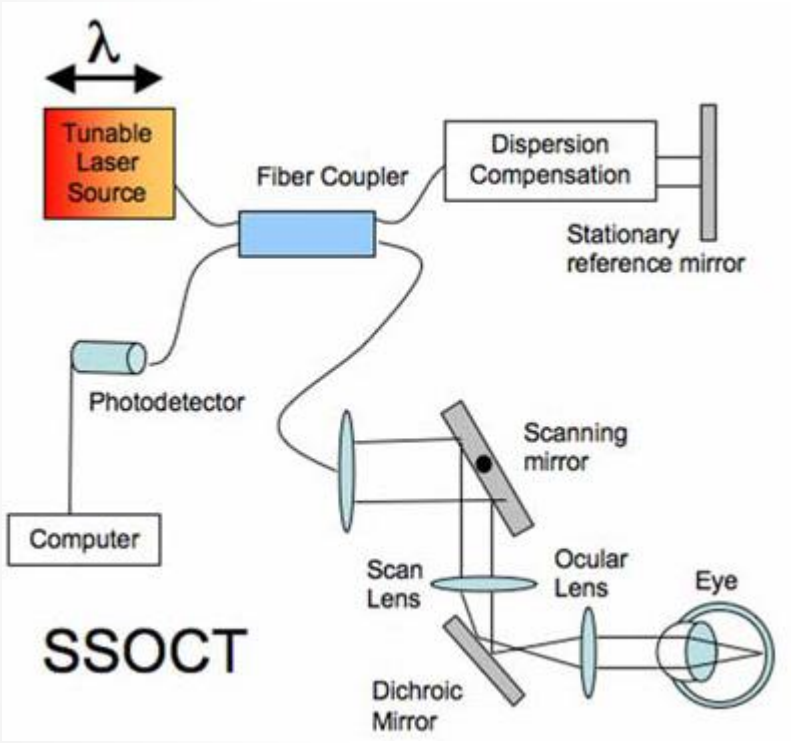
Chen et al, 2015

Uses available Fourier-domain OCTs

Subtraction of volumetric scans at different time points

Advantages over FA and ICG angiography:
- No dye / non-invasive
- 3 dimensional (volumetric) scan
- Faster

Swept-Source OCT



Schuman, 2008

Tunable laser source allows use of single photodetector rather than CCD array

→ ~500x faster than TD-OCT
→ 5-13x faster than SD-OCT

= even less motion artifact
= greater scan density
= greater transverse resolution for visualizing axons, blood vessels, even individual retinal cells

References

- Shuman JS. Spectral domain optical coherence tomography for glaucoma (An AOS thesis). Trans Am Ophthalmol Soc 2008; 106:426-458.
- Fujimoto JG, Pitris C, Boppart SA, Brezinski ME. Optical coherence tomography: an emerging technology for biomedical imaging and optical biopsy. Neoplasia 2000; 2:9-25.
- Chen CL, Zhang Q, Zhang A, and Wang RK. Optical Coherence Tomography/Ophthalmology: OCT angiography: A new approach with 'gold standard' capabilities and more. BioOptics World 2015.
- Adhi M, Duker JS. Optical Coherence tomography – current and future applications. Curr Opin Ophthalmol. 2013 May;24(3):213-21