OCT in Neuro-ophthalmology

Lugano, CH
27-FEB-2025, 18:00-18:20
axel petzold

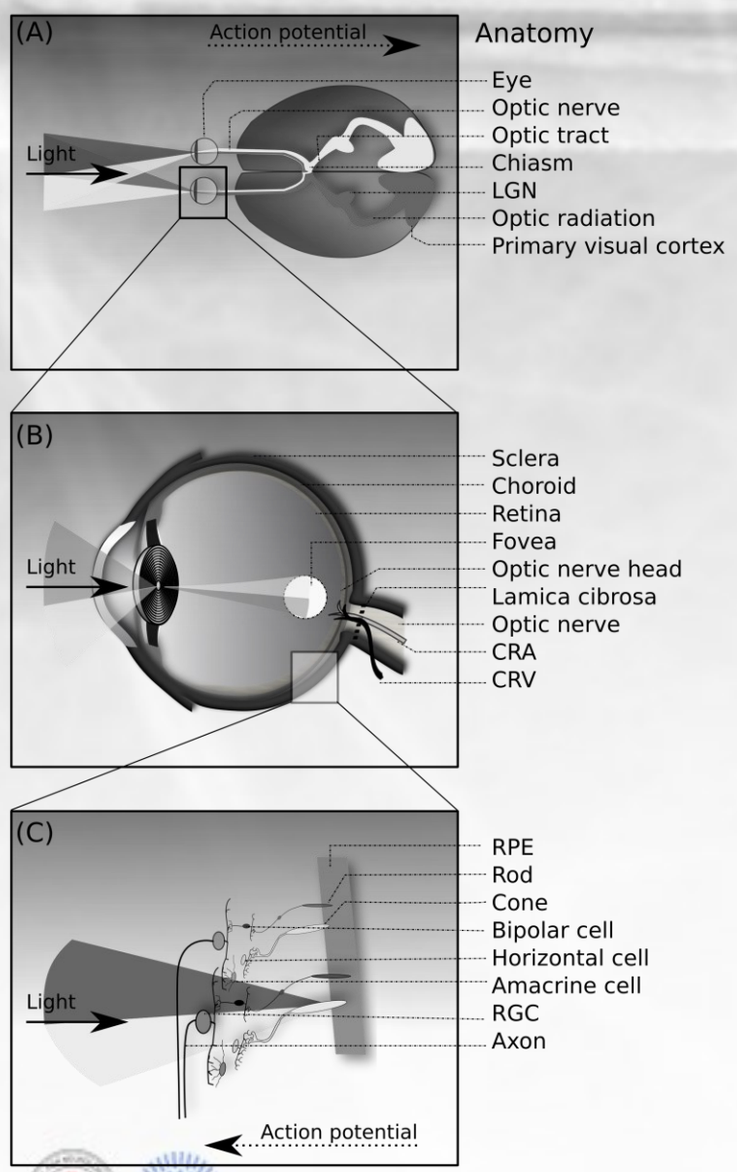
Disclosures

NIHR UK

Overview

- Background
- OCT, OCTA & adaptive optics
- Three red lines for OCT
- Retinal asymmetry
- Conclusion

The eye as a window to the brain



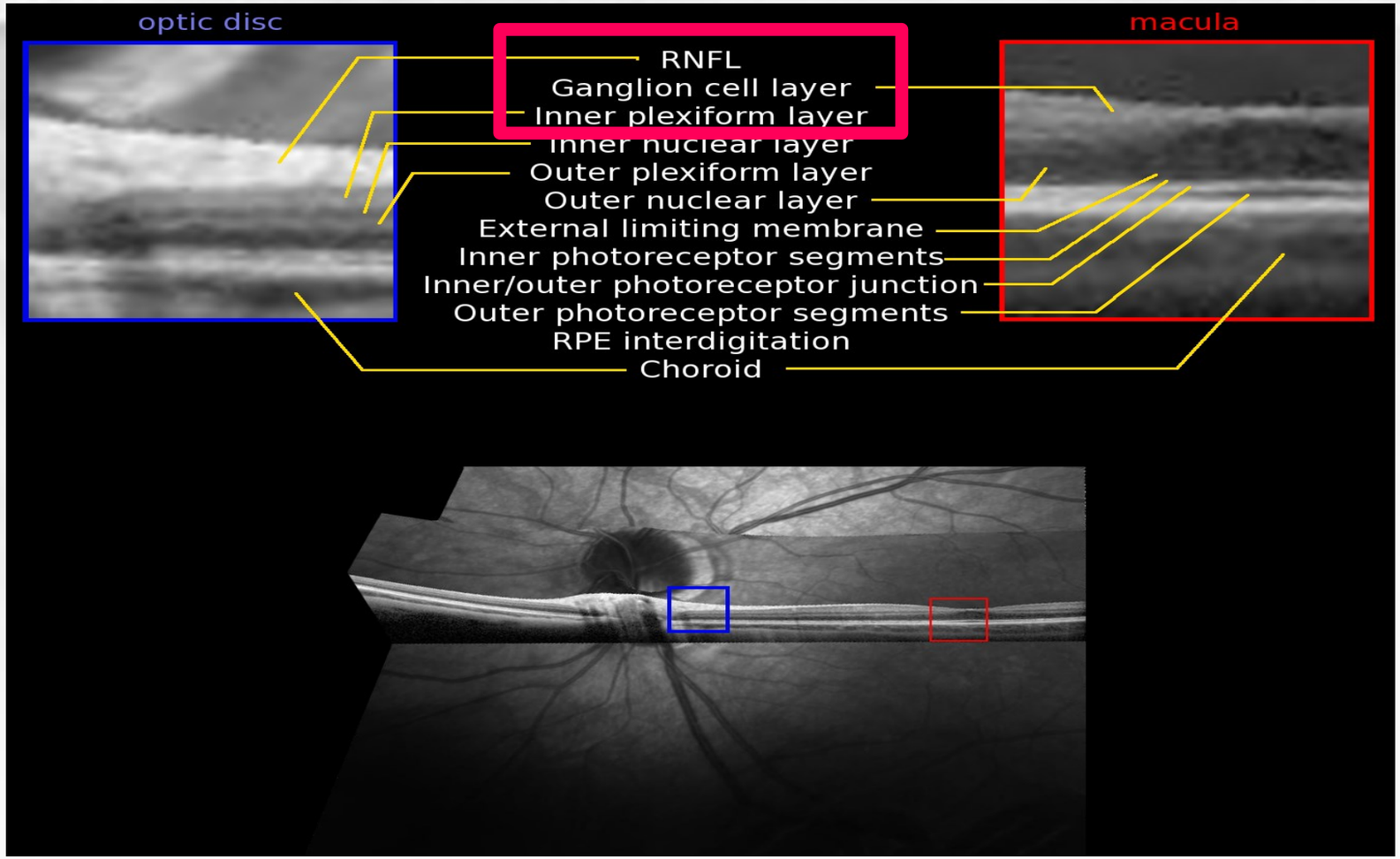
(A) The big picture:
Eye & Brain

(B) Opening the window:
Optic disc & retina

(C) Gazing through the window:
Cellular level

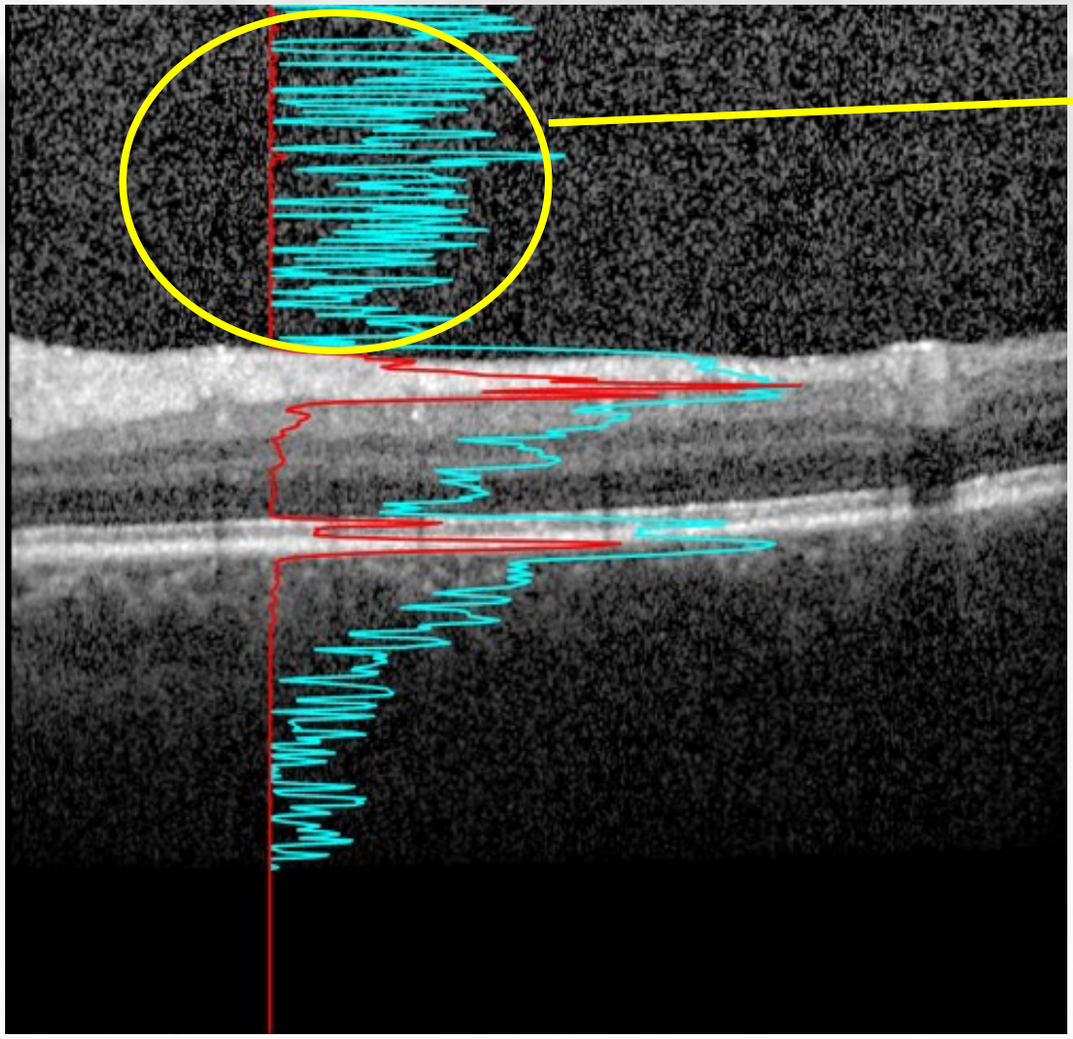
Petzold *et al.* Handbook of Neurology 2016

OCT



Petzold *et al.* TLN 2010

Anything else from OCT ?



What about this signal?

Useful in uveitis

ORIGINAL ARTICLE

Objective quantification of vitreous haze on optical coherence tomography scans: no evidence for relationship between uveitis and inflammation in multiple sclerosis

D. Coric[a,b], G. Ometto[c], G. Montesano[c,d], P. A. Keane[d], L. J. Balk[a,b], B. M. J. Uitdehaag[a], A. Petzold[a,b,e,f], D. P. Crabb[c] and A. K. Denniston[d,g,h]

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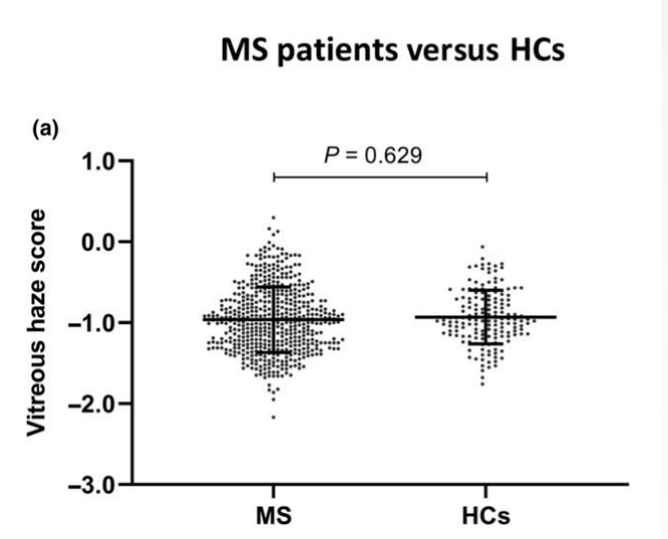
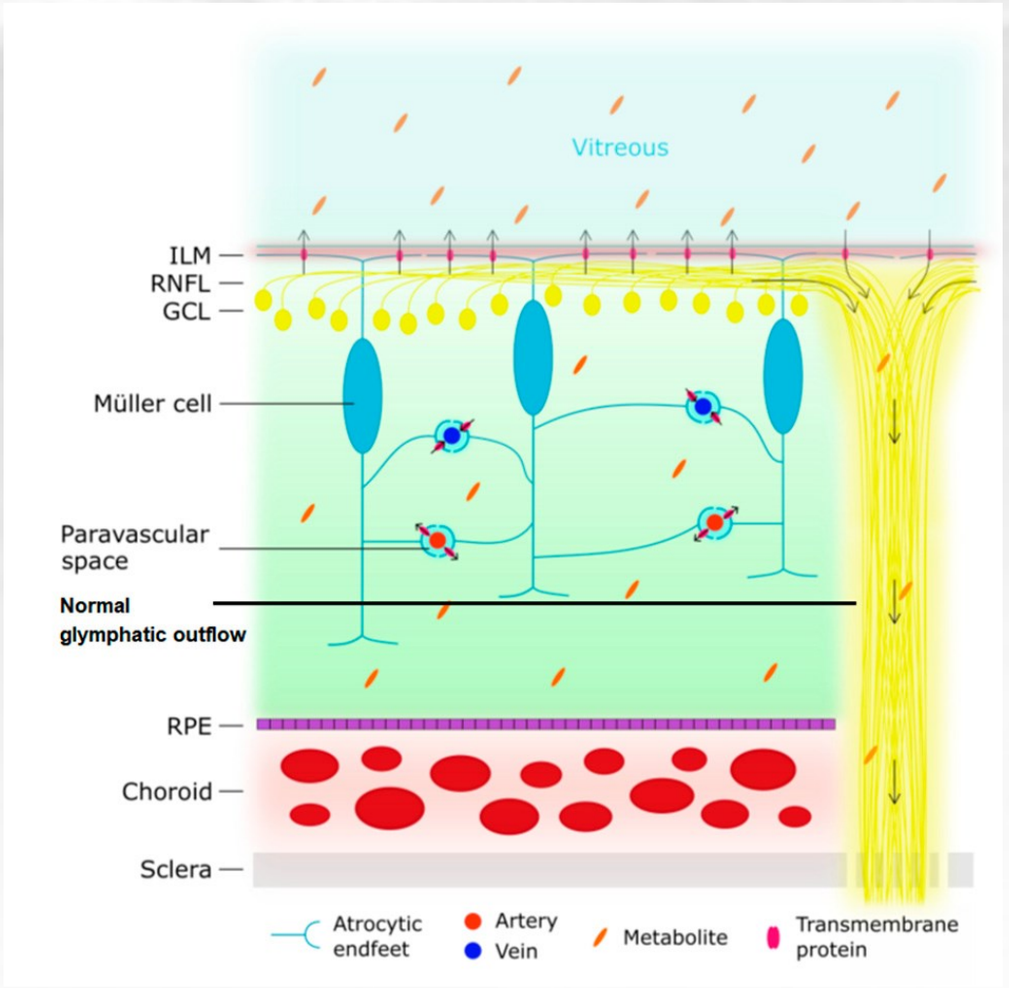
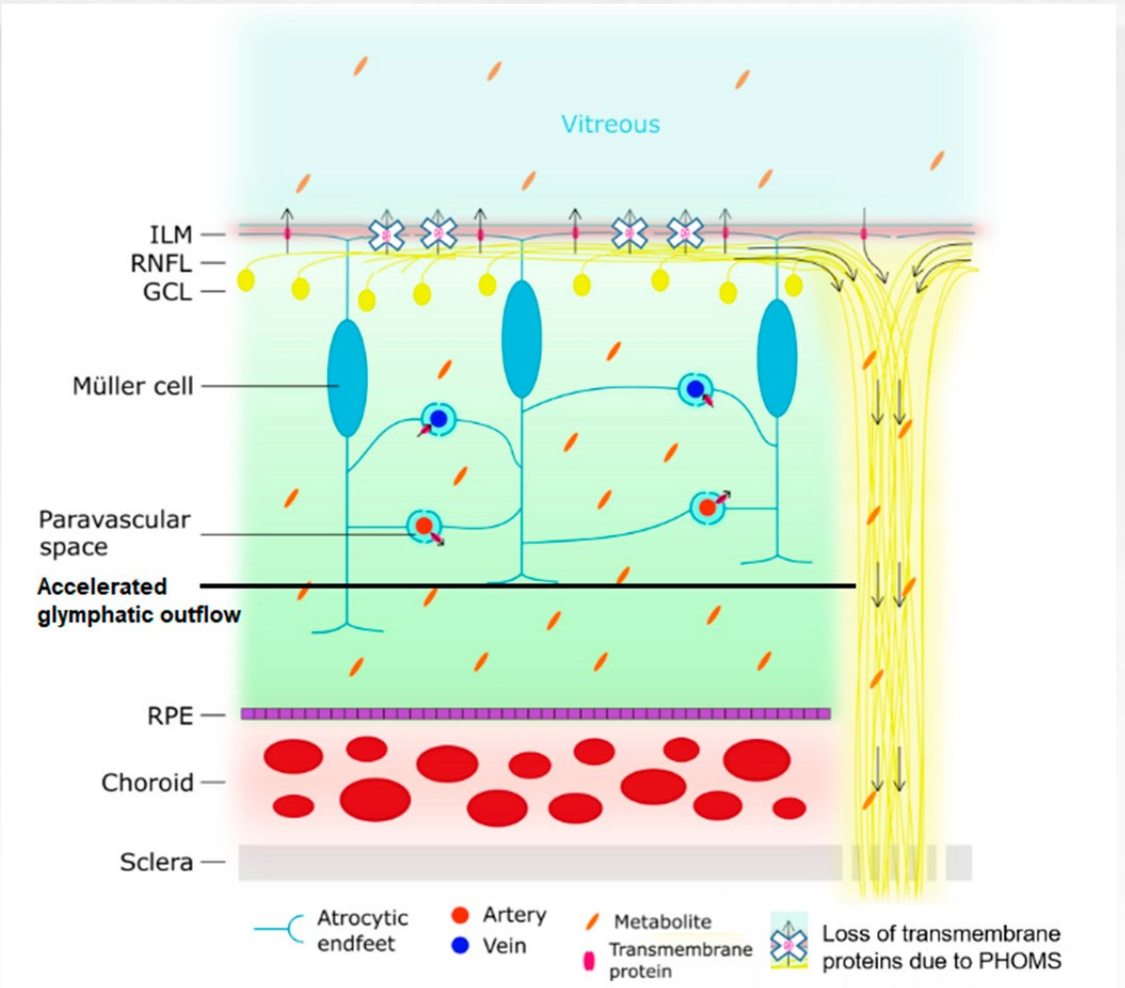
	MS patients $N = 290$	HCs $N = 85$	P value
Age (years), mean (±SD)	51.5 (±10.1)	49.3 (±8.2)	0.039
Sex (female:male)	195:95	53:32	0.402
Disease duration (years), mean (±SD)	17.9 (±7.0)	N/a	
Type of MS			
RRMS	200 (69.0%)	N/a	
SPMS	59 (20.3%)		
PPMS	31 (10.7%)		
EDSS, median [range]	3.5 [0–8.0]	N/a	
History of MSON			
No MSON	157 (54.1%)	N/a	
Unilateral MSON	81 (27.9%)		
Bilateral MSON	39 (13.4%)		
Unknown	13 (4.5%)		
Use of disease modifying therapy			
Current	93 (32.1%)	N/a	
Past	58 (20.0%)		
Never	139 (47.9%)		
Relapses in year prior to assessment			
Yes	34 (11.7%)	N/a	
No	256 (88.3%)		
mGCIPL thickness (μm), mean (±SD)	77.5 (±14.3)	92.2 (±6.0)	<0.001[a]
pRNFL thickness (μm), mean (±SD)	84.6 (±14.4)	95.1 (±7.9)	<0.001[a]
INL thickness (μm), mean (±SD)	40.4 (±3.3)	39.4 (±2.9)	0.003[a]
Vitreous haze score, mean (±SD)	−0.96 (±0.41)	−0.93 (±0.33)	0.629[a]

Only 6 patients (2.1%) had higher VC values than HC, suggesting uveitis.



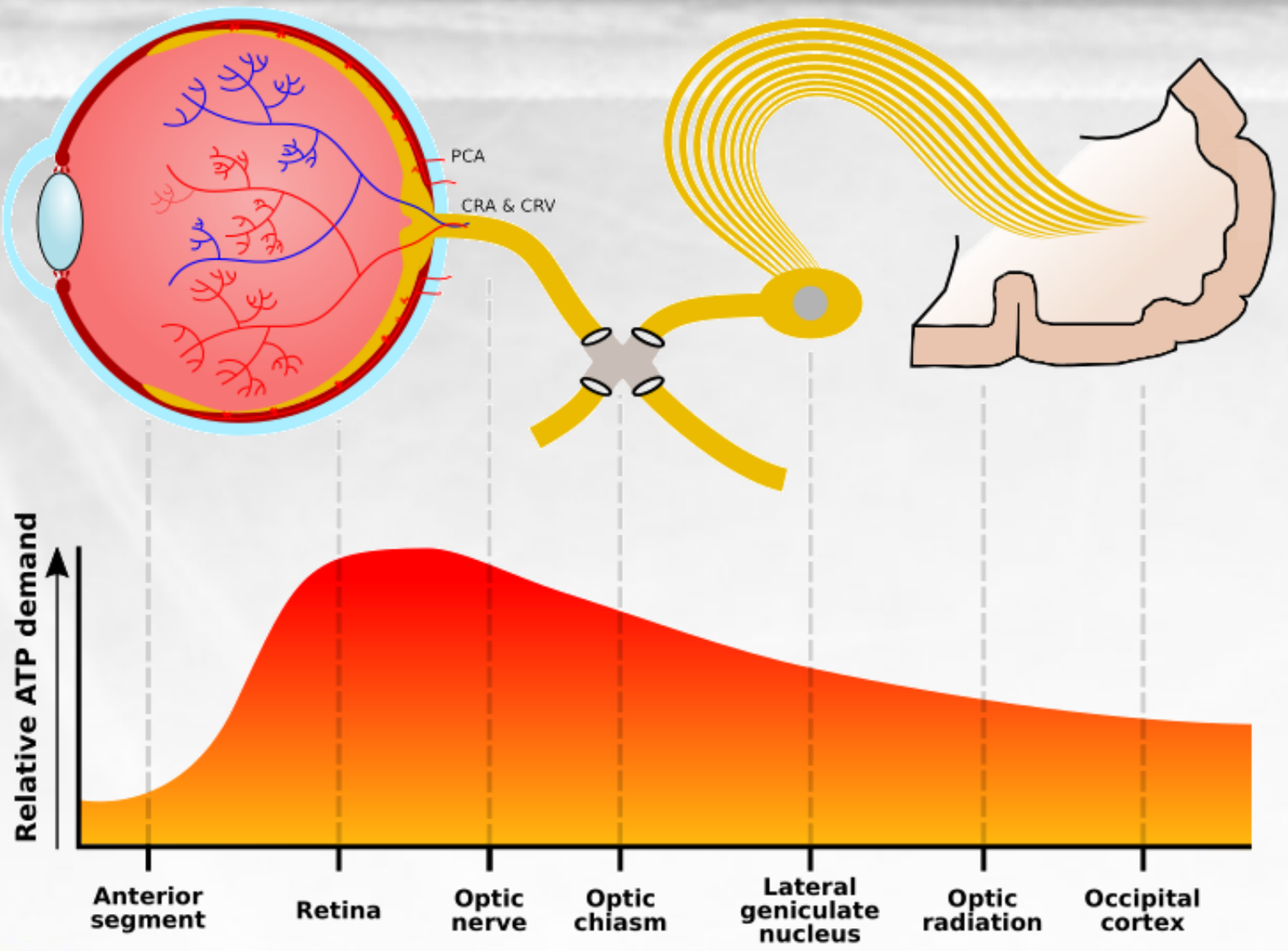
Retinal glymphatic system





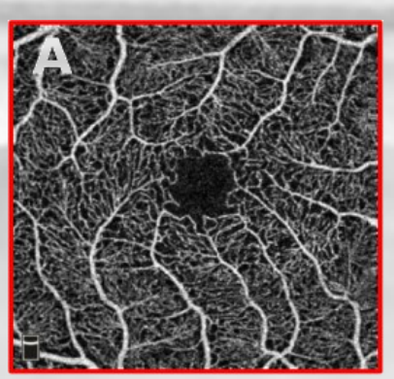
Kacar, S *et al* Brain Sci 2023

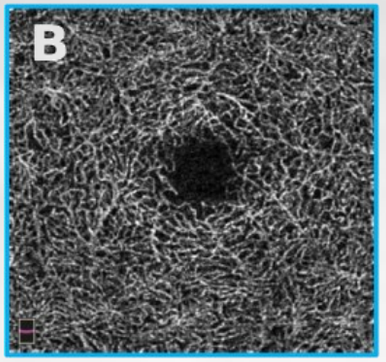
From eye to brain: energy

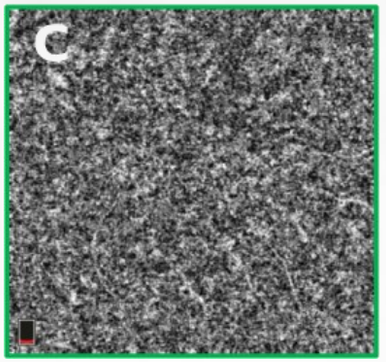


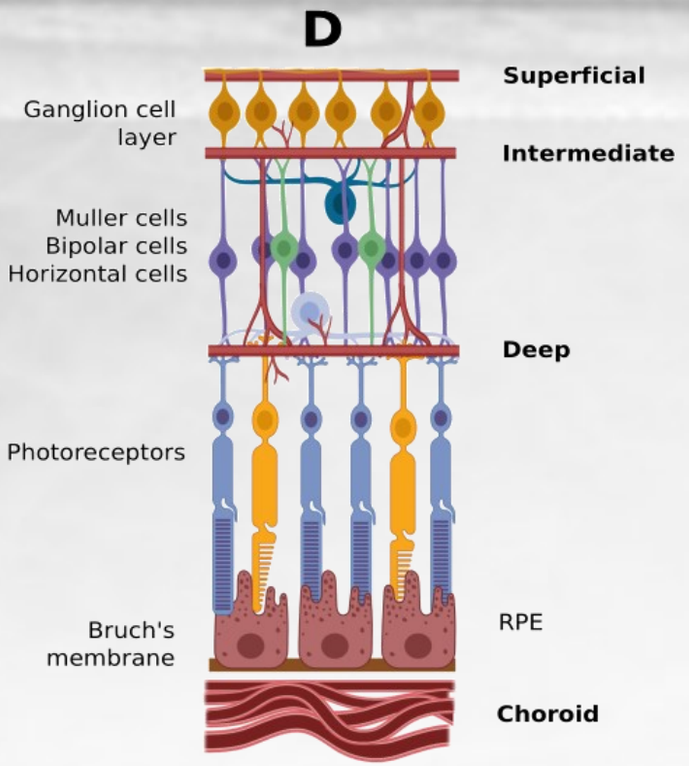
Kleerekooper, I *et al.* BRAIN 2020

In vivo “histology”



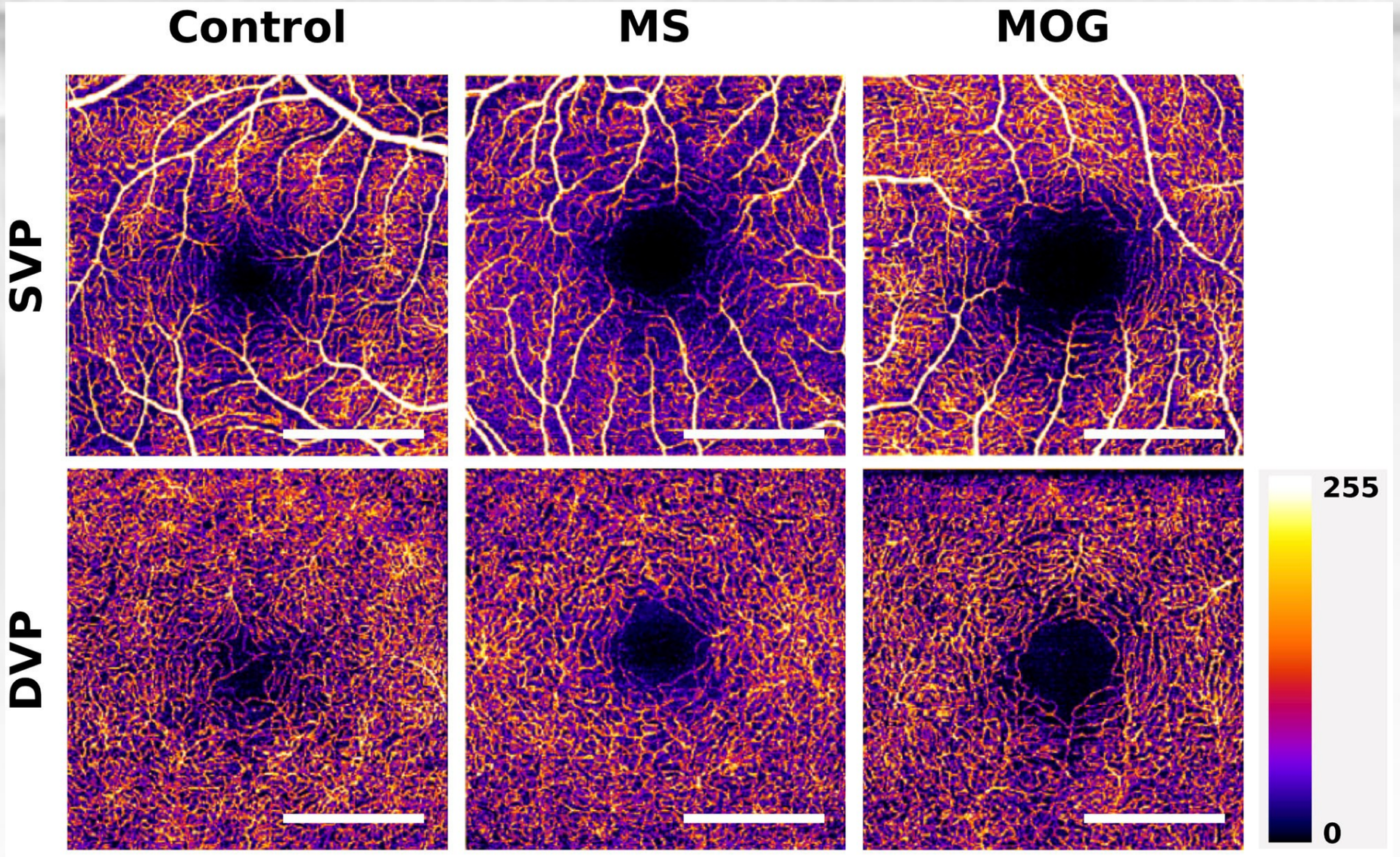






Kleerekooper et al. Front Neurol 2020

Foveal Avascular Zone (FAZ)



Kleerekooper et al. Front Neurol 2020

The OSCAR-MP Consensus Criteria for Quality Assessment of Retinal Optical Coherence Tomography Angiography

Rebecca Wicklein, MD, Charmaine Yam, MD, Christina Noll, MD, Lilian Aly, MD, Nicolas Banze, Eva Feodora Romahn, Elisabeth Wolf, Bernhard Hemmer, MD, Frederike C. Oertel, MD, PhD, Hanna Zimmermann, PhD, Philipp Albrecht, MD, Marius Ringelstein, MD, Carmen Baumann, MD, Nikolaus Feucht, MD, Josef Penkava, MD, Joachim Havla, MD, Jonathan A. Gernert, MD, Christian Mardin, MD, FEBO, Eleni S. Vasileiou, MD, Anneke Van Der Walt, MBChB, PhD, Omar Al-Louzi, MD, Sergio Cabello, Angela Vidal-Jordana, MD, PhD, Julia Krämer, MD, Heinz Wiendl, MD, Jana Lizrova Preiningerova, MD, PhD, Olga Ciccarelli, MD, PhD, Elena Garcia-Martin, MD, PhD, Veronika Kana, MD, Peter A. Calabresi, MD, Friedemann Paul, MD, Shiv Saidha, MBBCh, MD, Axel Petzold, MD, PhD, Ahmed T. Toosy, MD, PhD, FRCP, Benjamin Knier, MD, on behalf of IMSVISUAL Consortium

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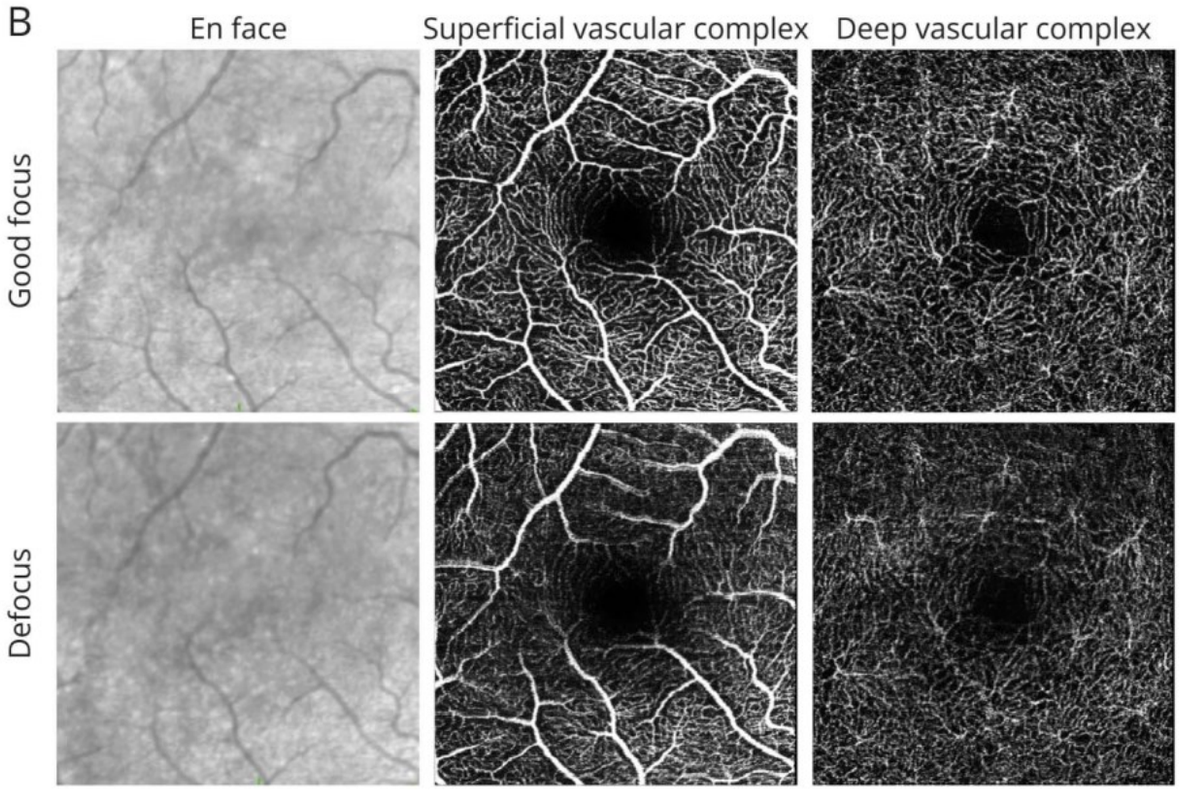
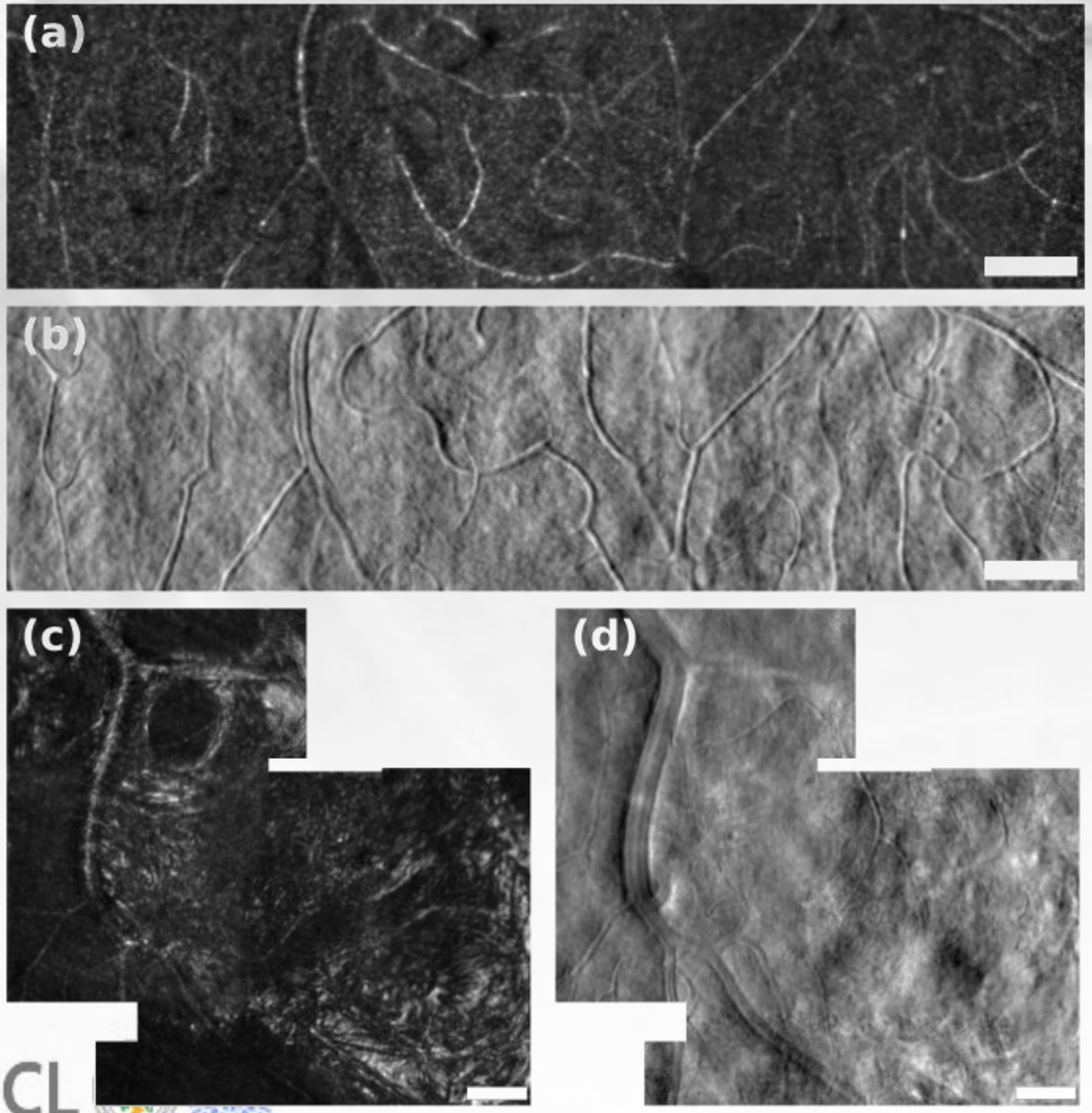
Neurol Neuroimmunol Neuroinflamm 2023;10:e200169. doi:10.1212/NXI.0000000000200169

Table 1 The OSCAR-MP QC Criteria for Retinal OCTA Scans

O	Obvious problems not covered by the items below Focus, defocus, beam placement, illumination, opacities, shadowing
S	Signal strength Consider device-specific thresholds for signal strength
C	Centration Evaluate correct placement of the scanning area depending on the region of interest
A	Algorithm failure Evaluate accurate segmentation of the different vessel plexus
R	Retinal pathology Check the presence of any retinal pathology and evaluate whether it impairs the analysis of the retinal vasculature
M	Motion artifacts Evaluate different types of motion artifacts and estimate the affected proportion of the image
P	Projection artifacts Search for projection artifacts of superficial vessels into deeper layers



The capillaries



Kleerekooper et al. Front Neurol 2020

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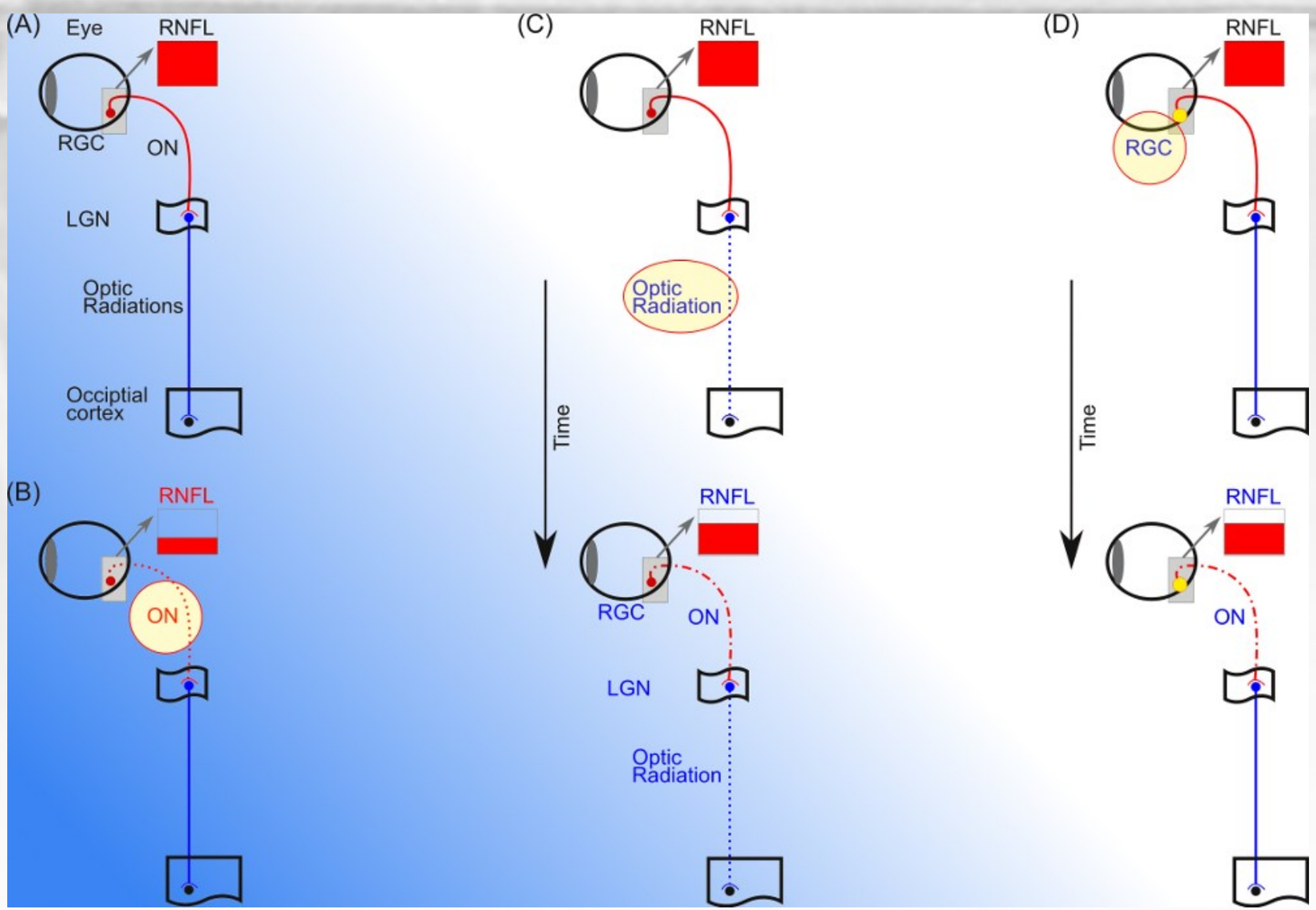
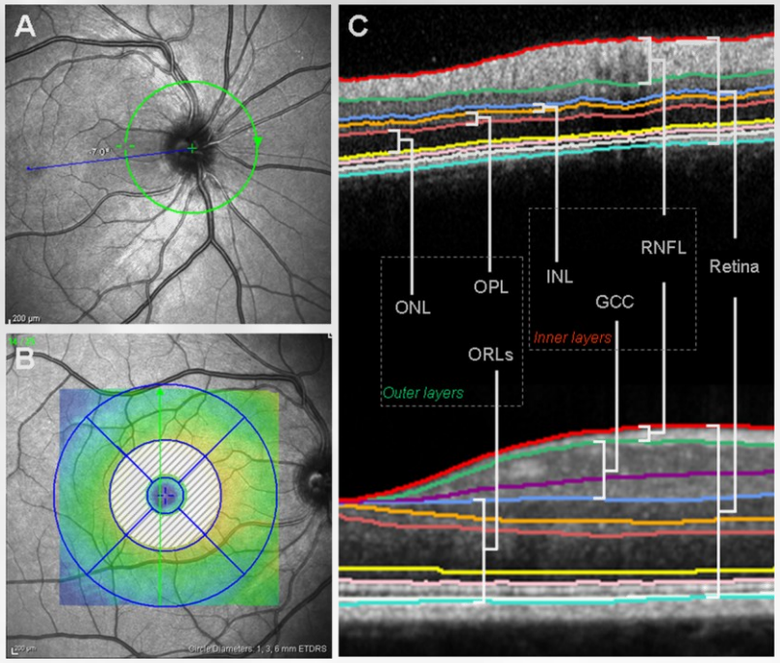
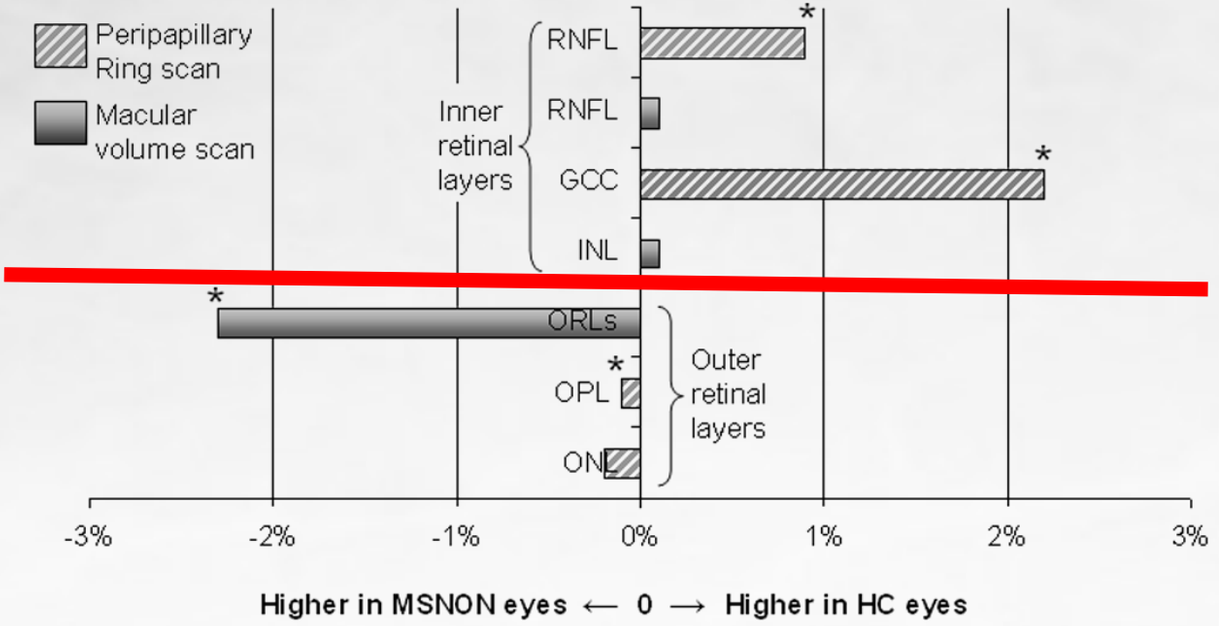
Trans-synaptic retrograde axonal degeneration



Petzold *et al.* TLN 2010

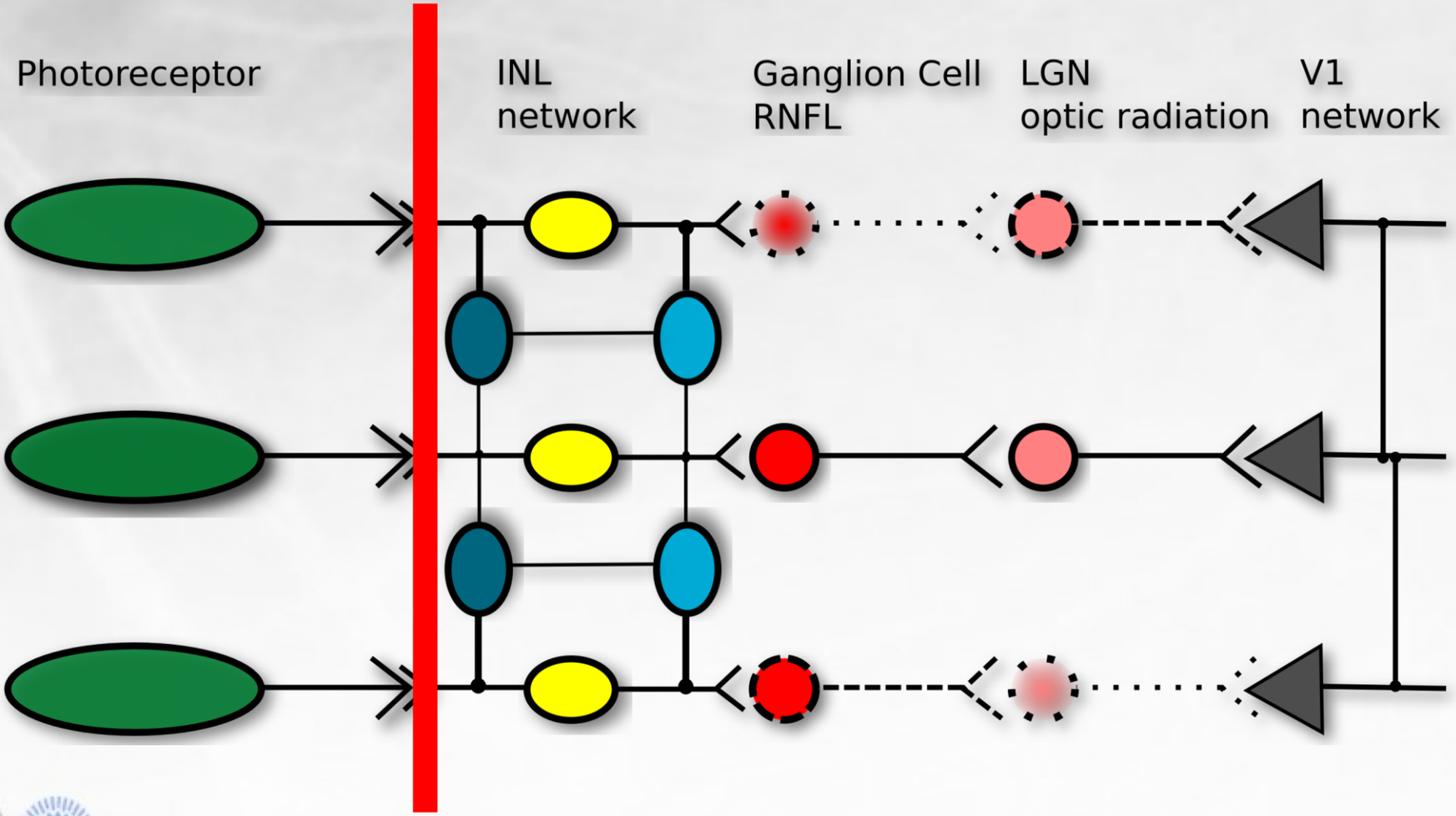
1st "red line" for pathology in the eye





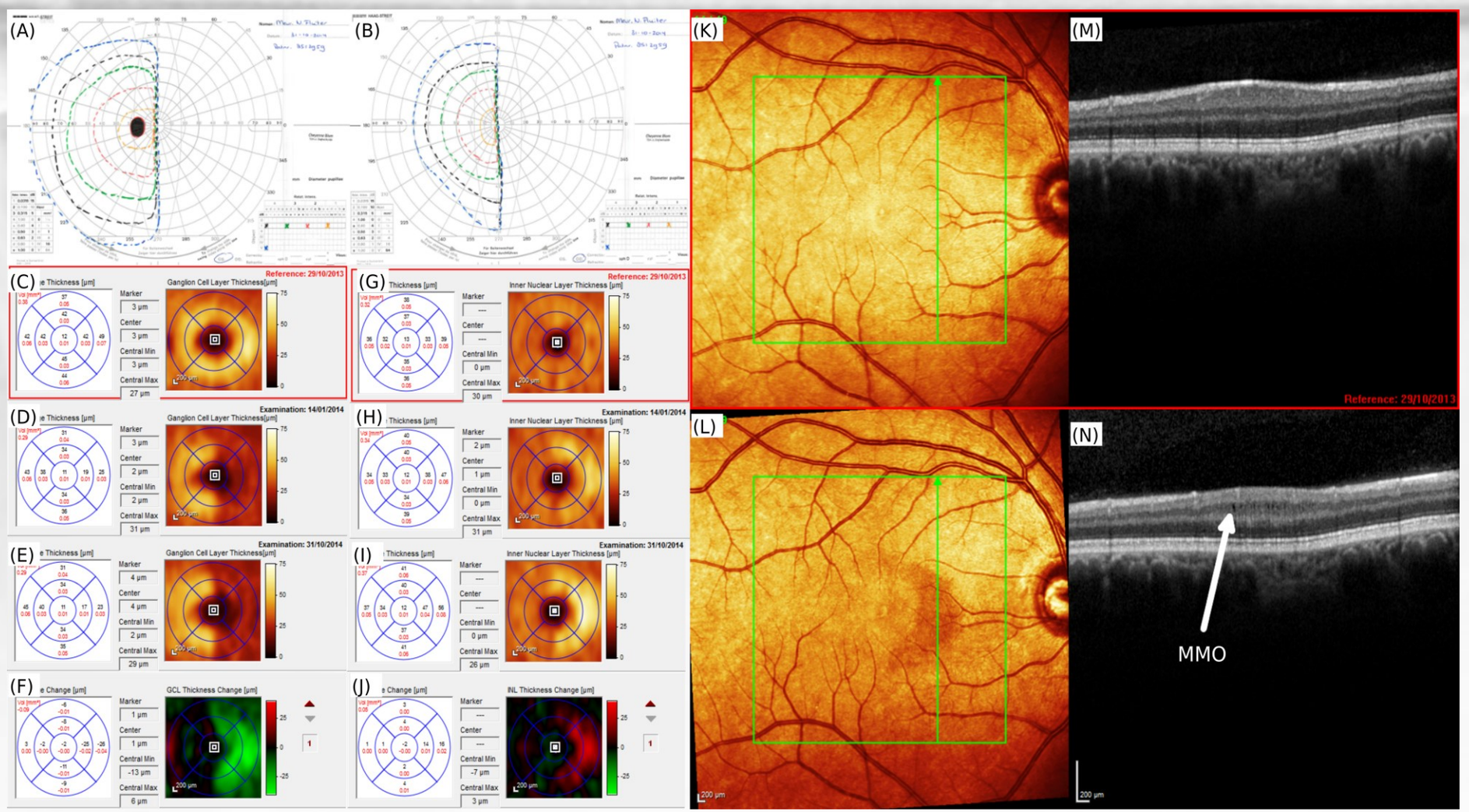
L. Balk *et al.* JNNP 2014

“Red line” means “stop” for neurodegeneration



L. Balk *et al.* JNNP 2014

Development of hemianopia

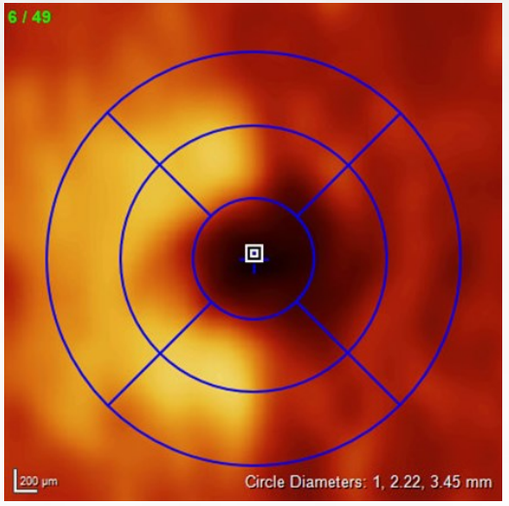


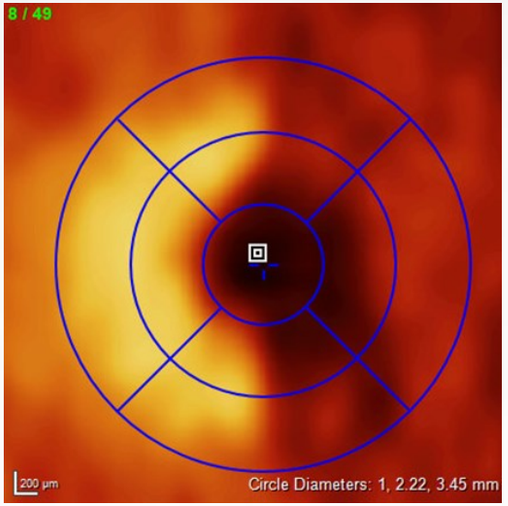
Vries-Knoppert *et al.* Brain 2019

Half moon sign

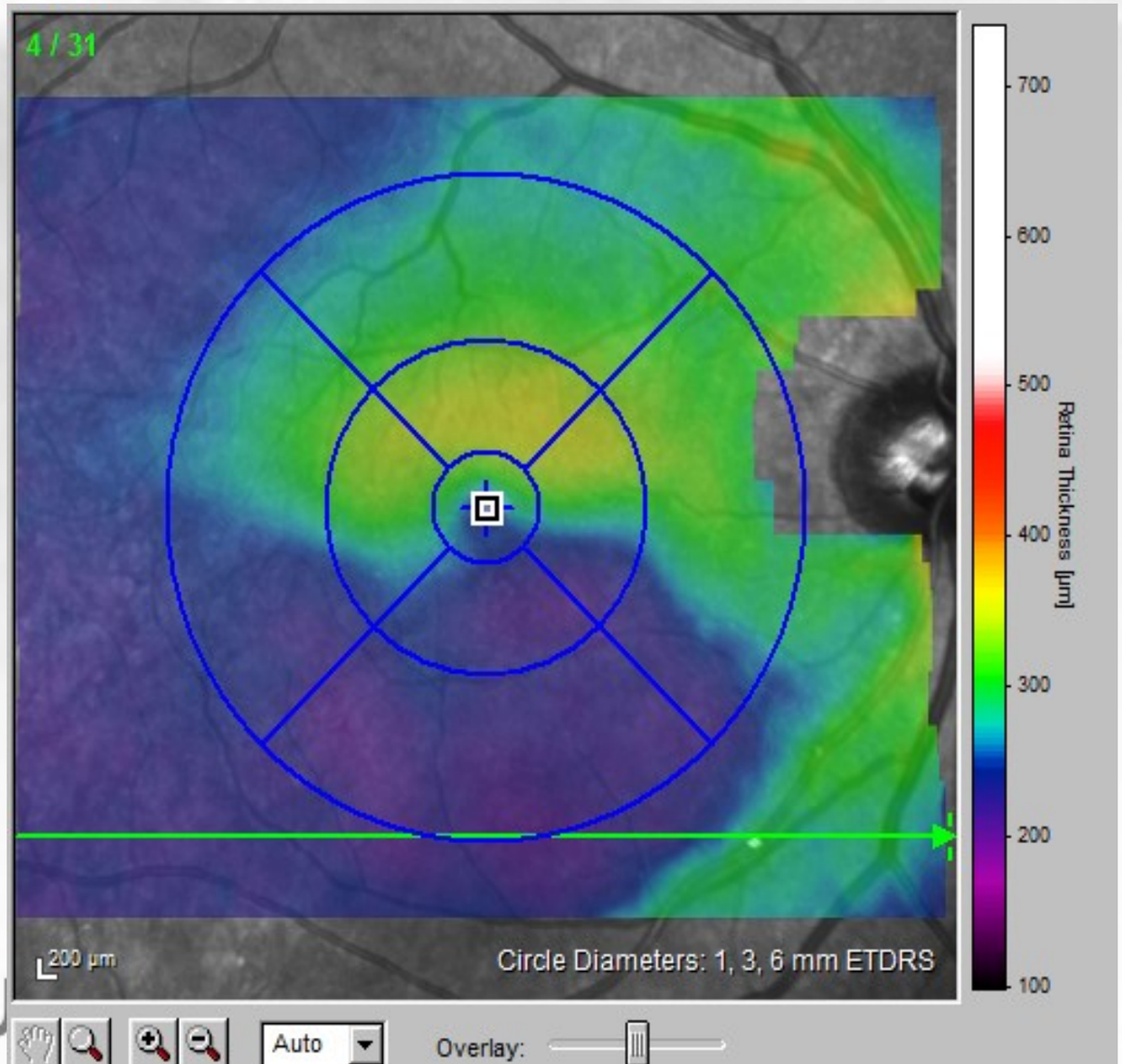
RE

LE





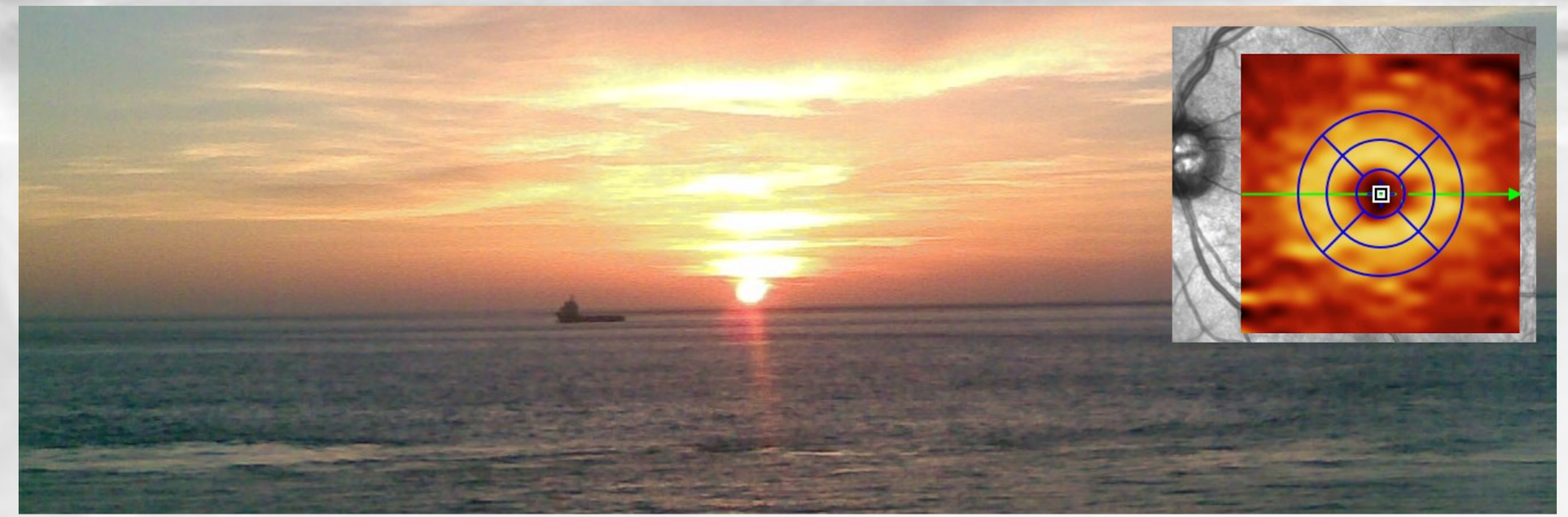
3rd “red line” for OCT pathology in the eye



In NAION, INL preserved

With CRA / BRA occlusion INL atrophied

Sunset Sign

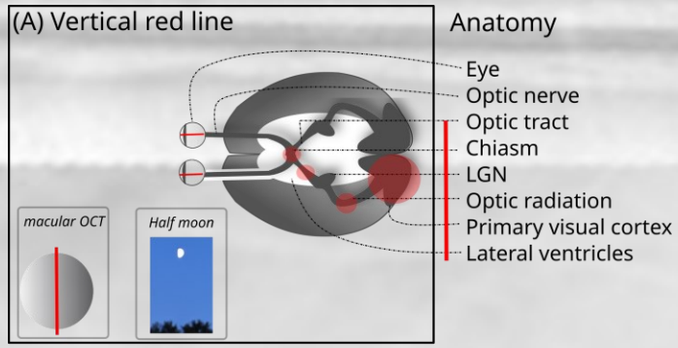


Think of NAION, BRAO
(amongst other things)

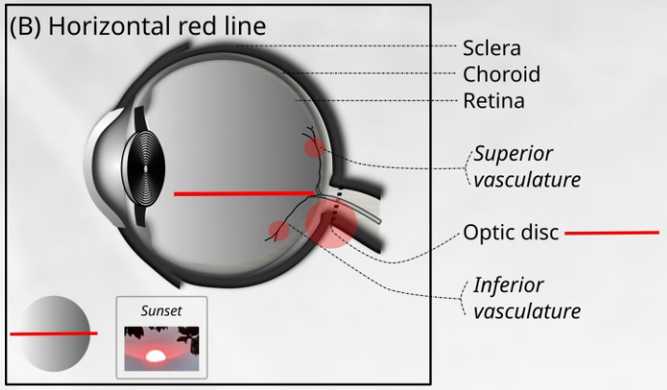
3 red lines summary

Red lines	Retina	Differential diagnosis
1. vertical	Macular “half moon”	Retrochiasmal lesions, brain surgery, stroke, Foster-Kennedy
2. horizontal	Macular “sunset”	(N)AION, Glaucoma, pathology at disc
3. Front-back	Above INL	ON, MS, AD, (N)AION, Glaucoma, IIH.
	Involves INL	BRAO, PAMM

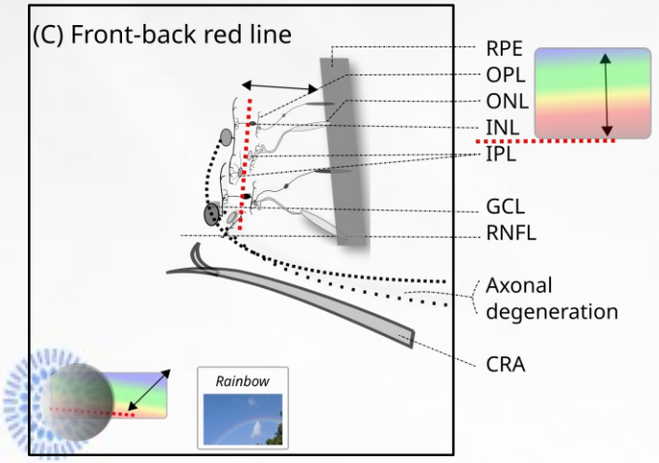
Three red lines for OCT in Neuro-ophthalmology



(A) Brain lesions cause ‘vertical’ asymmetry



(B) Optic disc pathology causes ‘altitudinal’ defects



(C) Retrograde axonal degeneration stops at the INL

Petzold JNO 2021

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Retinal Asymmetry

Retinal Asymmetry	Cutoff	OCT Device	Reference	Study group	Specificity	Sensitivity
mGCIPL pRNFL	6% 9%	Heidelberg	Coric *et al.* 2017	Unilateral MS-ON vs. HC	97	70
mGCIPL pRNFL	4.0µm 5.0µm	Heidelberg	Nolan-Kenney *et al.* 2019	Unilateral MS-ON vs. nonMSON	77 65	68 71
mGCIPL pRNFL	3.7µm 6.0µm	Zeiss			n/a n/a	n/a n/a
mGCIPL	3.5µm	Heidelberg	Behbehani *et al.* 2020	Unilateral ON vs. HC	98	100
mGCIPL	2.83µm	Heidelberg	Davion *et al.* 2020	Uni- or bilateral MS-ON vs. nonMSON	67	67
mGCIPL	4% / 4µm	Topcon	Petzold *et al.* 2020	nonMSON vs controls	83 / 87	52 / 44
mGCIPL	1.42µm 2%	Heidelberg	Outteryck *et al.* 2020	CIS patients with vs. without 3D-DIR MRI ON lesion	73 70	89 89
mGCIPL	4% / 4µm	Heidelberg	Oertel *et al.* 2023	AQP4-ON vs controls	96 / 98	82 / 75
mGCIPL	**4% / 4µm**	**Heidelberg**	**Volpe *et al.* 2024**	**MOG-ON vs controls**	**82 / 82**	**>99 / >99**

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Conclusion

- OCT in Neuro-ophthalmology
  - Structure, pathways, compartments, vasculature
- Clinical practise: 3 red lines for OCT
- Retinal asymmetry: relevant for new MS criteria

Gracie