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Université
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HÔPITAL FONDATION
Adolphe de ROTHSCHILD
LA RÉFÉRENCE TÊTE ET COU

L'OCT de la Macula normale

Alain Gaudric

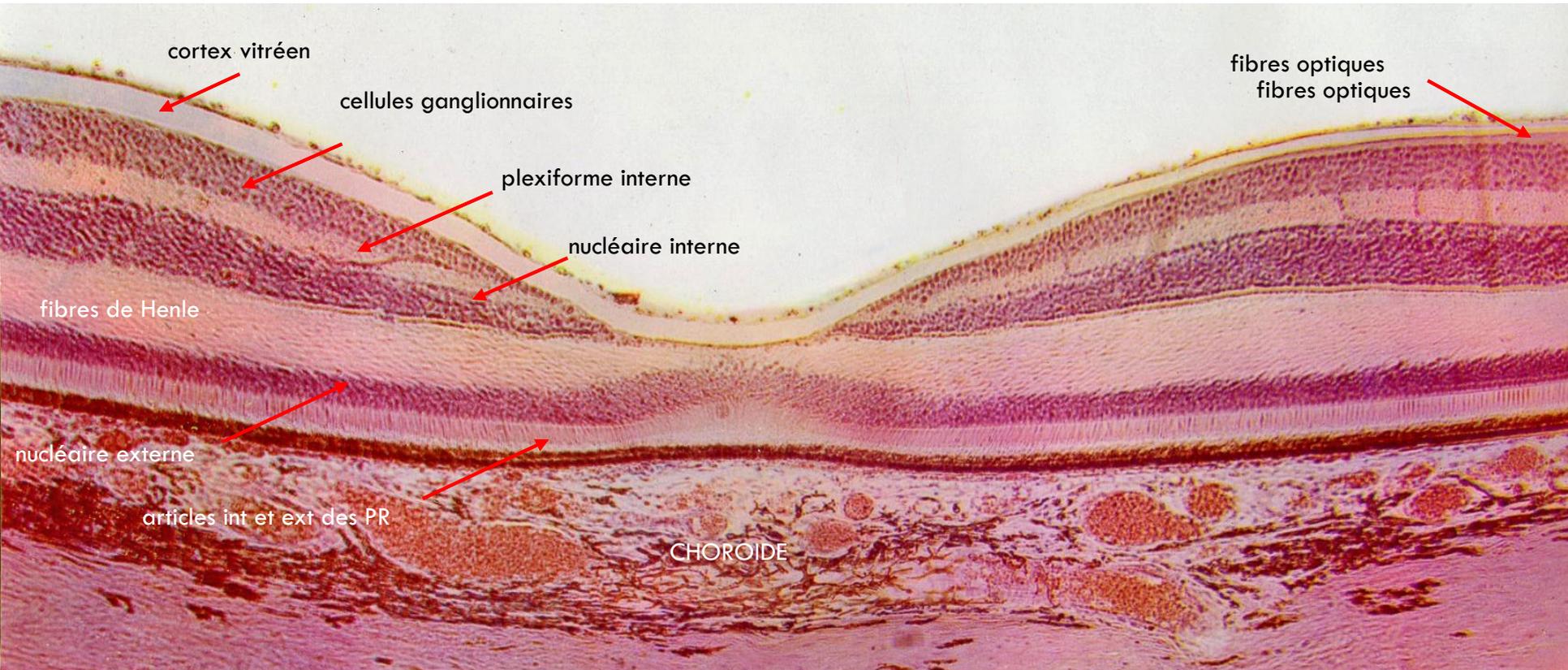


Service d'Ophtalmologie
Hôpital Lariboisière

Déclaration d'intérêts

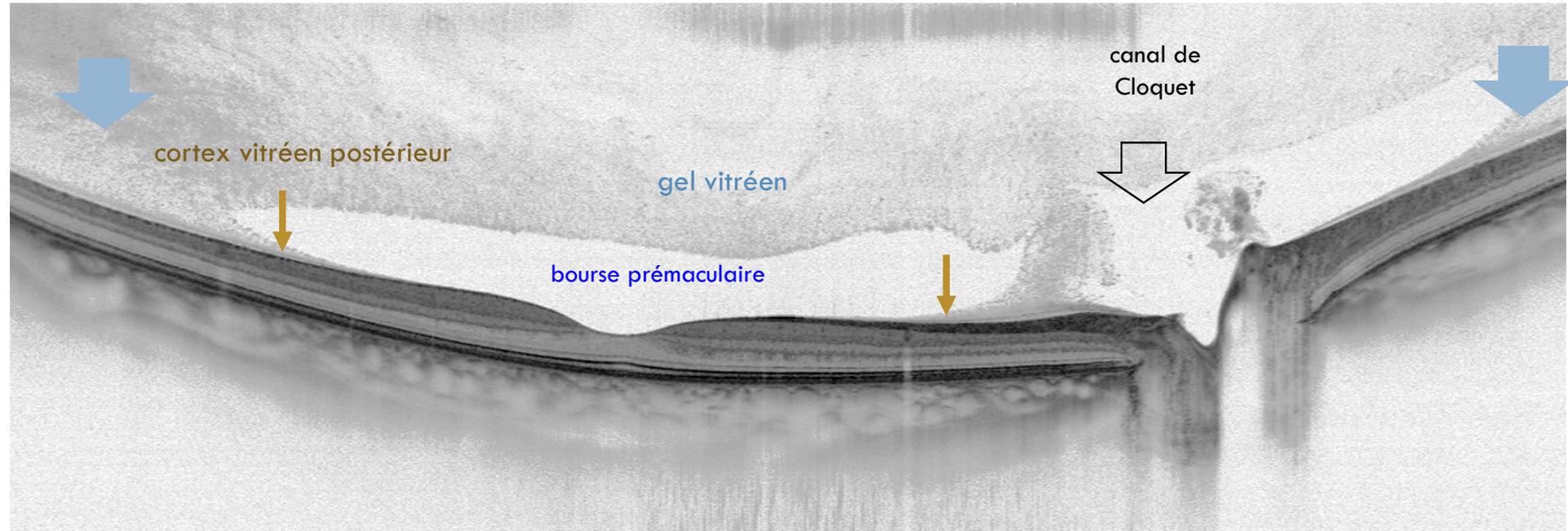
Aucun

La rétine en histologie

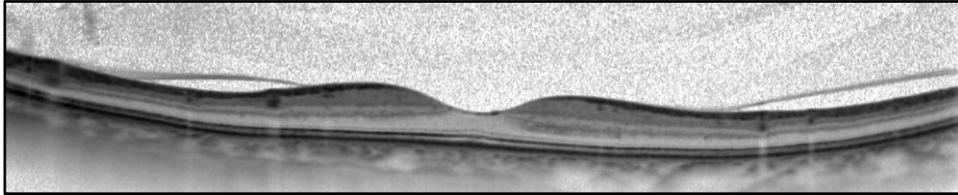


<http://collection-jmawas.fr>

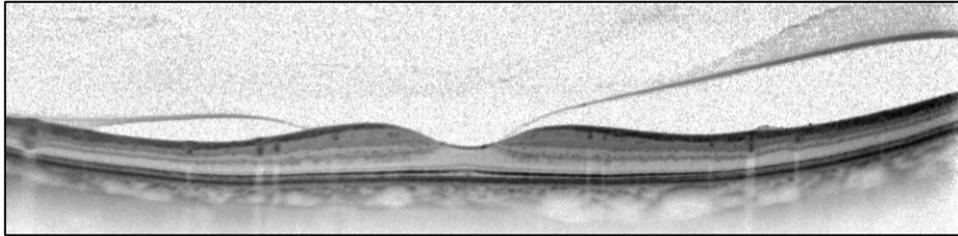
Le cortex vitréen postérieur normal



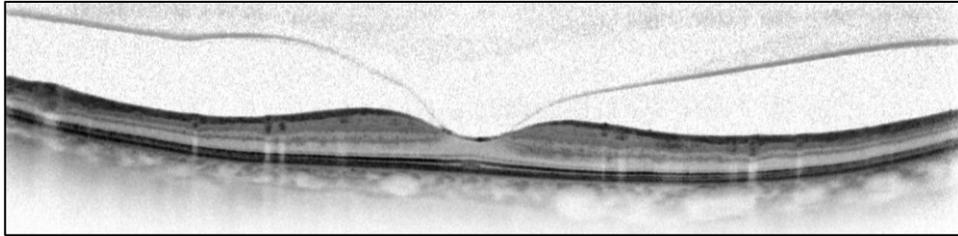
Le DPV normal



Adhésion Vitréo Maculaire

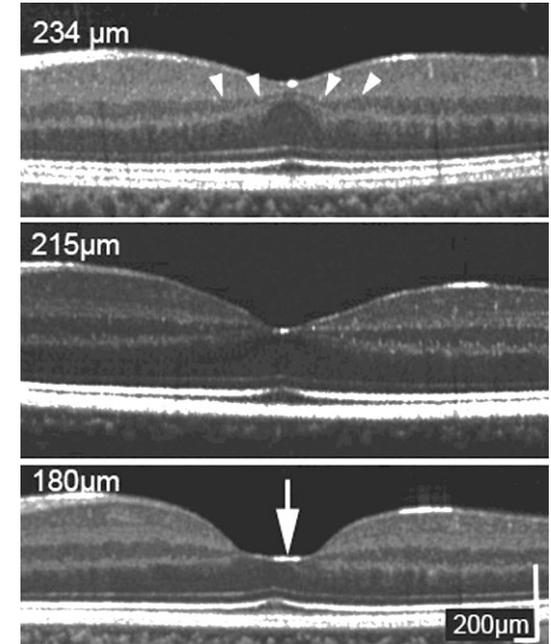
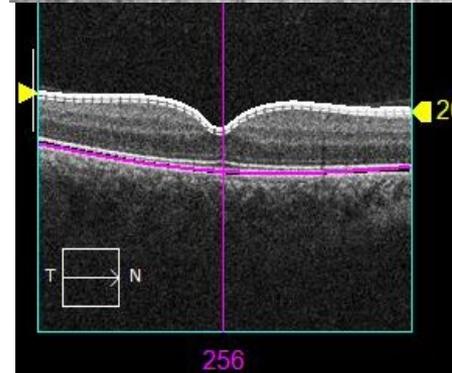
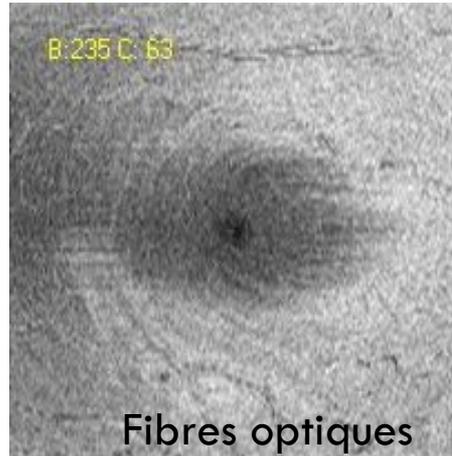
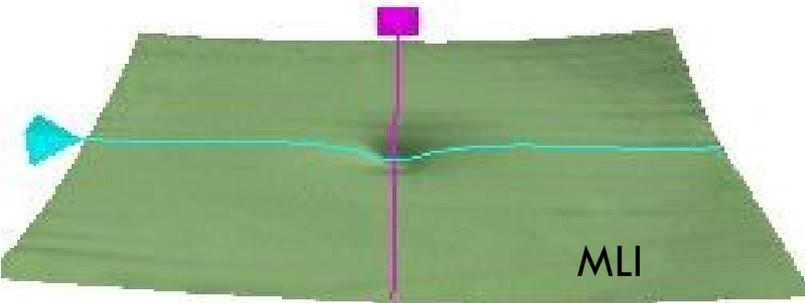
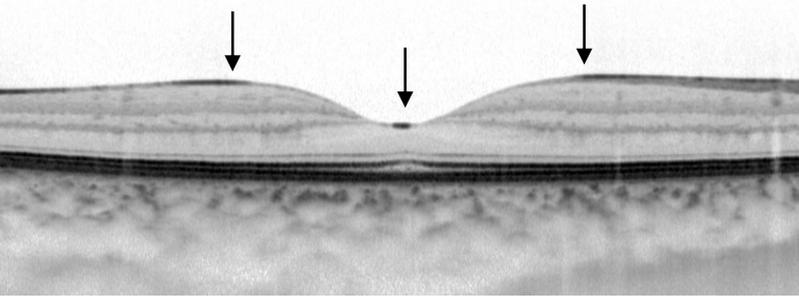


Décollement Vitréen Péri Fovéolaire



Décollement Postérieur du vitré

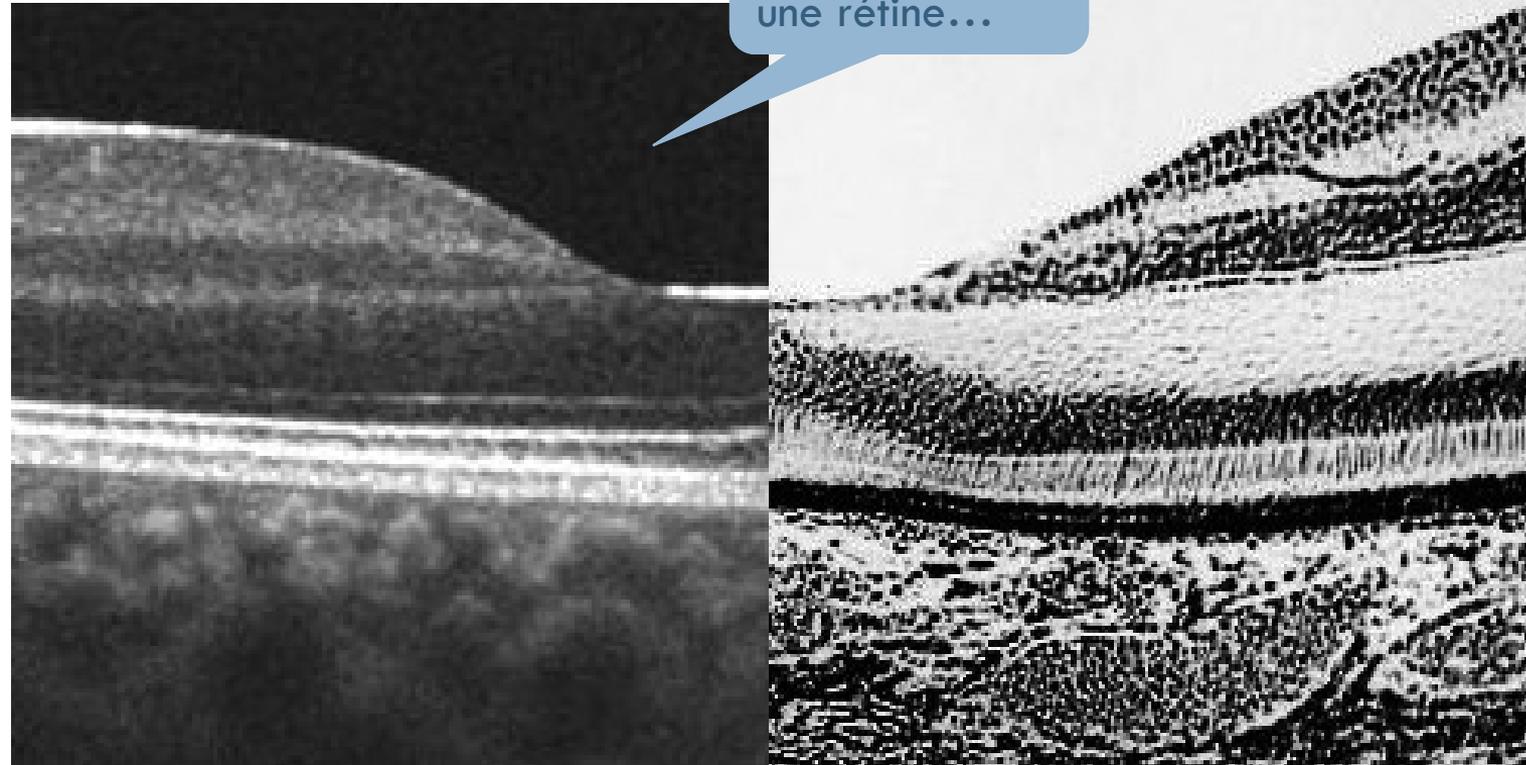
Profils et surface maculaires



Tick, S. & Paques, M. (2011). Foveal shape and structure in a normal population. IOVS, 52(8), 5105–5110

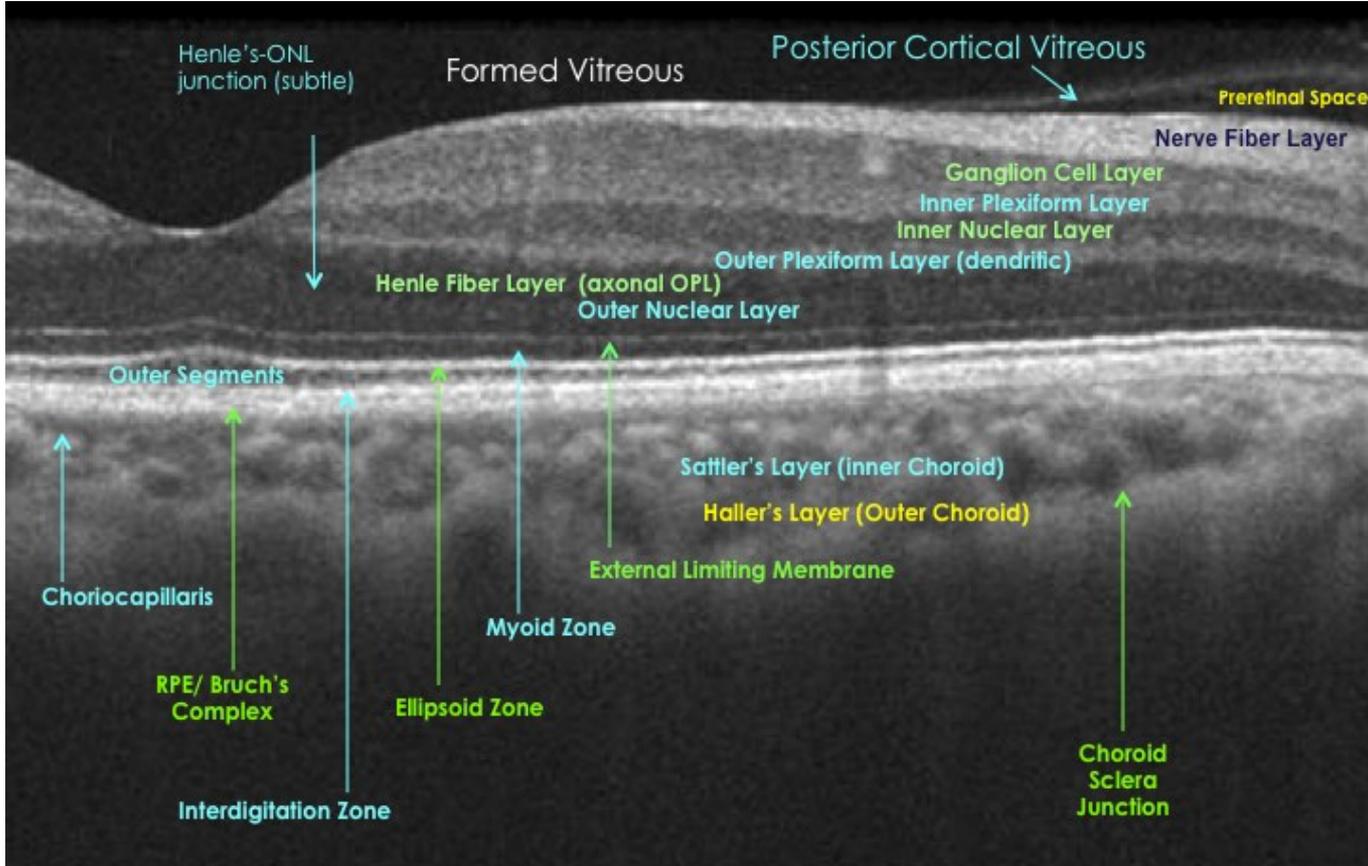
OCT et histologie

Ceci n'est pas
une rétine...



- L'OCT ressemble à l'histologie mais en diffère par de nombreux aspects

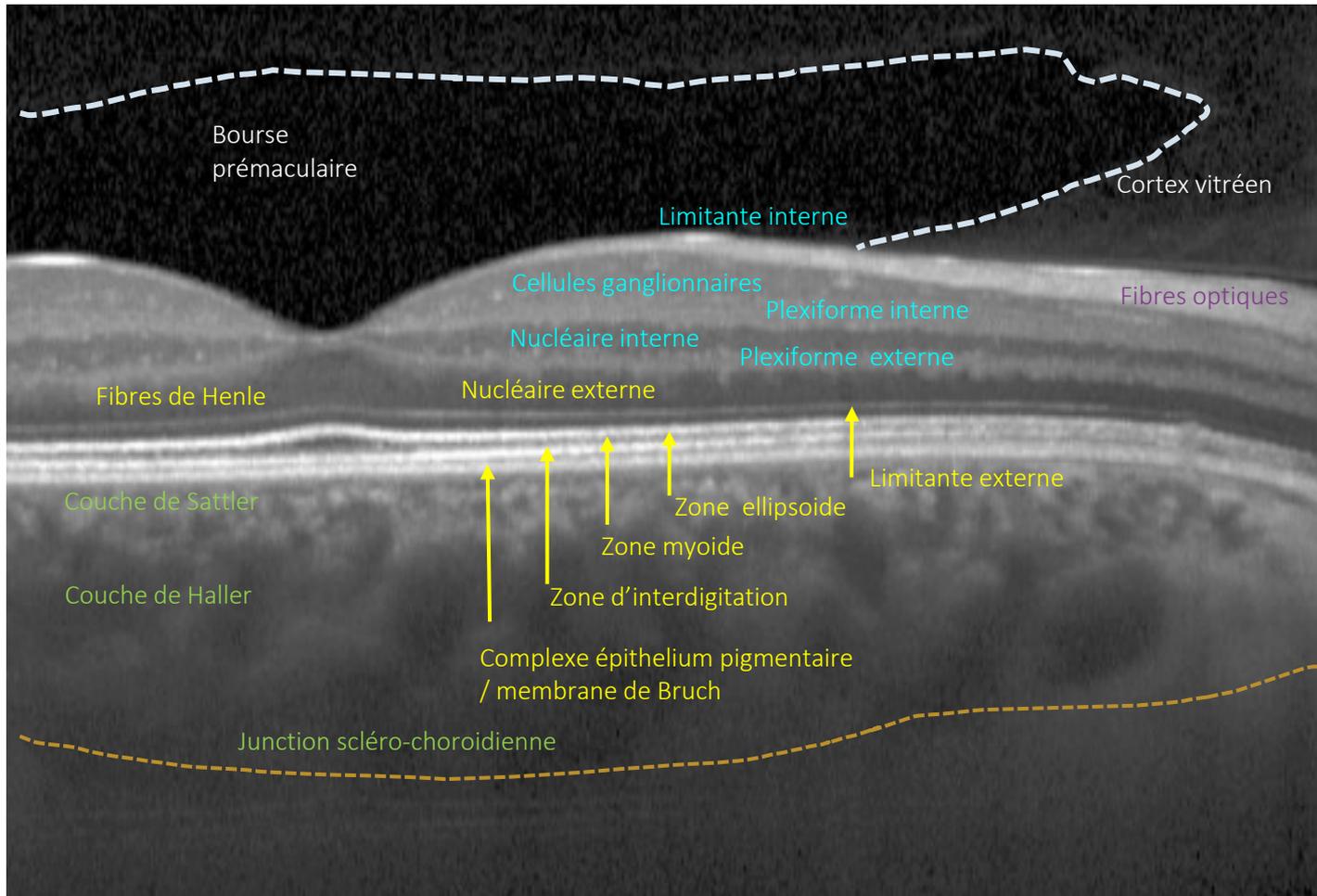
Nomenclature



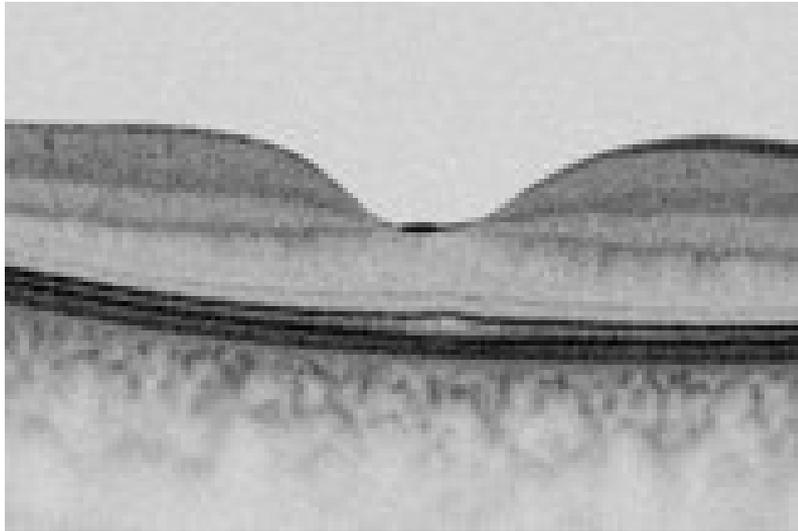
Staurenghi G, Sadda S, Chakravarthy U, Spaide RF, et al.

International Nomenclature for Optical Coherence Tomography (IN•OCT) Panel. Proposed lexicon for anatomic landmarks in normal posterior segment spectral-domain optical coherence tomography: the IN•OCT consensus.

Ophthalmology; 2014:1572-1578.



Le centre fovéolaire



- L'OCT ne montre pas la structure du centre de la foveola, qui a été étudiée par les anatomistes depuis plus d'un siècle mais élucidée seulement récemment
 - A. Rochon Duvigneaud 1907
 - S L Polyak 1941
 - Yamada 1969
 - A. Bringmann & A Reichenbach 2018

Le centre fovéolaire

RECHERCHES SUR LA FOVEA DE LA RÉTINE HUMAINE

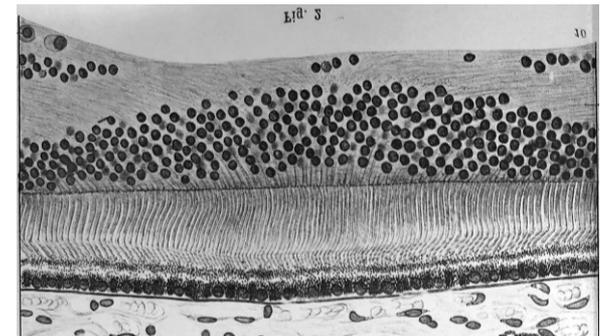
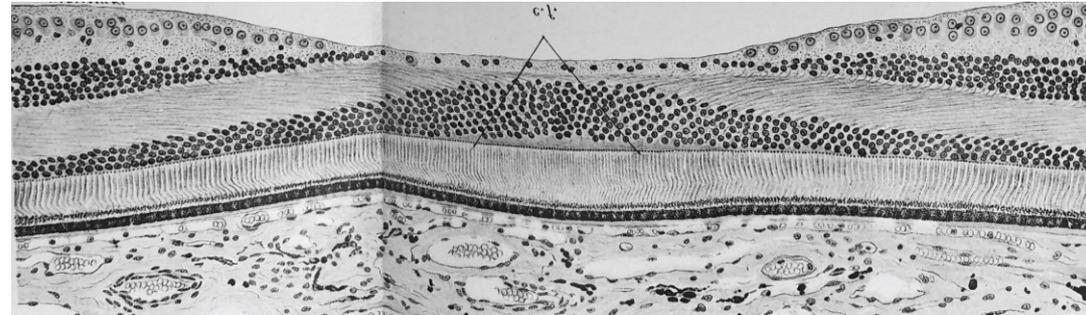
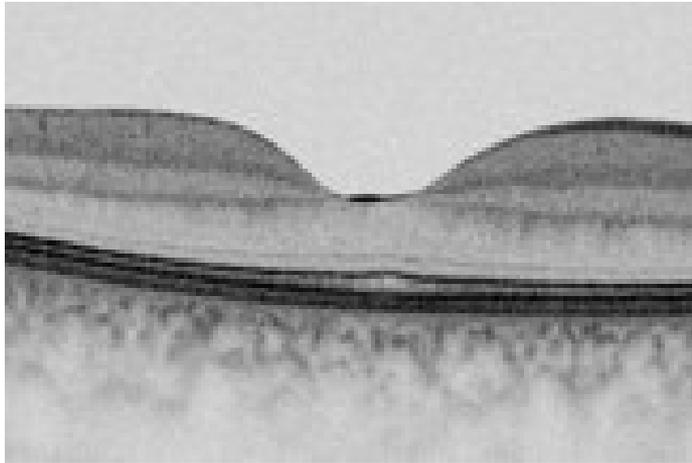
ET PARTICULIÈREMENT

SUR LE BOUQUET DES CÔNES CENTRAUX

Par le D^r ROCHON-DUVIGNEAUD

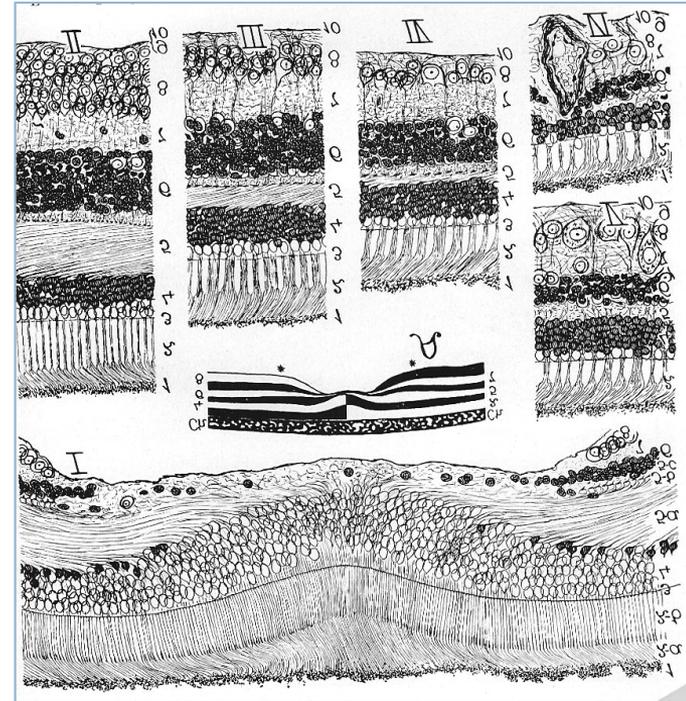
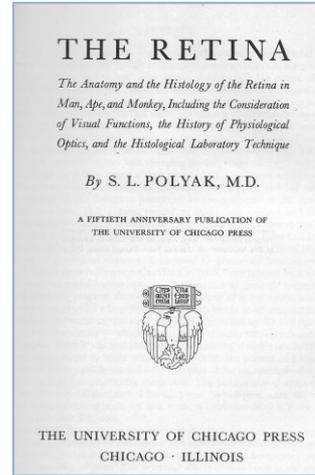
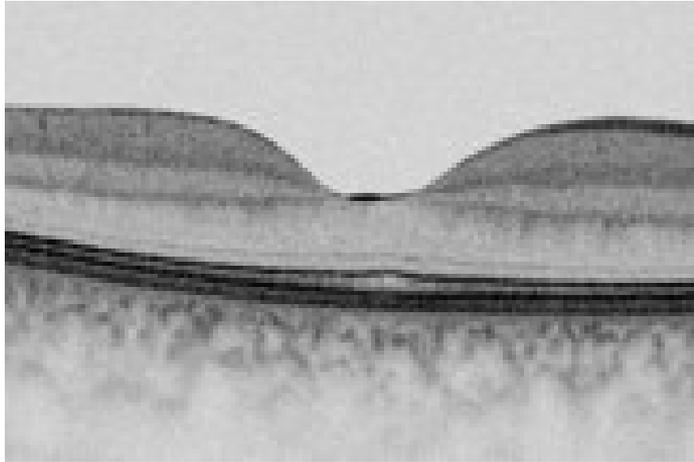
Ophthalmologiste de l'hôpital Laënnec.

PLANCHES X-XI



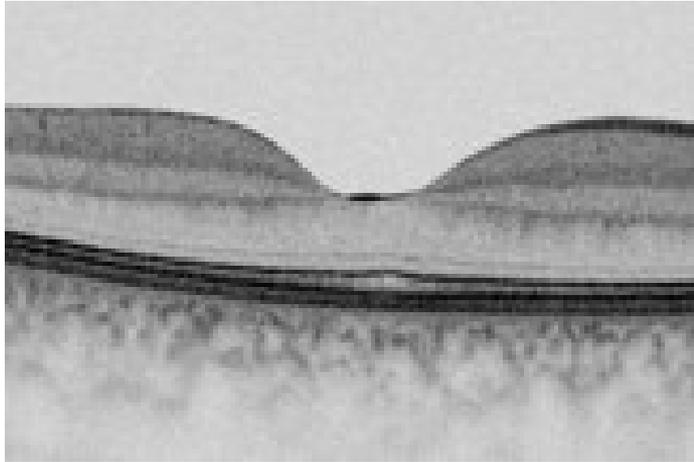
- Description du "bouquet des cônes centraux"

Le centre fovéolaire



- Description des couches cellulaires rétiniennes de la fovea à la périphérie

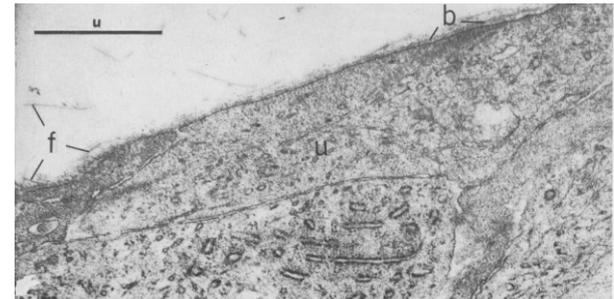
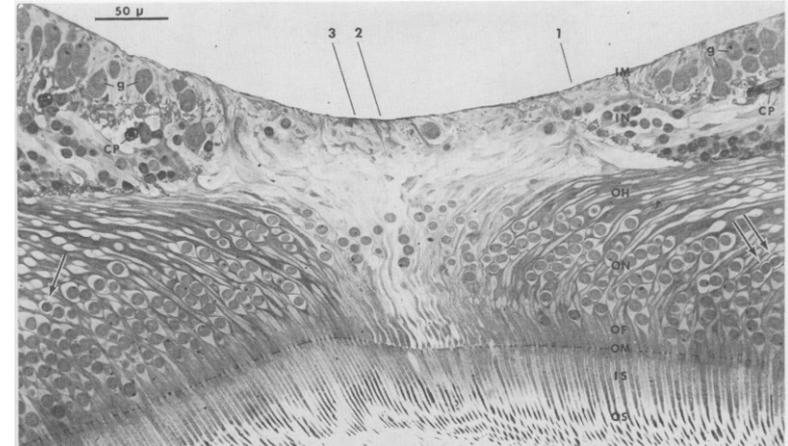
Le centre fovéolaire



Some Structural Features of the Fovea Centralis in the Human Retina

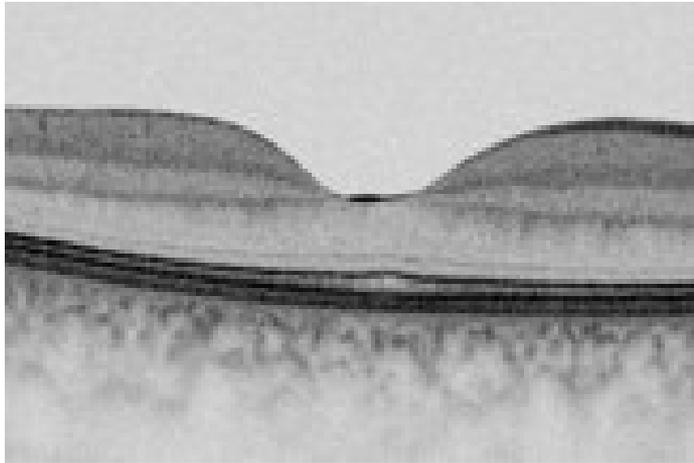
Eichi Yamada, MD, Los Angeles

Arch Ophthalmol. 1969;82(2):151-159

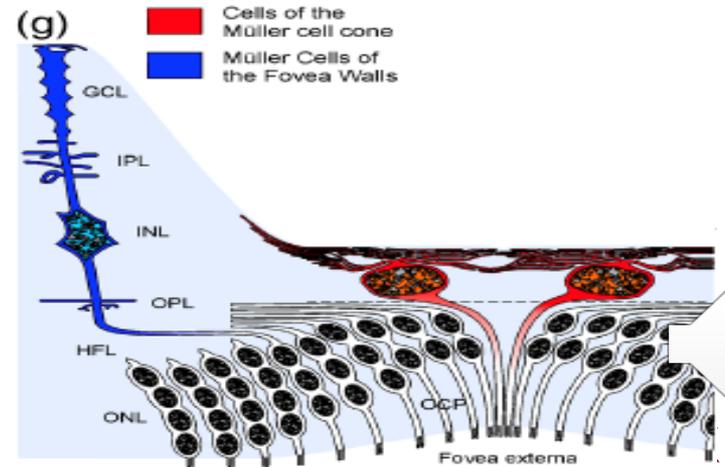
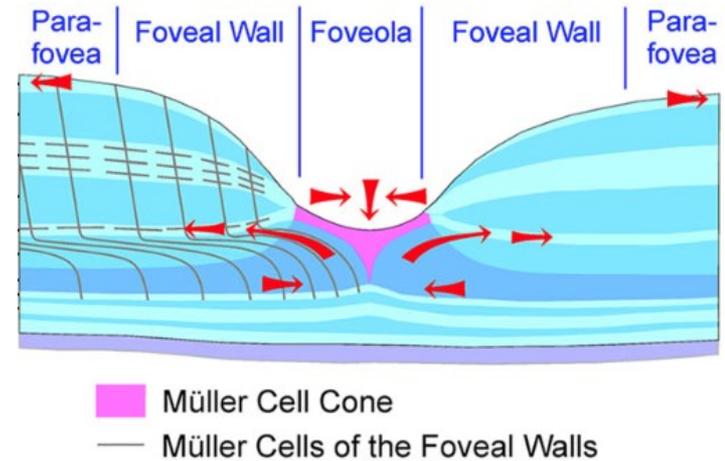


- Le plancher de la foveola est fermé par les expansions internes des cellules de Müller

Le centre fovéolaire



- Le centre de la foveola est constitué de cellules de Müller joignant directement la MLE et la MLI sans accompagner les axones des cônes centraux



Bringmann A, Wiedemann P. *International Ophthalmology*. online July 6, 2020:1-18.

Syrbe S, Bringmann A. et al. *Exp Eye Res*. 2018;167:110-117.

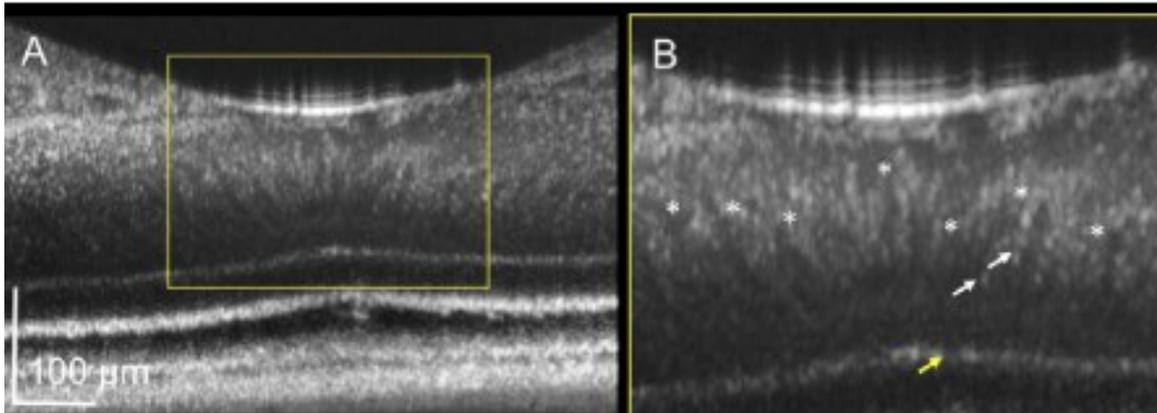
Le centre fovéolaire

tvst

Article

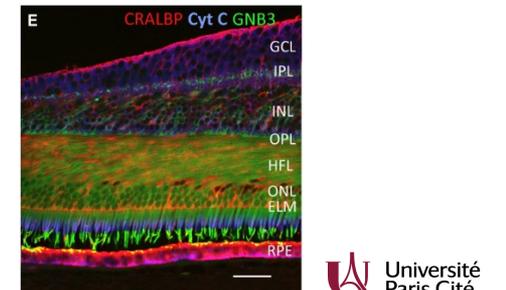
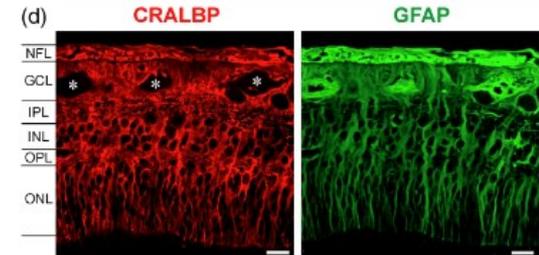
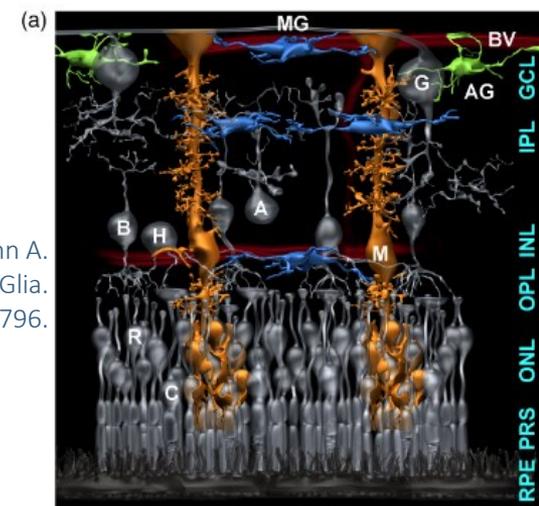
Human Foveal Cone and Müller Cells Examined by Adaptive Optics Optical Coherence Tomography

Shin Kadomoto¹, Yuki Muraoka¹, Akihito Uji¹, Sotaro Ooto¹, Kentaro Kawai¹, Masaharu Ishikura¹, Naomi Nishigori¹, Tadamichi Akagi¹, and Akitaka Tsujikawa¹



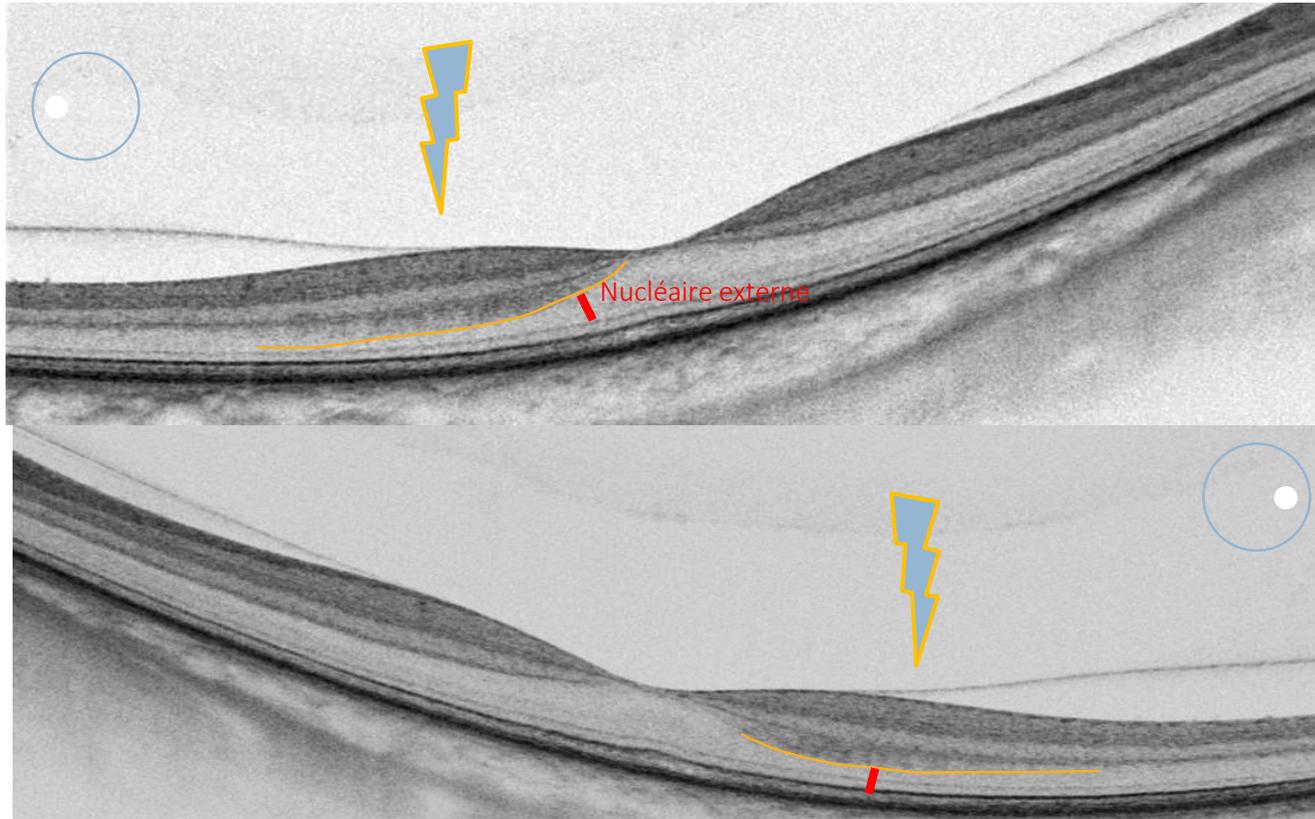
Transl Vis Sci Technology. 2021;10(11):17.

Reichenbach A, Bringmann A. Glia of the human retina. *Glia.* 2020;68(4):768-796.

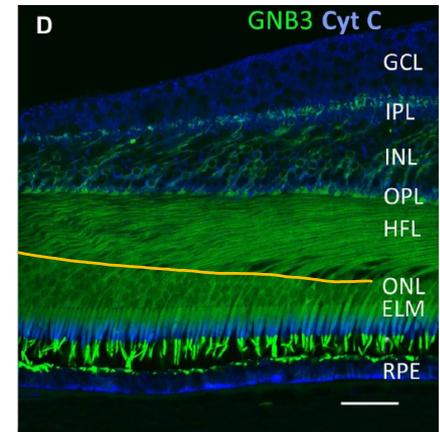


.Cuenca N, Ortuño-Lizarán I, Pinilla I. Cellular Characterization of OCT and Outer Retinal Bands Using Specific Immunohistochemistry Markers and Clinical Implications. *Ophthalmology.* 2018;125(3):

Fibres de Henle



- Lorsque la coupe est oblique (entrée par le bord de la pupille) les fibres de Henle deviennent réfléchives et visibles



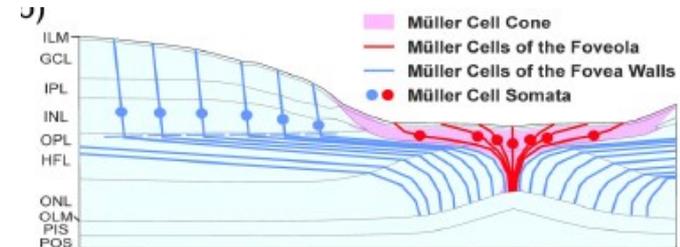
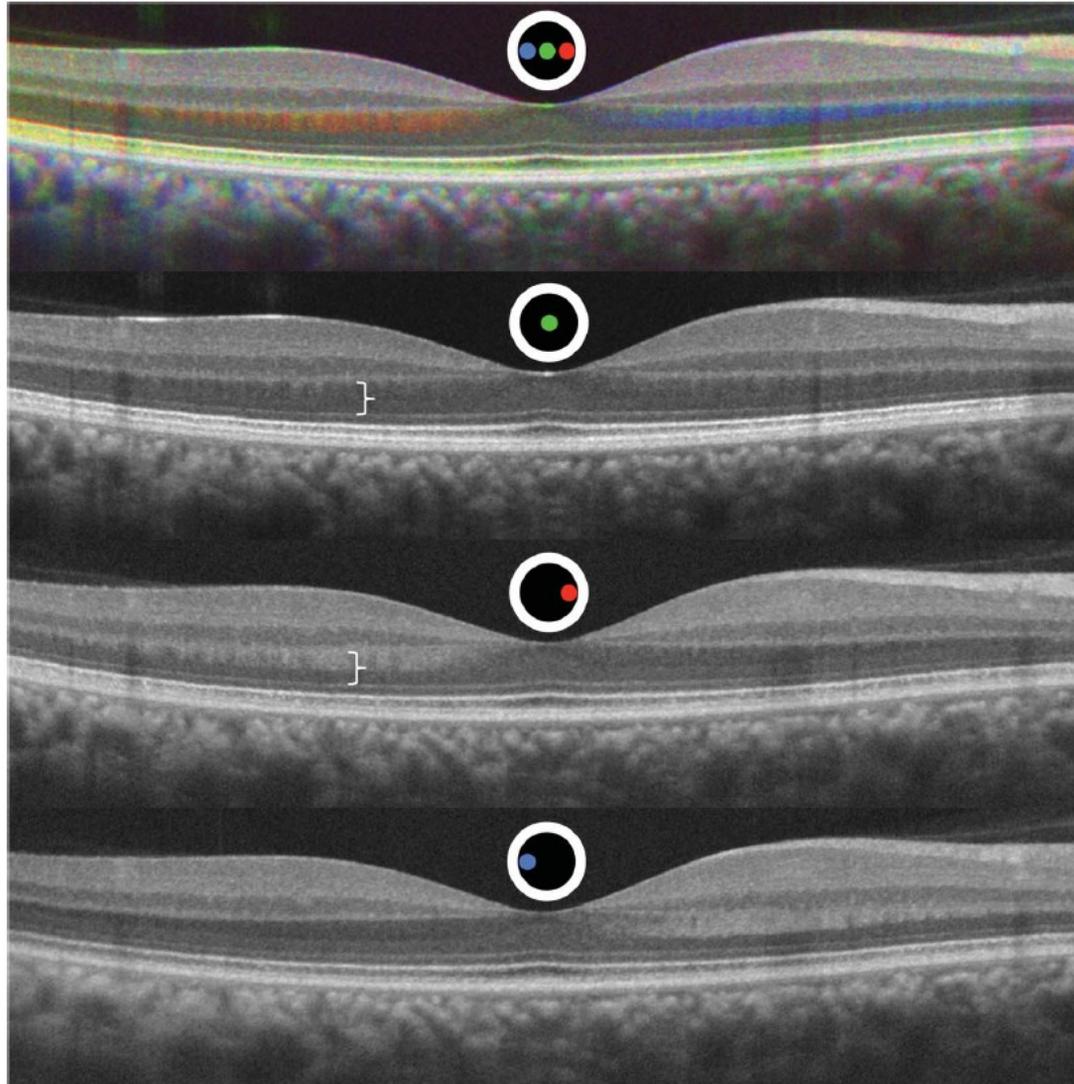
Lujan BJ, et al. Invest Ophthalmol & Vis Sci. 2011;52(3):1486-1492.

Cuenca, N. (2018). Ophthalmology, 125(3), 407-422.

DIRECTIONAL OPTICAL COHERENCE TOMOGRAPHY PROVIDES ACCURATE OUTER NUCLEAR LAYER AND HENLE FIBER LAYER MEASUREMENTS

BRANDON J. LUJAN, MD,** AUSTIN ROORDA, PhD,* JASON A. CROSKREY, MD,‡
ADAM M. DUBIS, PhD,§ ROBERT F. COOPER, BS,¶ JAN-KRISTINE BAYABO, BA,*
JACQUE L. DUNCAN, MD,** BHAVNA J. ANTONY, PhD,* JOSEPH CARROLL, PhD‡§¶

Retina (Philadelphia, Pa), 35(8), 1511–1520.

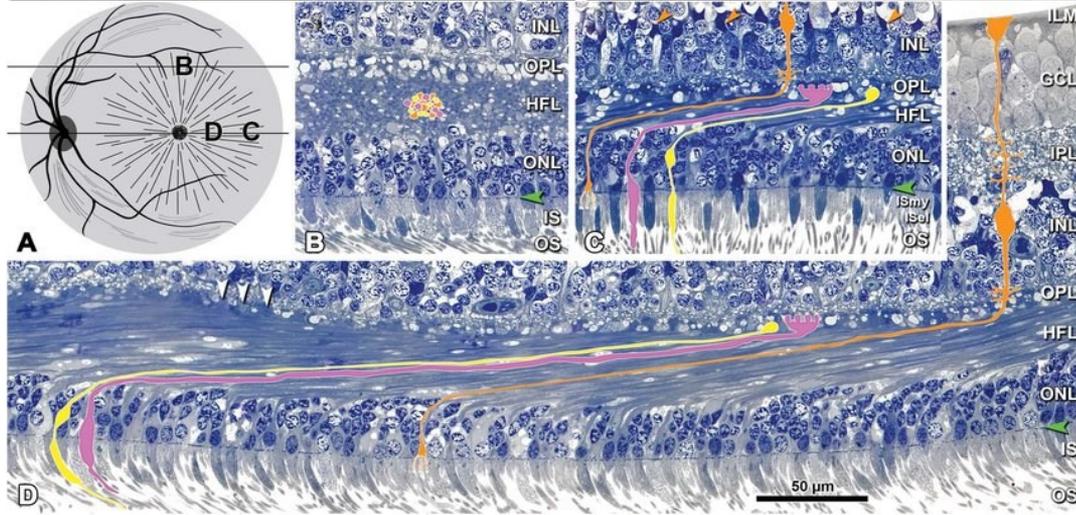
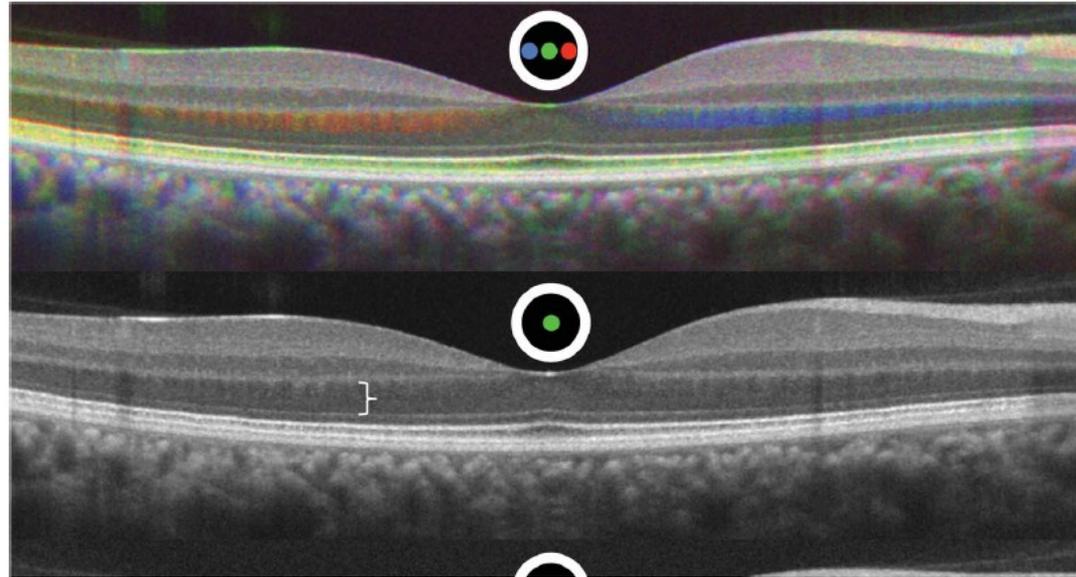
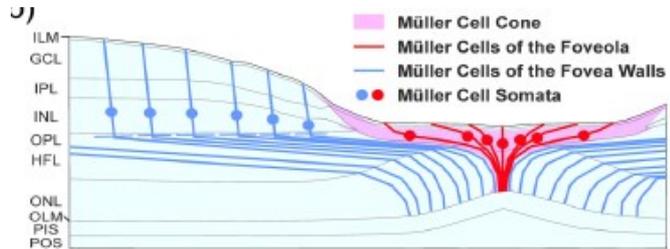


DIRECTIONAL OPTICAL COHERENCE TOMOGRAPHY PROVIDES ACCURATE OUTER NUCLEAR LAYER AND HENLE FIBER LAYER MEASUREMENTS

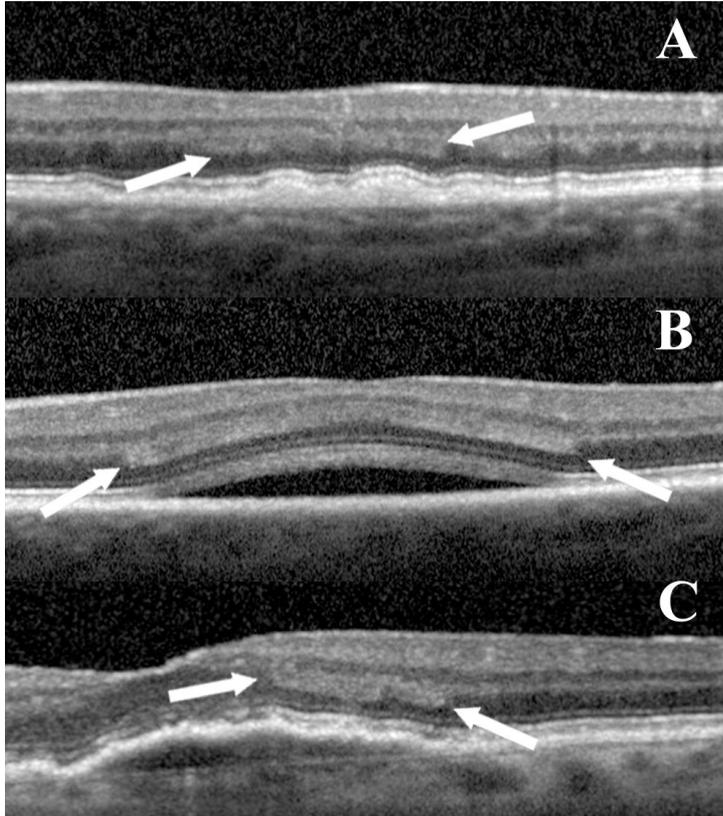
BRANDON J. LUJAN, MD,*† AUSTIN ROORDA, PhD,* JASON A. CROSKREY, MD,‡
 ADAM M. DUBIS, PhD,§ ROBERT F. COOPER, BS,¶ JAN-KRISTINE BAYABO, BA,*
 JACQUE L. DUNCAN, MD,** BHAVNA J. ANTONY, PhD,* JOSEPH CARROLL, PhD‡§¶

Retina (Philadelphia, Pa), 35(8), 1511–1520.

Li, M., Curcio, Ch. (2018). Retina. 38. 1.



Fibres de Henle

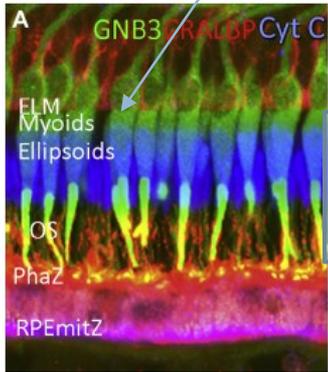
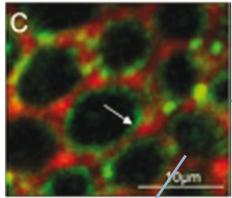


- Le soulèvement de la rétine externe modifie l'orientation des fibres de Henle qui peuvent devenir visibles au moins se partie
 - ▣ Et peuvent être confondues avec une exsudation intrarétinienne

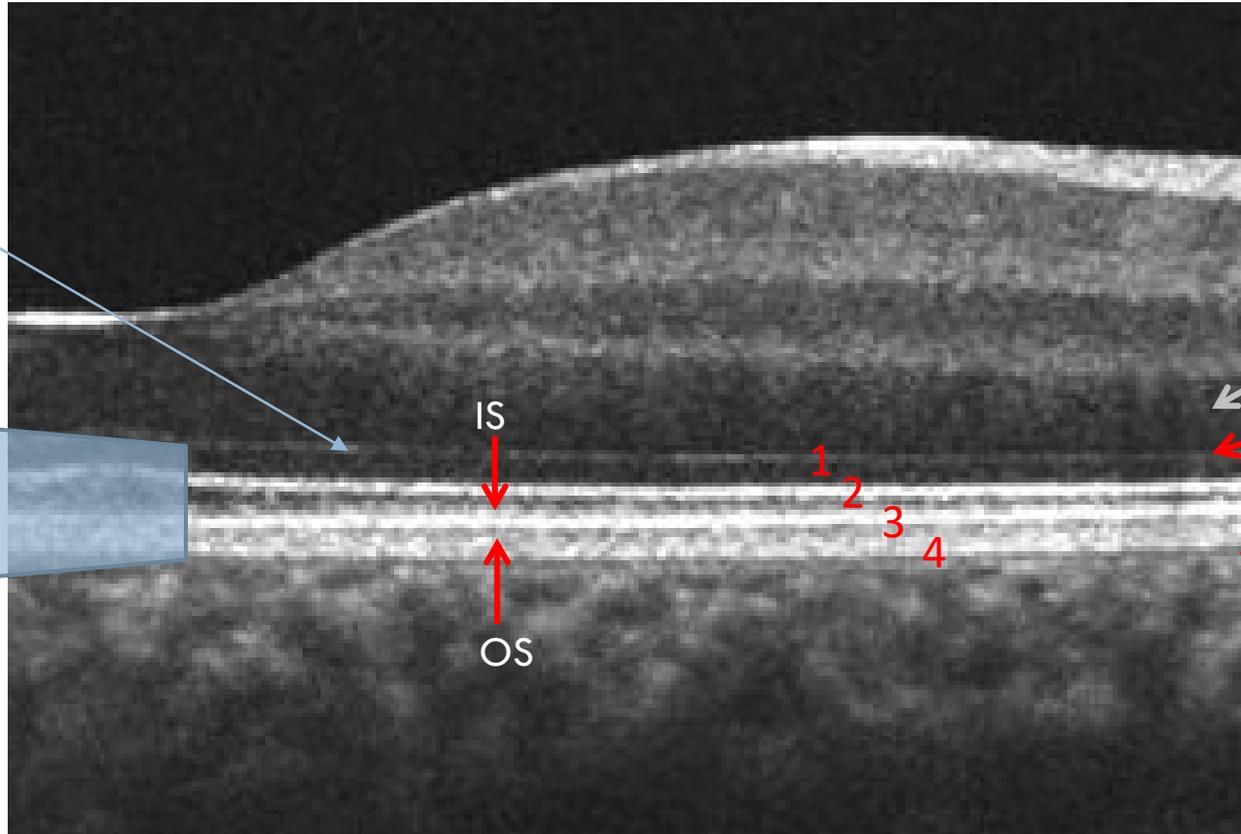
Mrejen S, Gallego-Pinazo R, Freund KB, Paques M. Recognition of Henle's fiber layer on OCT images. Ophthalmology. 2013;120(6):e32–3.e1.

Les "4 bandes externes"

Omri, S. Behar-Cohen, F.
Clinical Ophthalmology
2010, 183–195.

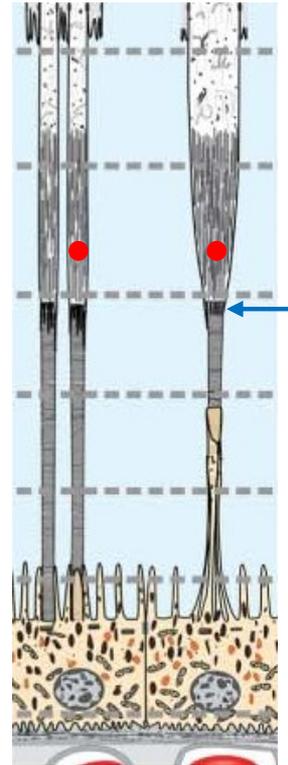
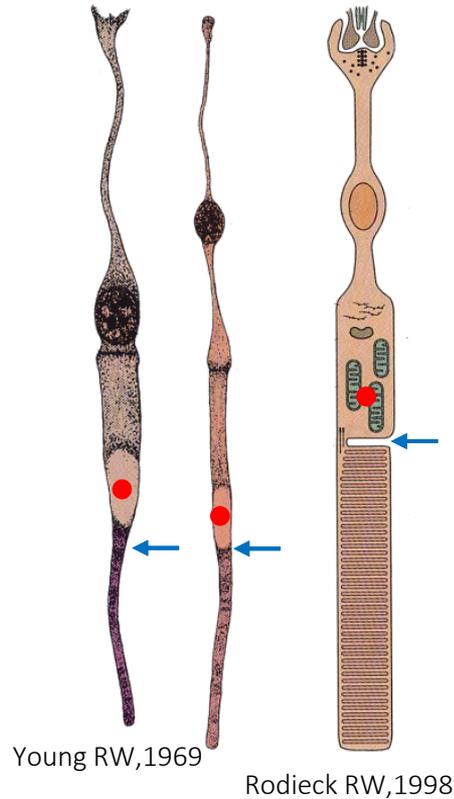


Cuenca, N., (2018)..
Ophthalmology, 125(3),
407–422.



ONL
ELM
EZ
IDZ
RPE

Controverses : IS/OS vs EZ



Spaide R, Curcio C 2011

- Si la bande hyper-reflective N°3 correspond à l'ellipsoïde
 - Sa disparition correspond à celle des segments internes des PR
- Si cette bande correspond à la jonction IS/OS
 - Sa disparition correspond à la disparition des segments externes qui peuvent régénérer

- Ellipsoid Zone
- ← Inner Segment / Outer Segment

Controverses IS/OS vs EZ

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

The IN

Giovanni Sta
for the Intern

Purpose: bands visible
Design: A
Coherence T
Participan
Methods:
independent a
were scrutiniz
history of ana
structures tha
unanimous co
Main Outc
Results:
retinal anaton
particular ana
include the m
Conclusio
proposed and
future publica
studies. *Opht*

iOVS investigative ophthalmology & visual science
an ARVO Journal

ISSUES RECENTLY ACCEPTED TOPICS FOR AUTHORS ABOUT ▾

Leading clinical and laboratory and vision research

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Multidisciplinary Ophthalmic Imaging | July 2015

RefMoB, a Reflectivity Feature Model-Based Automated Method for Measuring Four Outer Retinal Hyperreflective Bands in Optical Coherence Tomography

Douglas H. Ross; Mark E. Clark; Pooja Godara; Carrie Huisling; Gerald McGwin; Cynthia Owsley; Katie M. Litts; Richard F. Spaide; Kenneth R. Sloan; Christine A. Curcio

July 2015
Volume 56, Issue 8

Author Affiliations & Notes

This Article

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Invest. Ophthalmol. Vis. Sci. October 16, 2014 IOVS-14-14907

» Abstract
Full Text (PDF)

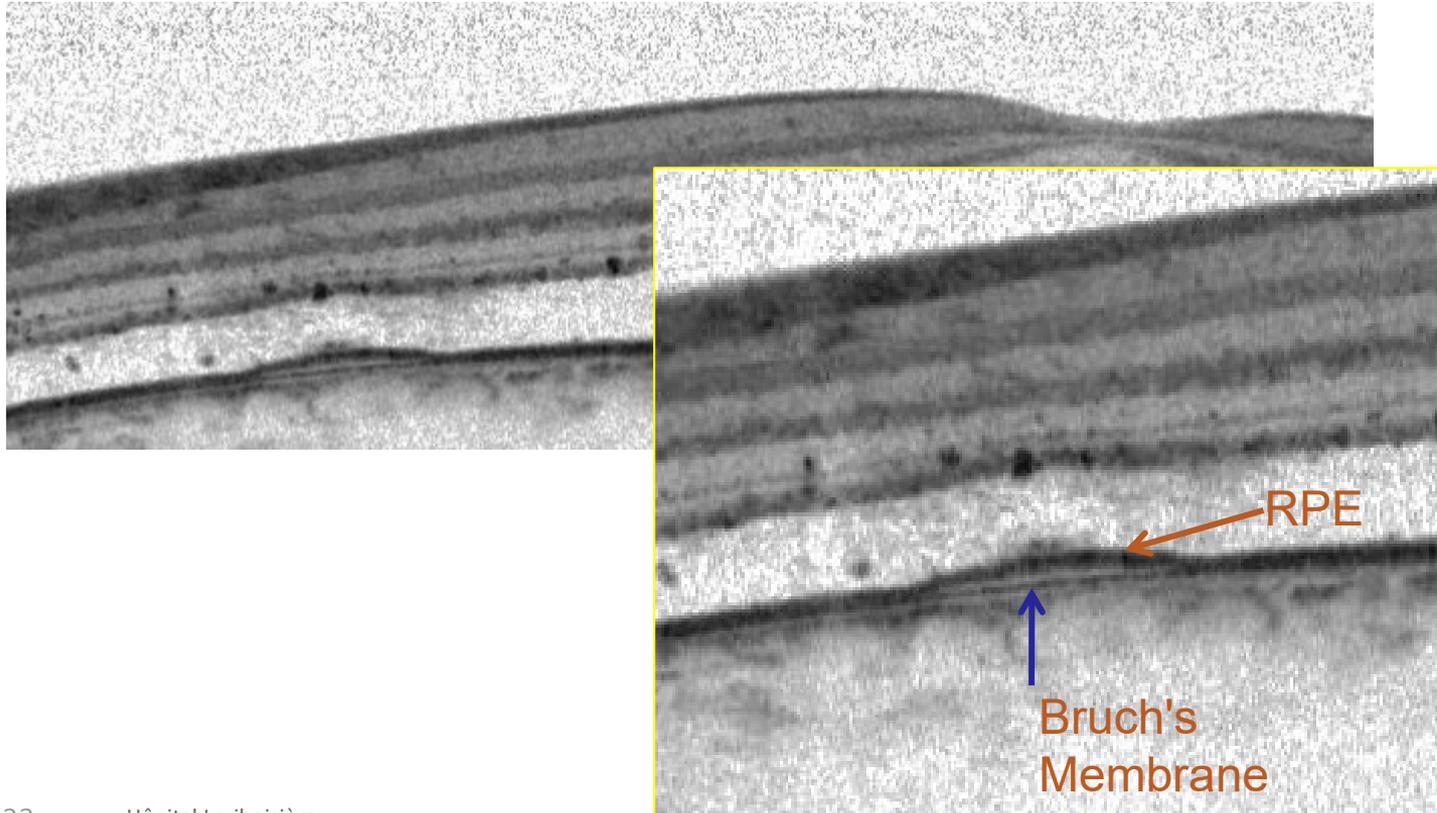
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Article

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Epithelium Pigmentaire et Membrane de Bruch



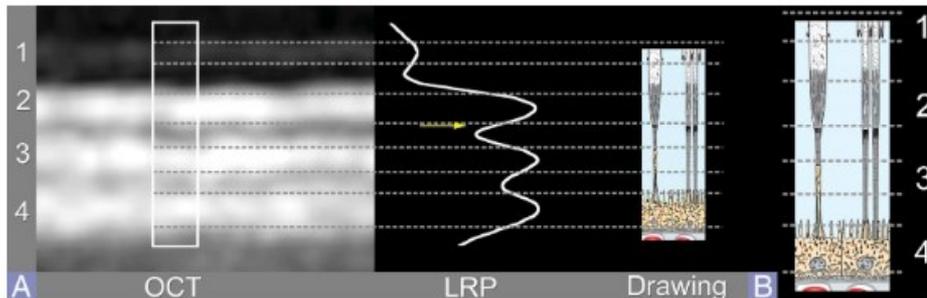
Épithélium pigmentaire

ANATOMICAL CORRELATES TO THE BANDS SEEN IN THE OUTER RETINA BY OPTICAL COHERENCE TOMOGRAPHY

Literature Review and Model

RICHARD F. SPAIDE, MD,*† CHRISTINE A. CURCIO, PhD‡

Retina 2011;31(8):1609-1619.



La bande de l'épithélium pigmentaire pourrait comprendre , l'EP, la membrane de Bruch et une portion de la choriocapillaire

Methods

UHR SD-OCT:

- Scanning rate: 128 kHz.
- Scan protocol: HD raster
 - 1800 A-scans x 241 B-scans
 - 9 mm x 6 mm
 - A-scans separated by 5 μ m.

Image display:

- Linear display of the OCT signal amplitude

Thickness measurements:

- Thickness of RPE
- RPE-BrM complex
- The gap between RPE & BrM

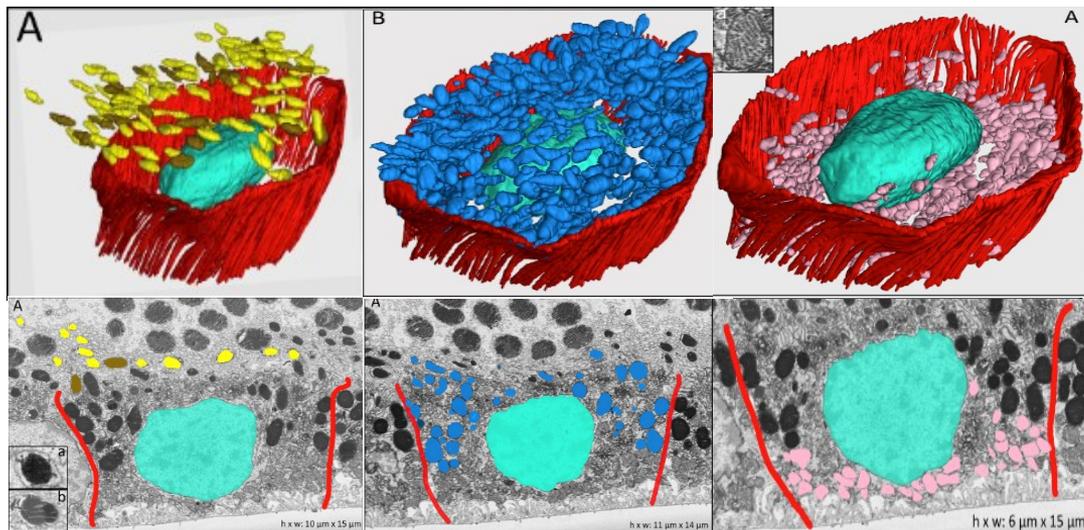
Logarithmic display Linear display

Un traitement différent de l'image pourrait faire apparaître la mbne de Bruch

Épithélium pigmentaire

Atlas of Human Retinal Pigment Epithelium Organelles Significant for Clinical Imaging *Invest Ophth Vis Sci.* 2020;61(8):13.

Andreas Pollreisz,¹ Martina Neschi,¹ Kenneth R. Sloan,^{2,3} Michael Pircher,⁴
Tamara Mittermueller,¹ Dennis M. Dacey,⁵ Ursula Schmidt-Erfurth,¹ and Christine A. Curcio²



Mélanosomes et
lipofuscine dans les
villosités apicales

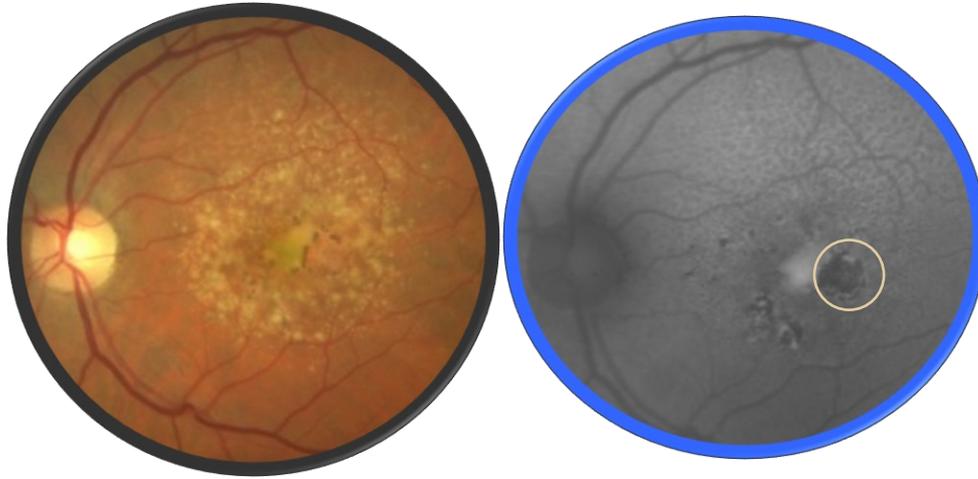
Lipofuscine,
Mélanolipofuscine,
Mélanosomes

Mitochondries

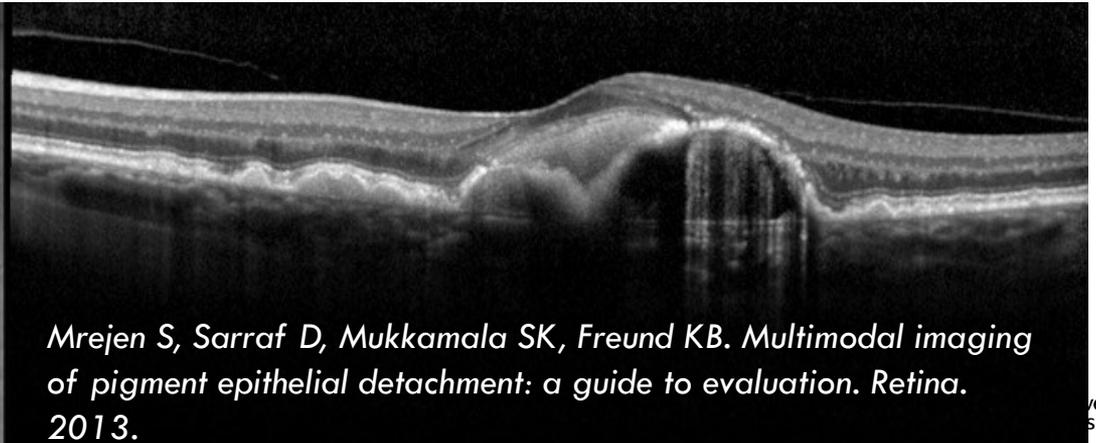
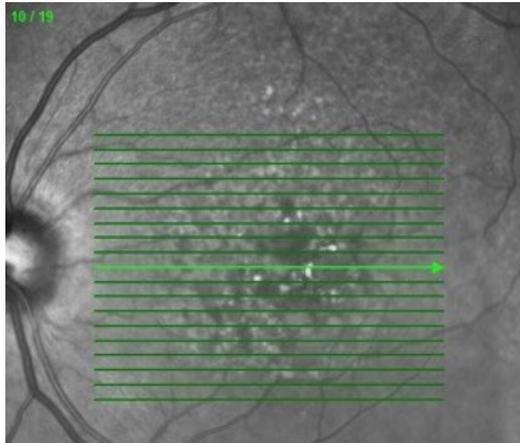
Le fort signal OCT de l'EP et la forte atténuation des structures postérieures sont très probablement générés par la combinaison de mélanosomes, de lipofuscine, de mélanolipofuscine et de mitochondries, alors que les noyaux ne rétrodiffusent que faiblement la lumière.

À l'inverse, la perte ou la redistribution des organelles et l'amincissement, la migration ou la mort des cellules peuvent contribuer à l'hypertransmission de la lumière dans la choroïde.

Épithélium pigmentaire



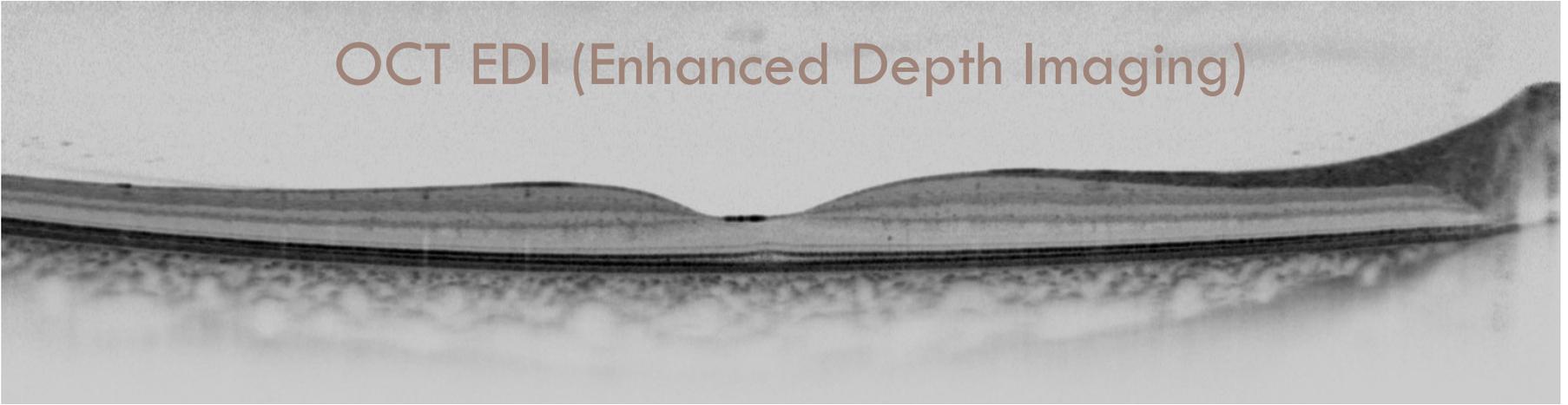
Malgré la persistance de l'intensité du signal de l'EP, les effets d'hypertransmission correspondent à un changement dans la composition des cellules de l'EP observée aussi en AF



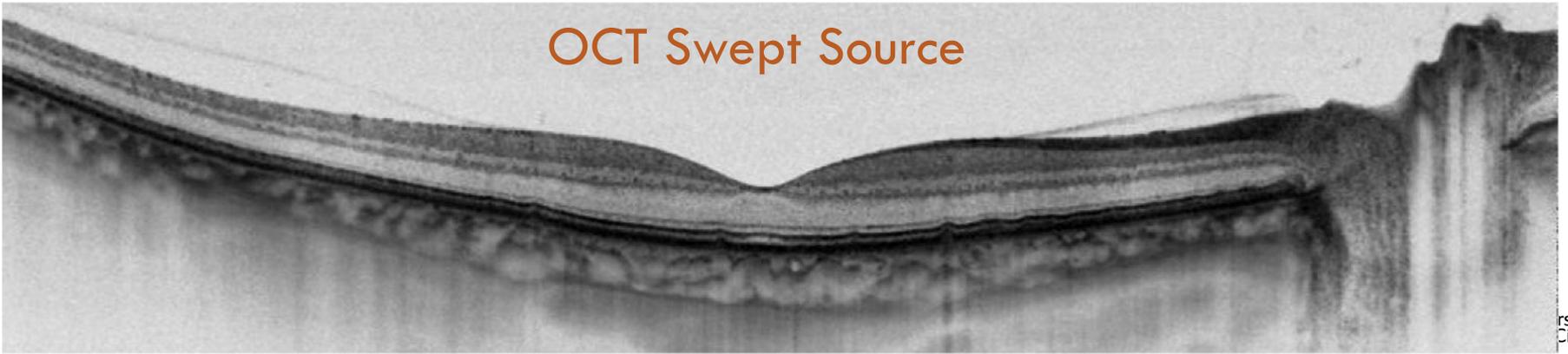
Mrejen S, Sarraf D, Mukkamala SK, Freund KB. Multimodal imaging of pigment epithelial detachment: a guide to evaluation. *Retina*. 2013.

Choroïde

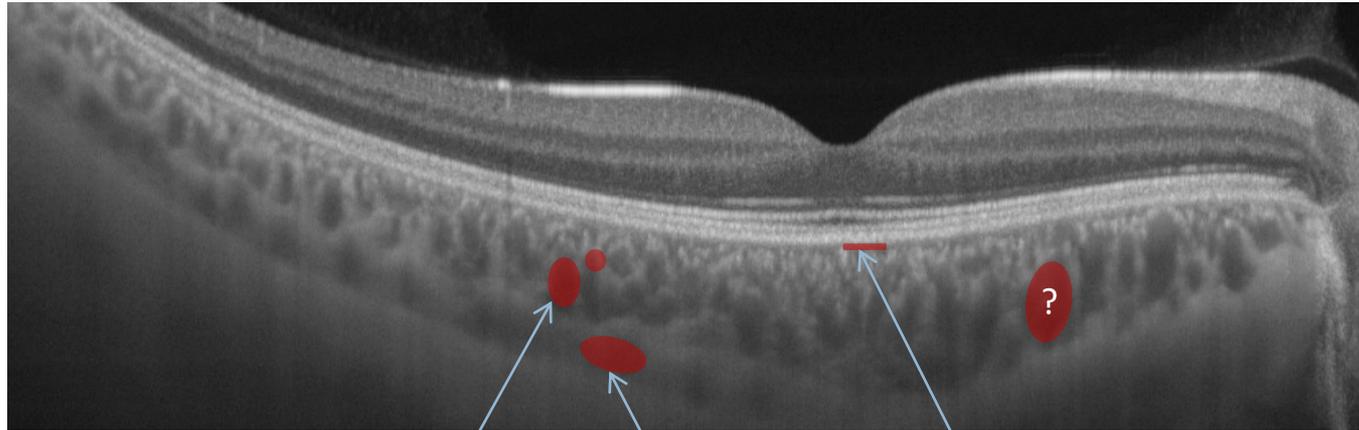
OCT EDI (Enhanced Depth Imaging)



OCT Swept Source



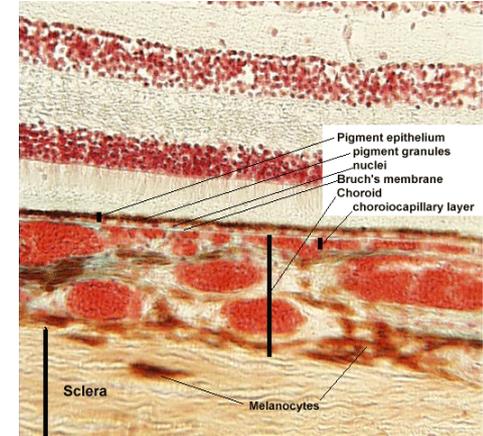
Choroïde



Couche de Sattler

Couche de Haller

Choriocapillaire



Sclera

Melanocytes

Pigment epithelium
pigment granules
nuclei
Bruch's membrane
Choroid
choriocapillary layer

OCT : Lecture et Mesures

Quelques détails sur les paramètres d'acquisition

■ Cirrus

- Cube 6x6mm
- 128 B scans de 512 A scans
 - espacement 47 μ
- ou 200 B-scans x 200 A-scans

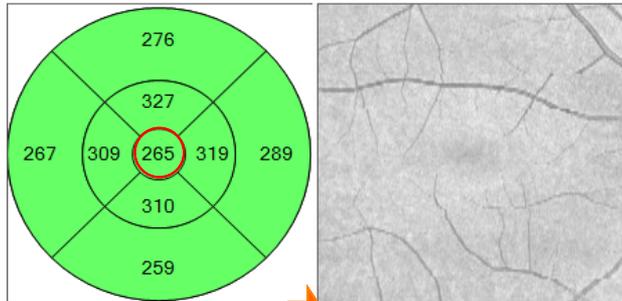
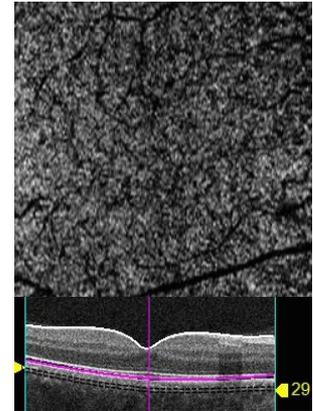
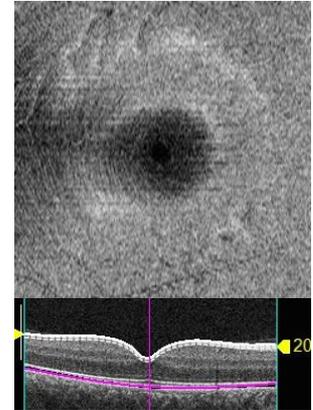
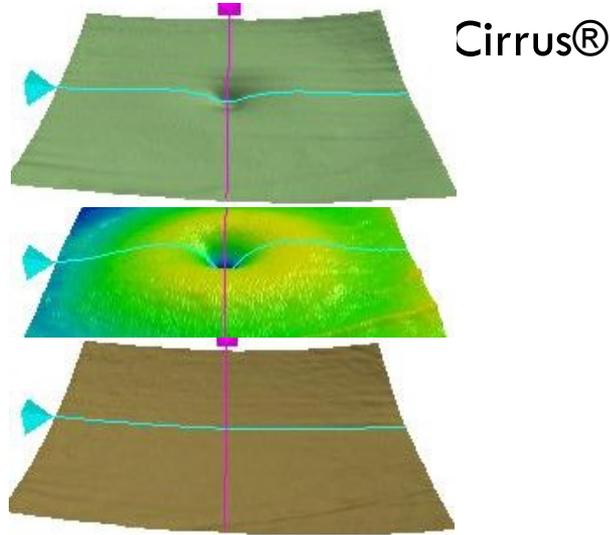
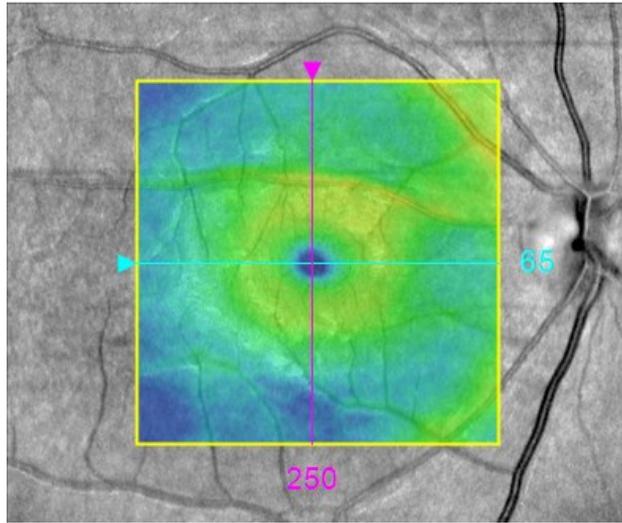
- 5 raster B-scans de 1024 A-scans
 - espacement standard 250 μ
 - recommandé 75 μ
- 1 ligne avec sommation 20x1024

■ Spectralis

- Cube 25°x25° = 6x6 mm
- 49 B-scans de 512 A-scans (HR)
 - espacement 120 μ
- 97 B-scans :
 - espacement 60 μ

- Possibilité de rétrécir la fenêtre pour focaliser sur un point d'intérêt.
 - 20°x5° , 25 lignes, 1024 A scans , espacement 60 μ

Épaisseur maculaire normale

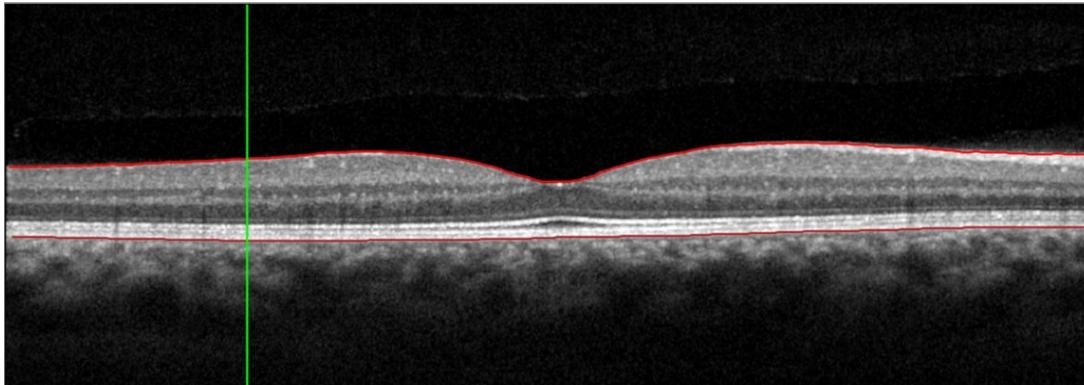
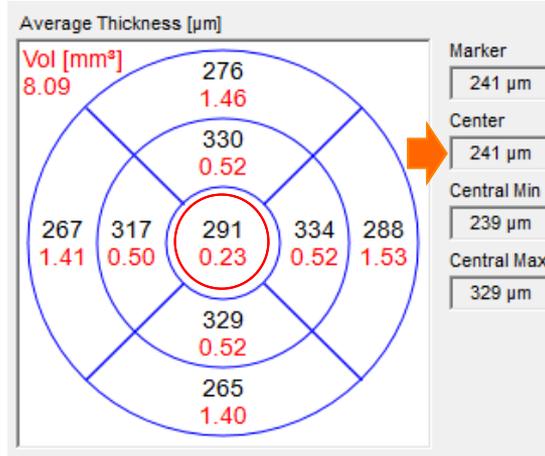


Épaisseur ILM-RPE (μm) Fovéa: 250, 65
 Hôpital Lariboisière

Le plan de référence externe est la surface de l'EP

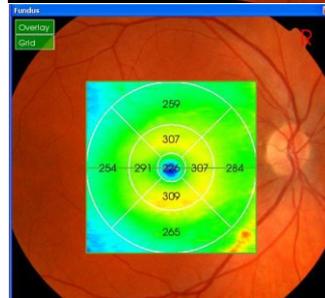
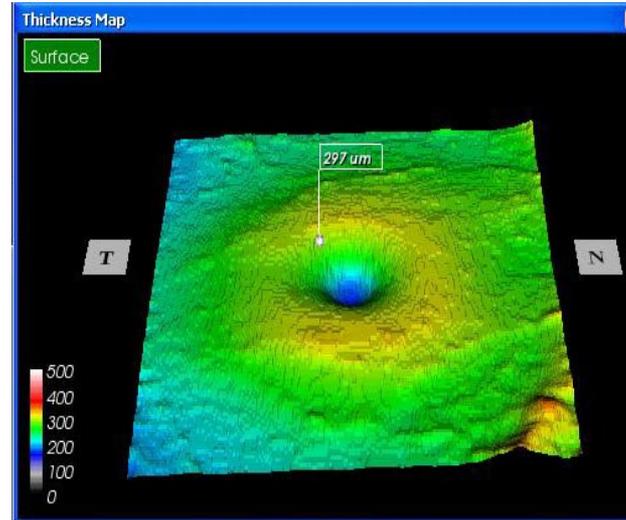
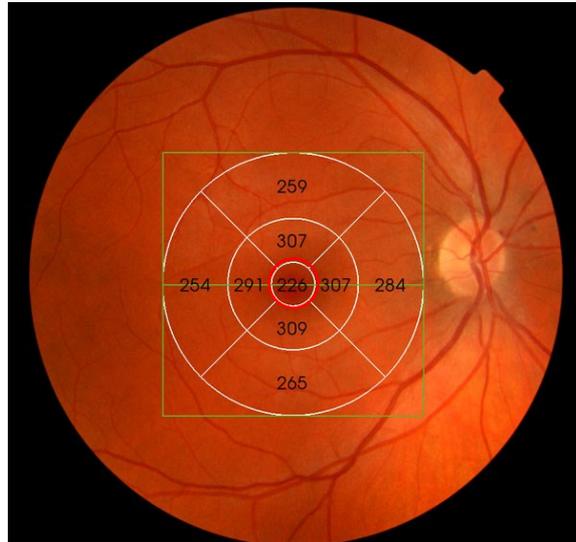
Épaisseur Sous-zone centrale (μm)	Volume Cube (mm^3)	Épaisseur Moy Cube (μm)
265	10,1	281

Épaisseur maculaire normale



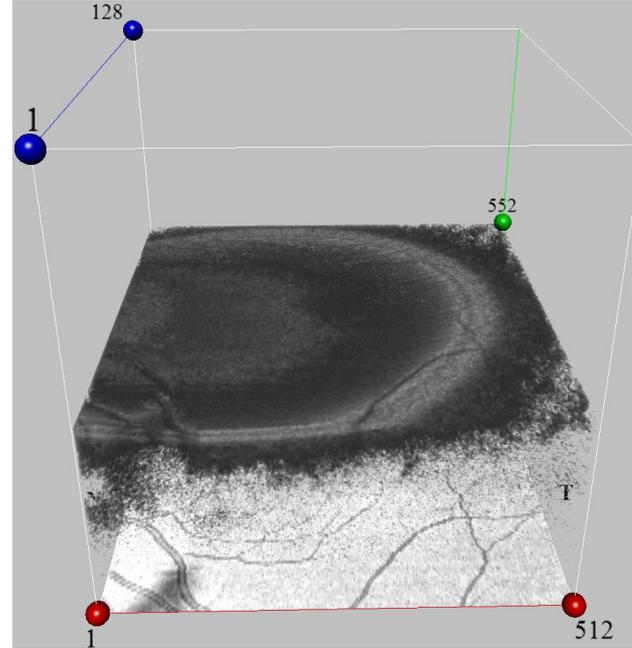
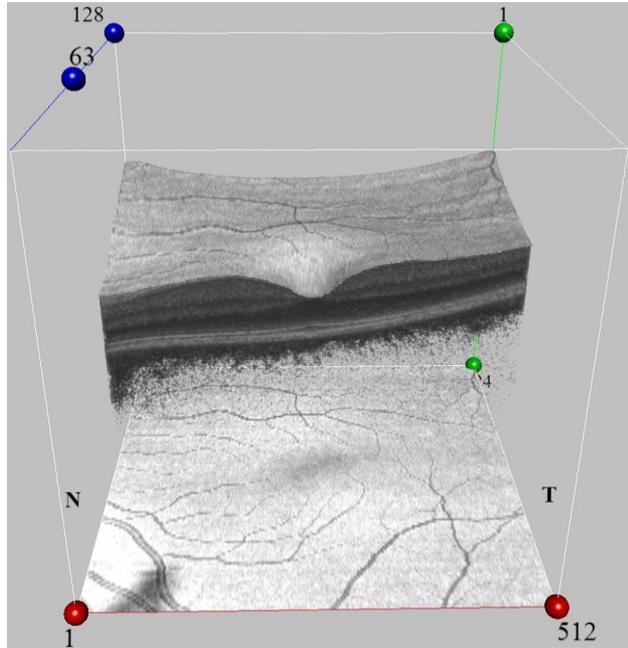
Le plan de référence externe est la membrane de Bruch

Épaisseur maculaire normale



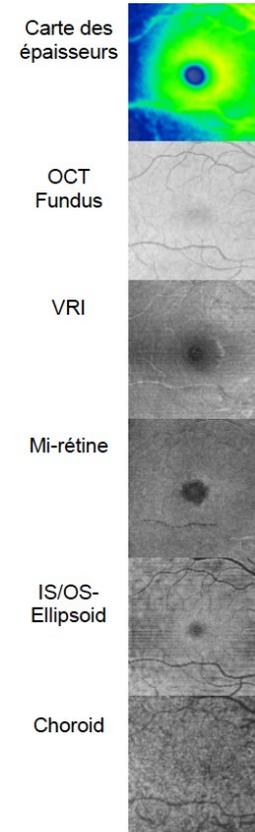
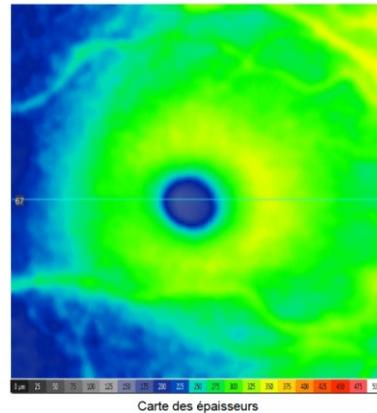
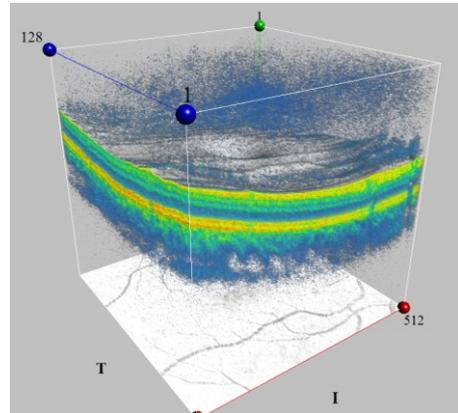
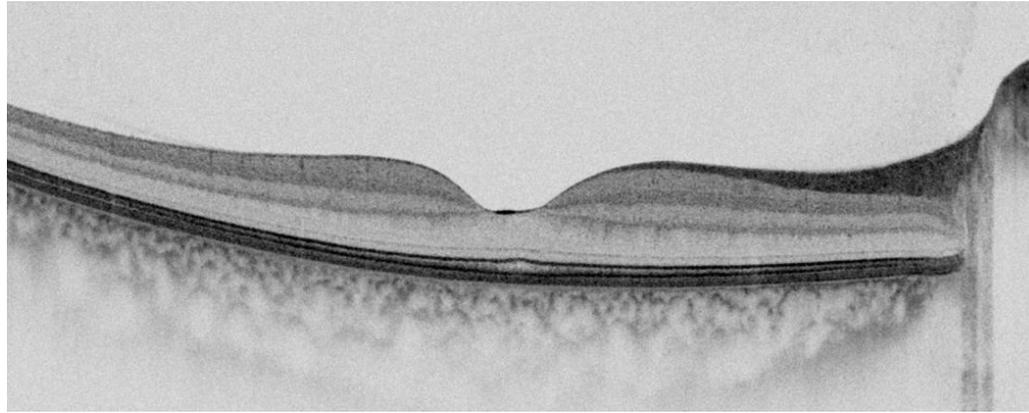
Le plan de référence externe est la surface de la zone d'interdigitation

Cartographie maculaire

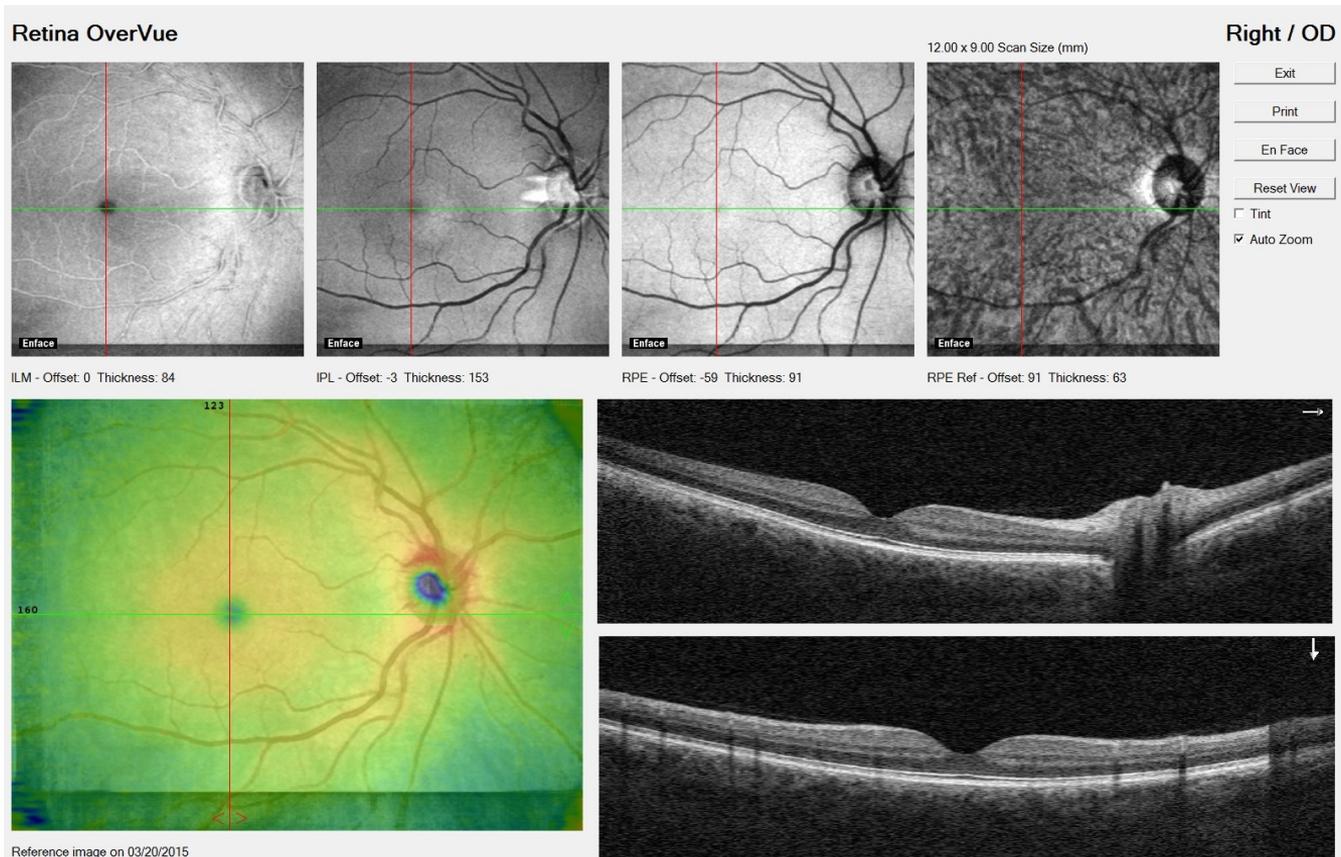


- SD OCT acquiert un volume qui peut être coupé
 - en coupes sagittales et transverses (B scan)
 - ou frontales (en face), (C scan)

Segmentation et coupes frontales (en face)

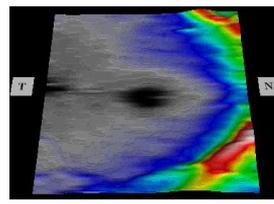
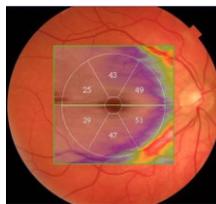
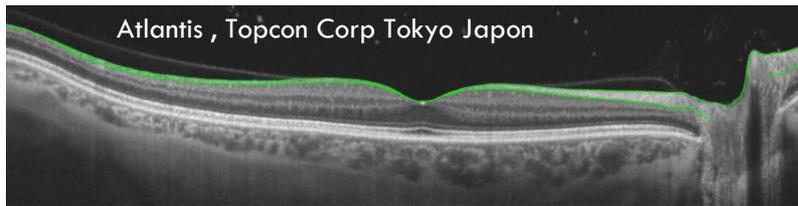


Segmentation et coupes frontales (en face)

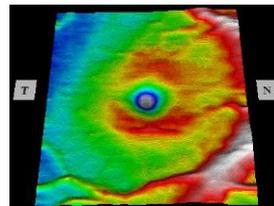
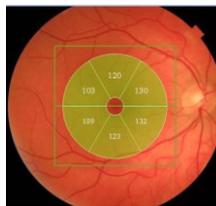
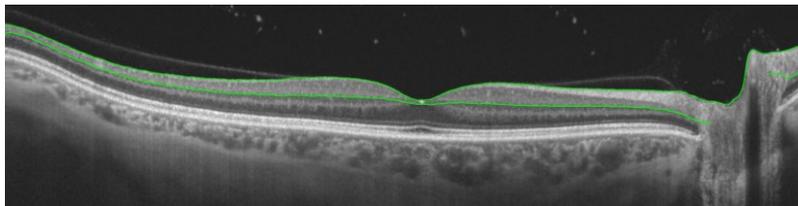


- Le recours aux images "en face" n'est pas assez utilisé.
- très utile pour les pathologies de l'interface
- pour les ruptures de l'EZ
- pour le diamètre des TM etc..

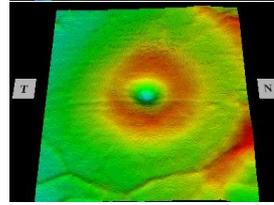
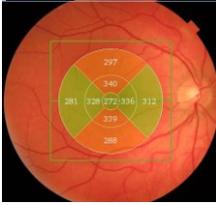
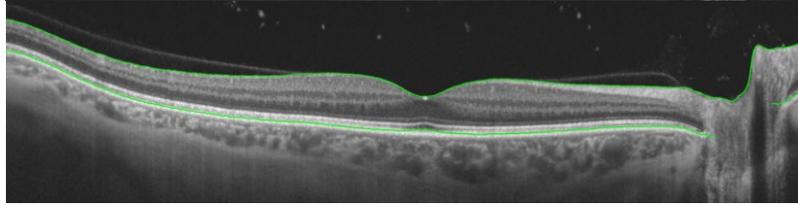
Segmentation et coupes frontales (en face)



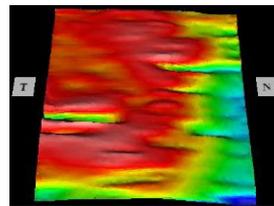
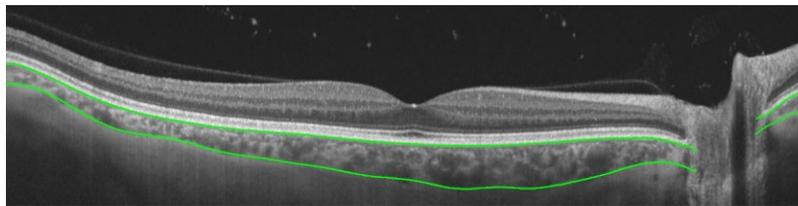
Fibres optiques



Nucléaire interne



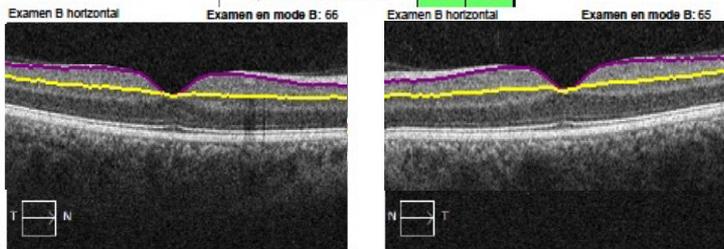
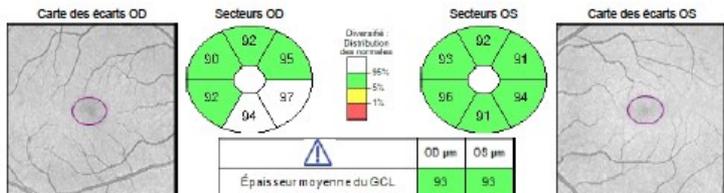
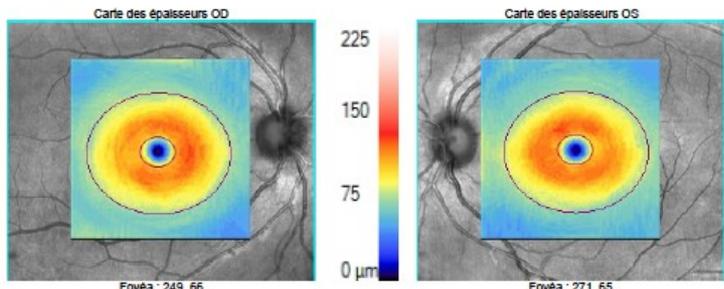
Pleine épaisseur



Choroïde

Épaisseur des cellules ganglionnaires

Analyse des cellules ganglionnaires : Macular Cube 512x128 OD OS



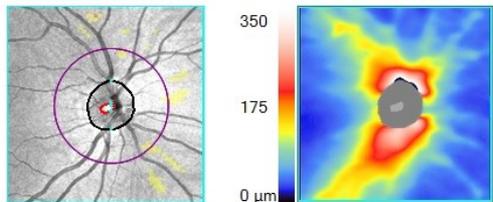
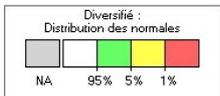
- la précision de la mesure dépend de la qualité de la segmentation
 - le plus souvent exacte dans le glaucome
 - peut être sujette à artefacts en cas de pathologie de la rétine

Épaisseur des fibres optiques



Puissance du signal 9/10

Centre du disque: (0,15,0,00)mm

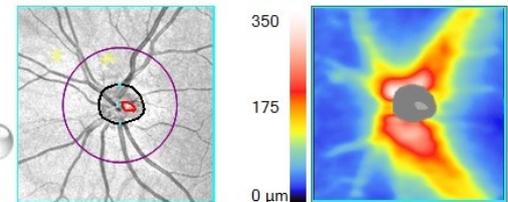


	OD	OS
Épaisseur moyenne RNFL	97 µm	103 µm
Symétrie RNFL	89%	
Aire de l'ANR	1,53 mm ²	1,22 mm ²
Aire du disque	1,63 mm ²	1,28 mm ²
Rapport C/D moyen	0,26	0,25
Rapport C/D vertical	0,20	0,22
Volume de l'excavation	0,027 mm ³	0,019 mm ³

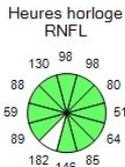
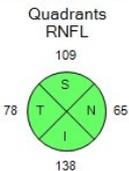
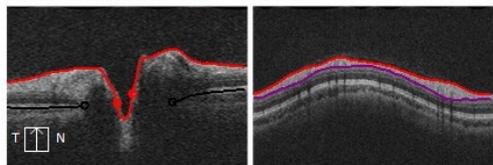
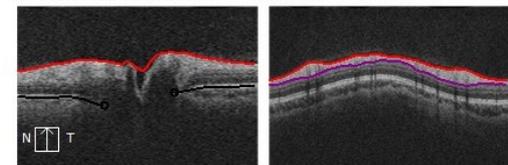
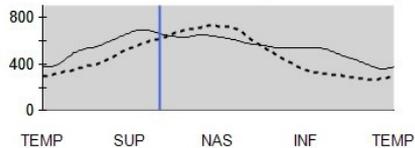


Puissance du signal 10/10

Centre du disque(0,10,0,03)mm

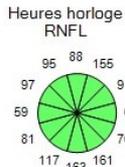
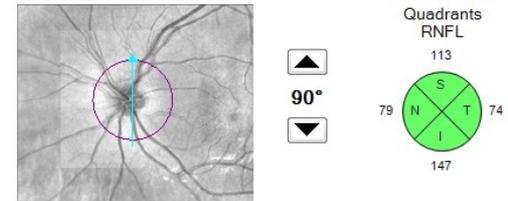
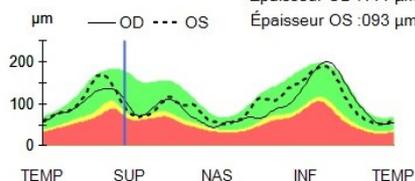


OU Épaisseur du bord de la neurorétine
Échantillon : 122
Épaisseur OD : 664 µm
Épaisseur OS : 620 µm



Transparence 50%

OU Épaisseur RNFL
Échantillon : 60
Épaisseur OD : 111 µm
Épaisseur OS : 093 µm



Transparence 50%

Choroïde

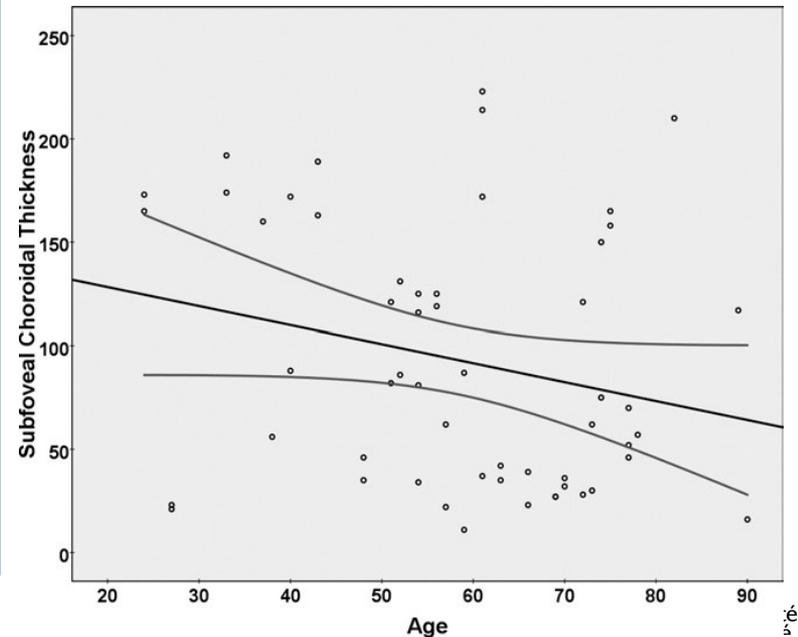
A Pilot Study of Enhanced Depth Imaging Optical Coherence Tomography of the Choroid in Normal Eyes

RON MARGOLIS AND RICHARD F. SPAIDE

- La diminution de l'épaisseur choroïdienne est surtout détectable après 50 ans
- L'épaisseur choroïdienne diminue de 12 à 16% chaque décennie
- L'épaisseur et le volume choroïdien décroissent avec l'âge
- La densité vasculaire choroïdienne diminue avec l'âge

1. Margolis R, Spaide RF. Am J Ophthalmol. 2009;147(5):811-815.
2. Fujiwara A et al. Am J Ophthalmol. July 2016.
3. REVIEW by Tan K-A, et al. Surv Ophthalmol. 2016;61(5):566-581.

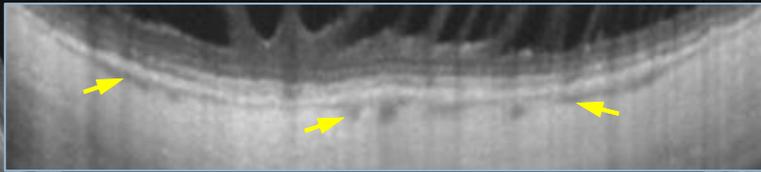
- 448 μ dans un groupe d'âge de 36 ans
- 203 μ dans un groupe d'âge de 65 ans



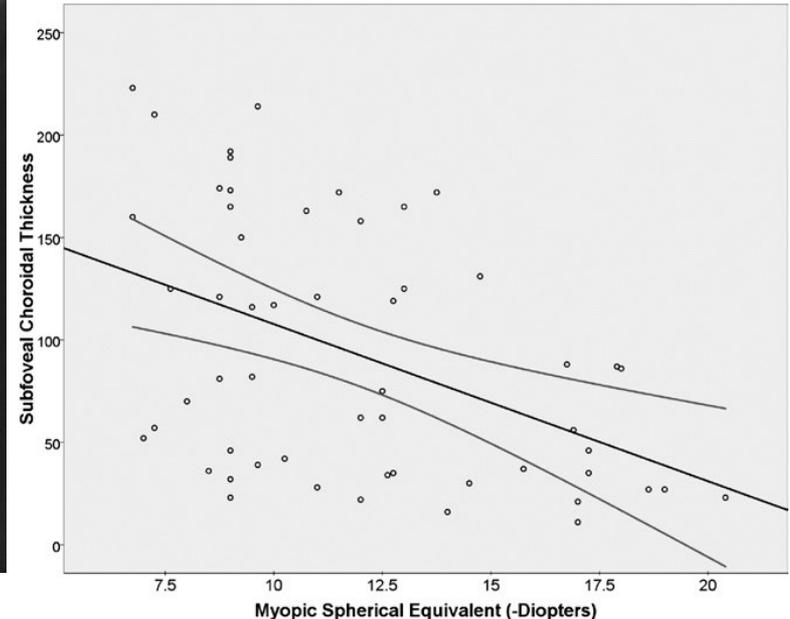
Choroïde

Enhanced Depth Imaging Optical Coherence Tomography of the Choroid in Highly Myopic Eye:

TAKAMITSU FUJIWARA, YUTAKA IMAMURA, RON MARGOLIS, JASON S. SLAKTER, AND RICHARD F. SPAIDE



- Dans la fovea , l'épaisseur choroidienne moyenne diminue avec la myopie forte : -8.7μ par dioptrie myopique

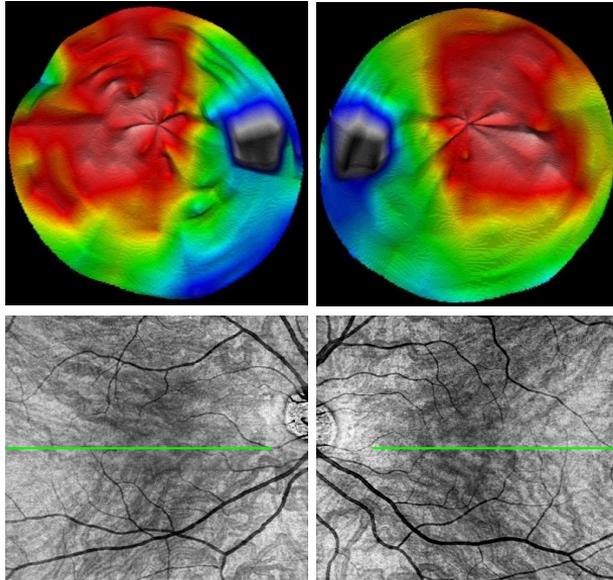


Variations de l'épaisseur choroïdienne chez le sujet normal

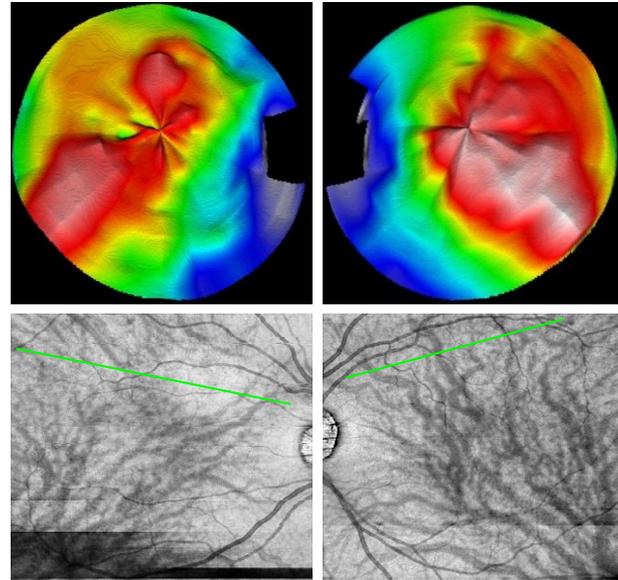
- Diminution avec l'âge ⁽²⁾
- Diminution avec la longueur axiale ⁽³⁾
- Variation diurne $\pm 34 \mu$ de 9h à 17 h ⁽¹⁾
- *Augmentation au 2^{ème} trimestre de la grossesse* ⁽⁴⁾

1. *Usui S, al. Circadian changes in subfoveal choroidal thickness and the relationship with circulatory factors in healthy subjects; IOVS 2012;53:*
2. *Wakatsuki Yet al. Correlation of Aging and Segmental Choroidal Thickness Measurement using Swept Source Optical Coherence Tomography in Healthy Eyes. Chan-Ling. PLoS ONE. 2015;10(12):e0144156*
3. *Li XQ, et al. Subfoveal choroidal thickness in relation to sex and axial length in 93 Danish university students. IOVS. 2011;52:843*
4. *Sayin N, Kara N, Pirhan D, et al. Subfoveal choroidal thickness in preeclampsia: comparison with normal pregnant and nonpregnant women. Semin Ophthalmol. 2014;29:11*

Topographie de l'épaisseur choroiidienne



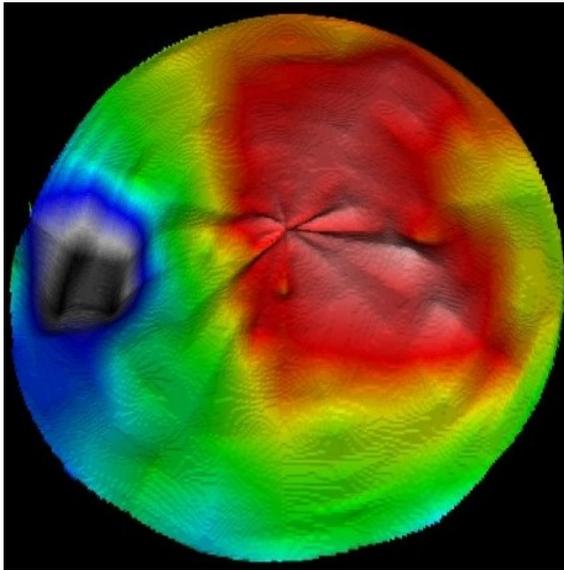
La choroïde nasale est toujours plus fine que la temporale



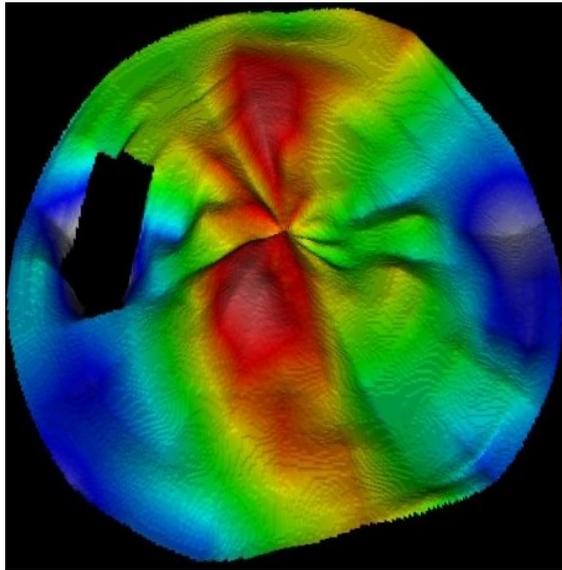
- Symétrie H-B dans 60% des cas
- En rapport avec la symétrie de drainage veineux

- Assymétrie H-B dans 40% des cas
- En rapport avec les lignes de partage du drainage veineux

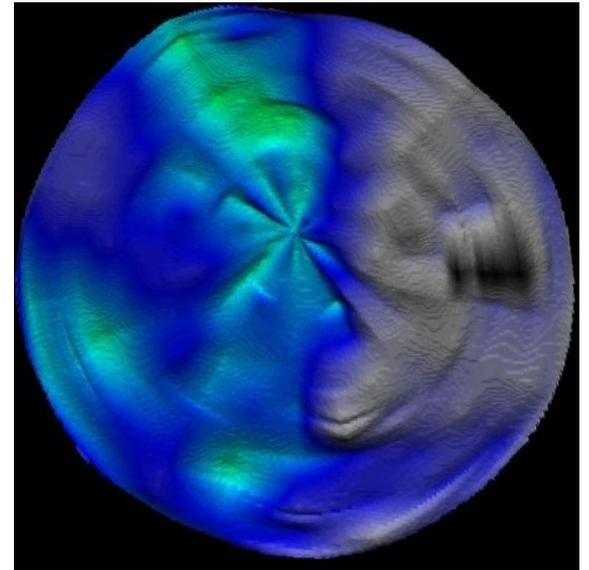
Topographie de l'épaisseur choroïdienne



Thick choroid



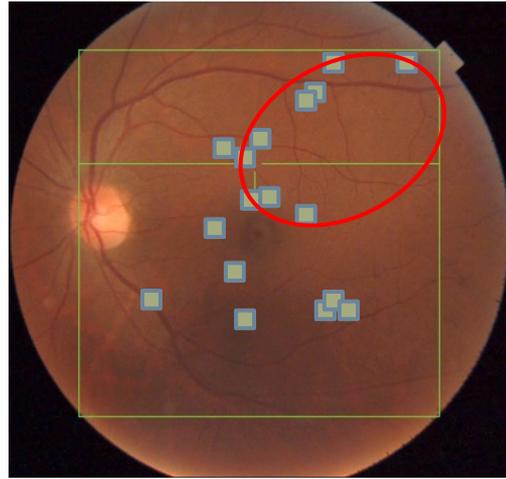
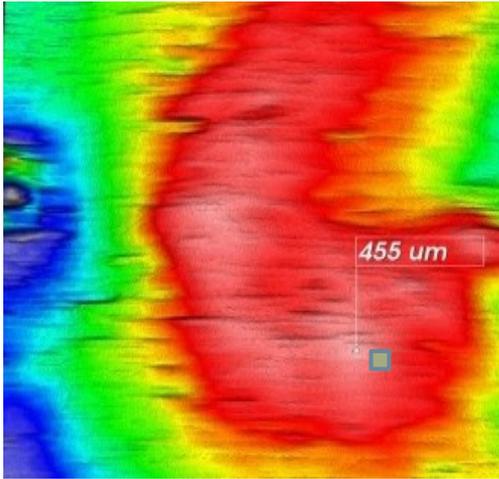
Medium choroid



Thin choroid

- La symétrie haut bas ne dépend pas de l'épaisseur moyenne de la choroïde

Topographie de l'épaisseur choroïdienne



- Dans une série de 66 yeux de patients normaux (*LRB, Sara Touhami*)
 - Âge moyen : 40 (22-50)
 - Épaisseur choroïdienne rétrofovéolaire moyenne : 340 μ
 - Supérieure à 400 μ : 30% des cas
 - Épaisseur choroïdienne maximum moyenne : 395 μ

Combined 60° Wide-Field Choroidal Thickness Maps and High-Definition En Face Vasculature Visualization Using Swept-Source Megahertz OCT at 1050 nm

Kathrin J. Mohler,¹ Wolfgang Draxinger,¹ Thomas Klein,¹ Jan Philip Kolb,^{1,2} Wolfgang Wieser,¹ Christos Haritoglou,³ Anselm Kampik,⁴ James G. Fujimoto,⁵ Aljoscha S. Neubauer,⁴ Robert Huber,^{1,2} and Armin Wolf⁴

IOVS 2015;56(11):6284.

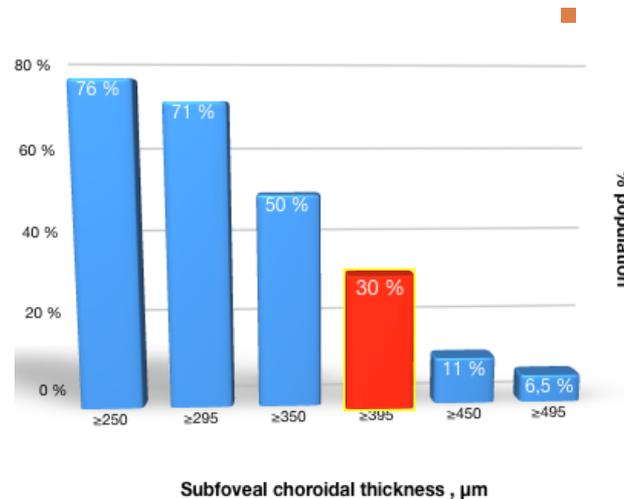
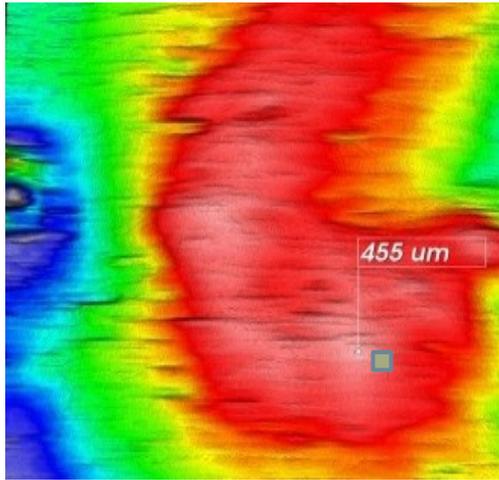
Major review

Optical coherence tomography: Imaging of the choroid and beyond

Sarah Mrejen, MD, Richard F. Spaide, MD*

Survey Ophthalmol, 58(5), 387–429.

Topographie de l'épaisseur choroïdienne



Dans une série de 66 yeux de patients normaux (*LRB, Sara Touhami*)

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 - Supérieure à 400 μ : 30% des cas

Invest Oph Vis Sci. 2020;61(3):38-38.

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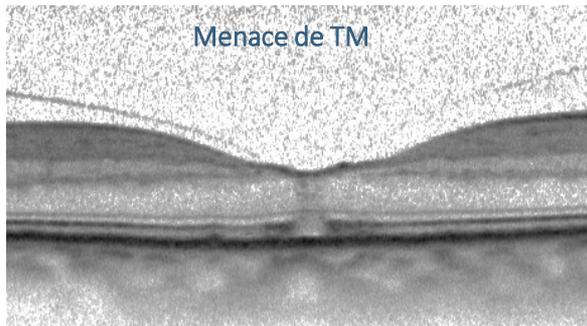
IOVS 2015;56(11):6284.

Multidisciplinary Ophthalmic Imaging

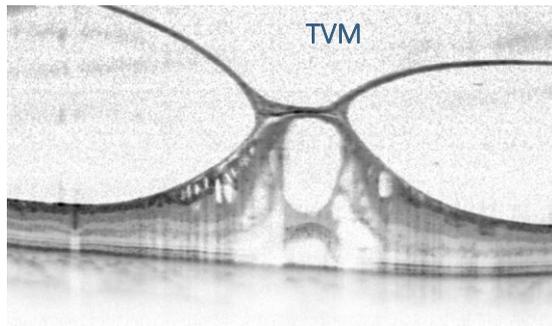
Topographic Variations of Choroidal Thickness in Healthy Eyes on Swept-Source Optical Coherence Tomography

Sara Touhami,^{1,2} Elise Philippakis,¹ Sarah Mrejen,³ Aude Couturier,¹ Céline Casteran,¹ Priscille Levent,¹ Ramin Tadayoni,¹ and Alain Gaudric¹

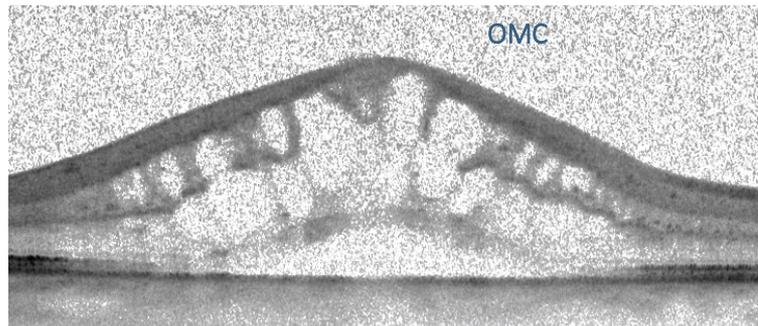
Menace de TM



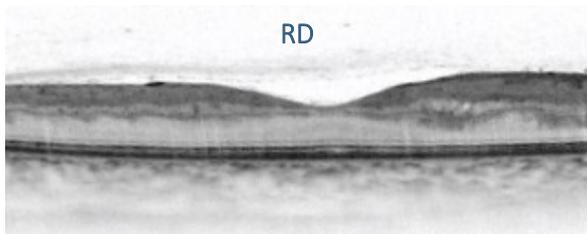
TVM



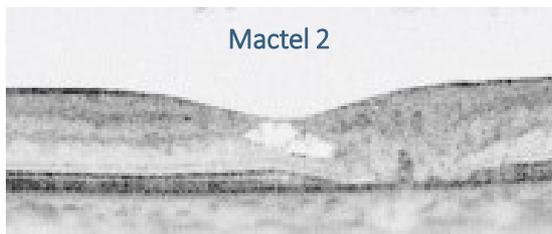
OMC



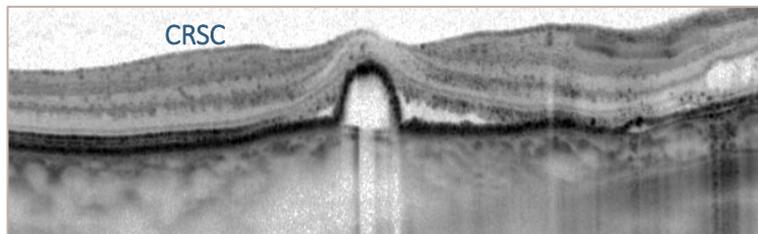
RD



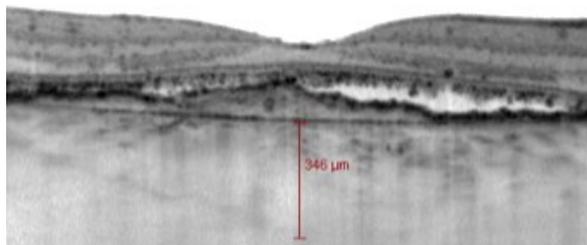
Mactel 2



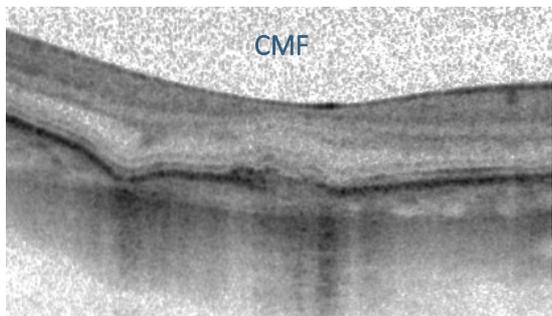
CRSC



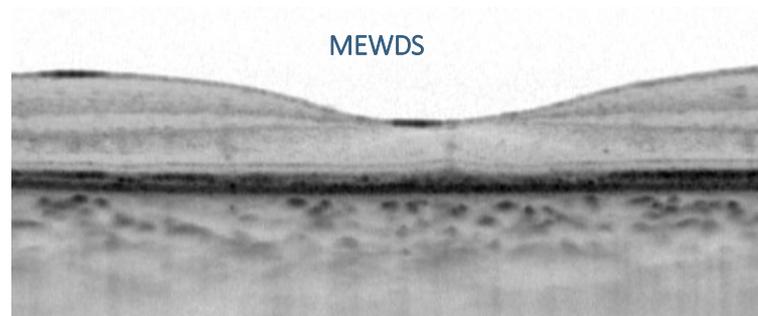
NVC 1



CMF



MEWDS



L'OCTAngio de la Macula normale

Alain Gaudric, Sophie Bonnin, Carlo Lavia



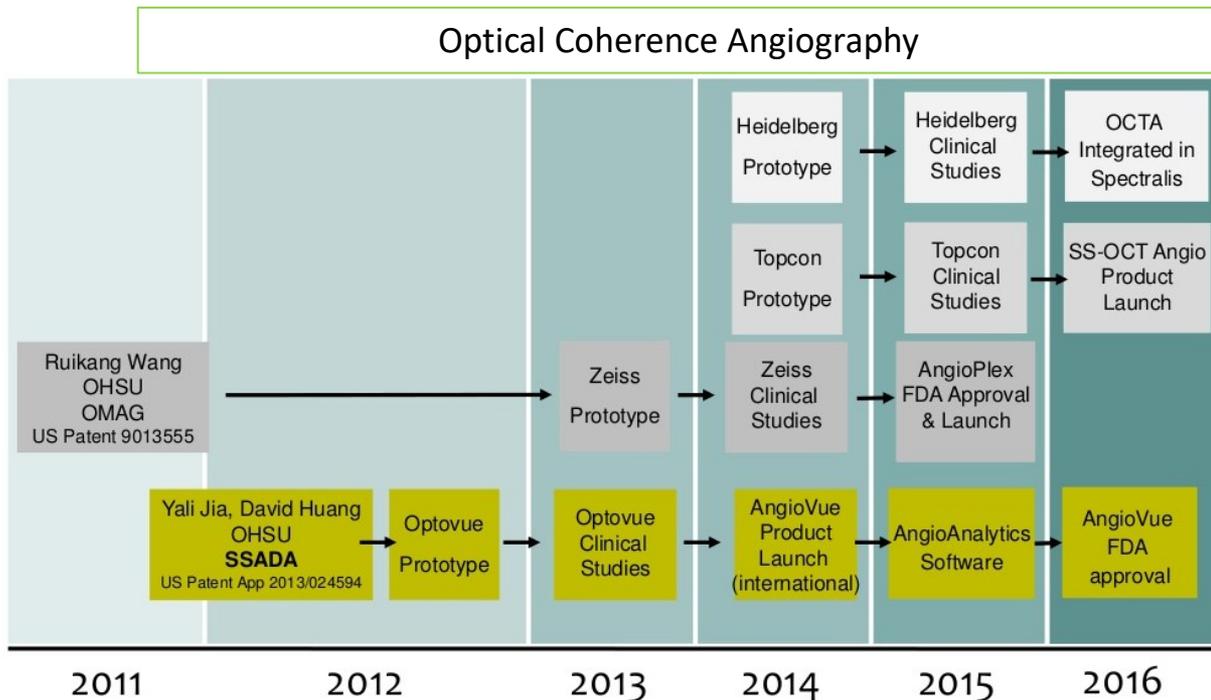
Bref historique

Optical Doppler Tomography

Speckle variance detection methods

Split-spectrum amplitude-decorrelation angiography with optical coherence tomography

Yali Jia,¹ Ou Tan,¹ Jason Tokayer,² Benjamin Potsaid,^{3,4} Yimin Wang,¹ Jonathan J. Liu,³ Martin F. Kraus,^{3,5} Hreesh Subhash,¹ James G. Fujimoto,³ Joachim Hornegger,⁵ and David Huang^{1,*}



Yali Jia



David Huang

MIT/ Casey Eye
Institute Portland

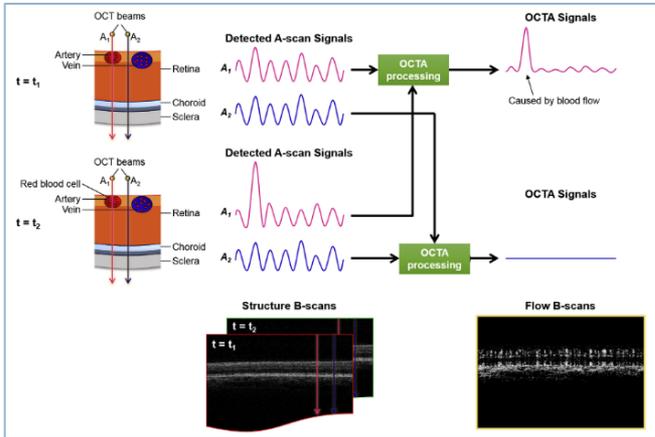
Principe résumé de l'OCTA

- Les images OCTA sont générées à l'aide d'une plate-forme basée sur l'OCT.
- Le tissu rétinien est stationnaire.
 - Des scans B séquentiels au même endroit de la rétine sont inchangés, à l'exception du mouvement des globules rouges
- La comparaison des balayages B, décalés dans le temps mais pas dans l'espace, pixel par pixel,
 - génère une imagerie de contraste de mouvement de la vascularisation rétinienne, en volume.

Principe de l'OCTA

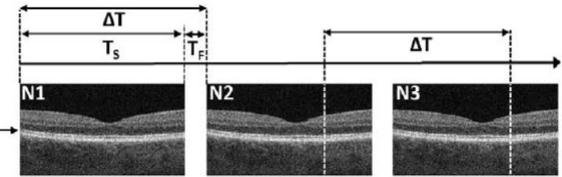
Interscan time: $\Delta T = T_F + T_S$

OCT beam back to initial position: fly back (TF)



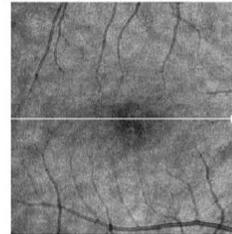
Opt Express. 2012;20(4):4710-4725

B-scan acquisition time (T_S)



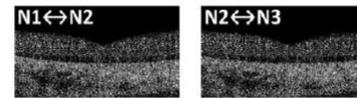
Commercial OCTA:
2 to 4 repeated B-scans

En Face OCT

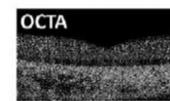


A scan acquired at a certain rate \rightarrow B scan

L1



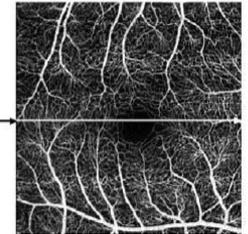
L2



L3



En Face OCTA



Interscan time makes the difference
Longer: higher sensitivity to intraretinal movements and bulk eye motion

Projection Artifacts Removal

52

Biomedical Optics EXPRESS

Projection-resolved optical coherence tomographic angiography

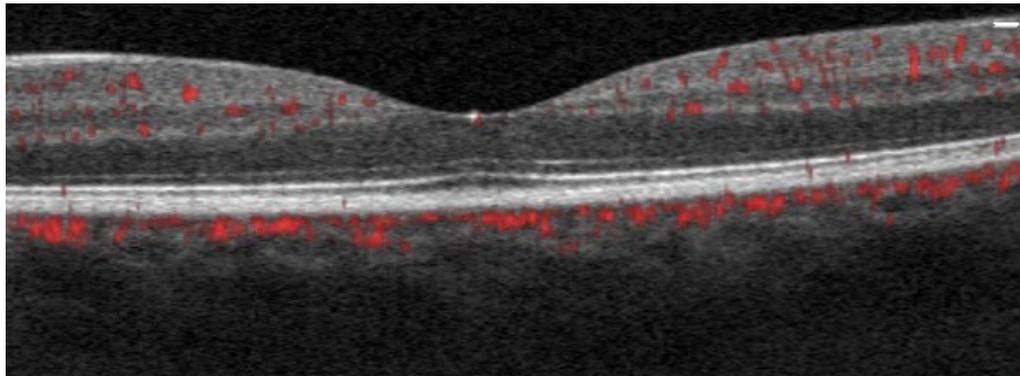
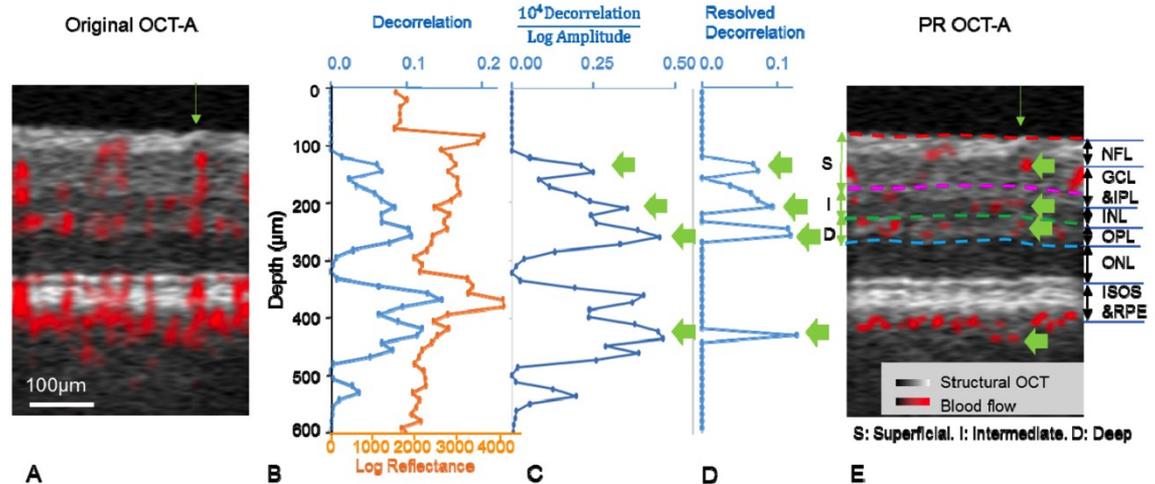
Miao Zhang, Thomas S. Hwang, J. Peter Campbell, Steven T. Bailey, David J. Wilson, David Huang and Yali Jia*

Casey Eye Institute, Oregon Health & Science University, Portland, OR 97239, USA
*jiaya@ohsu.edu

Zhang M, Hwang TS, Campbell JP, et al.

Biomed Opt Express, BOE. 2016;7(3):816-828.

Casey Eye Institute, Oregon Health & Science University



"This new algorithm identifies voxels with in situ flow as those where intensity-normalized decorrelation values are higher than all shallower voxels in the same axial scan line"

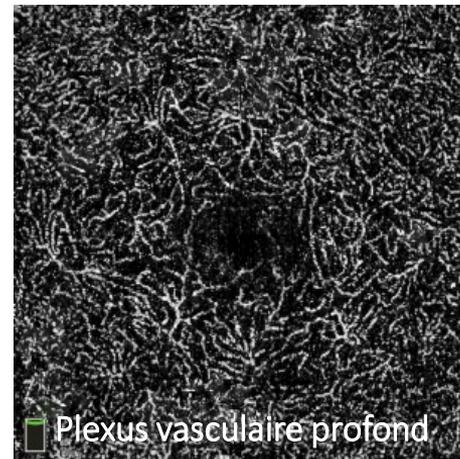
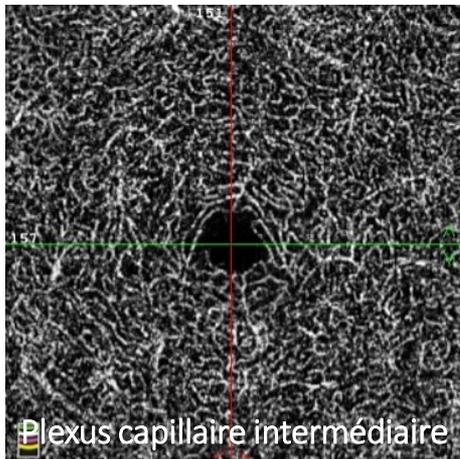
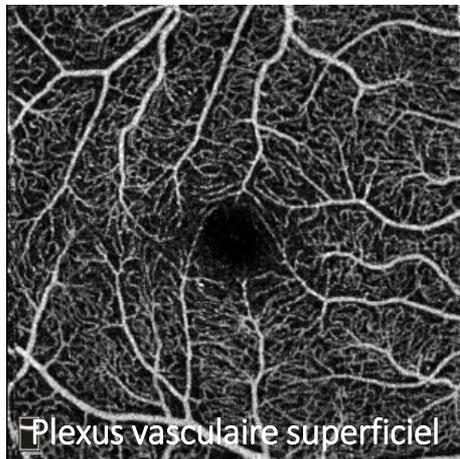
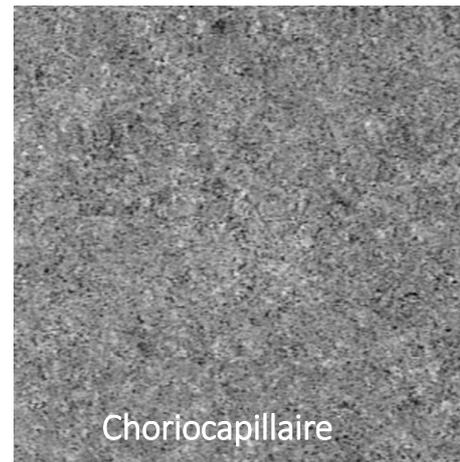
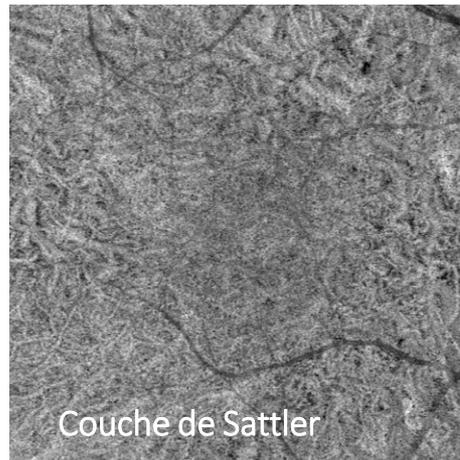
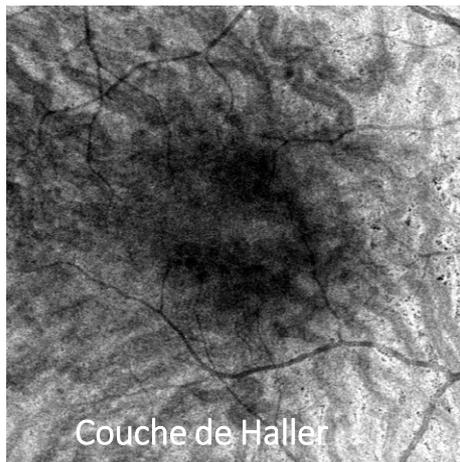
Optovue has developed a 3D projection artifacts removal (3D PAR) software, that we used for analyzing the retinal capillary network in normal.

Différents algorithmes utilisés

- Les fabricants d'appareils d'OCT ont développé des algorithmes propriétaires pour générer l'image des vaisseaux obtenus par contraste de mouvement et gérer les artéfacts .
- Les résultats de mesure de densité ne sont pas comparables d'un appareil à l'autre

Manufacturer	Device Name	OCT Modality	Algorithm	Scanning Speed (A-scans/sec)
Carl Zeiss Meditech	Cirrus HD-OCT Angioplex	Spectral domain	OMAG	68,000
	PLEX Elite 9000	Swept source	OMAG	100,000
Canon	OCT-HS100	Spectral domain	Modified FSADA	70,000
Heidelberg Engineering	Spectralis OCT Angiography	Spectral domain	FSADA	85,000
Nidek	RS-3000 Advance Angioscan	Spectral domain	CODAA	53,000
OPTOPOL	REVO NX OCTA	Spectral domain	SOA	110,000
Optovue	RTVue XR Avanti Angiovue	Spectral domain	SSADA	70,000
Topcon	DRI OCT Triton	Swept source	OCTARA	100,000

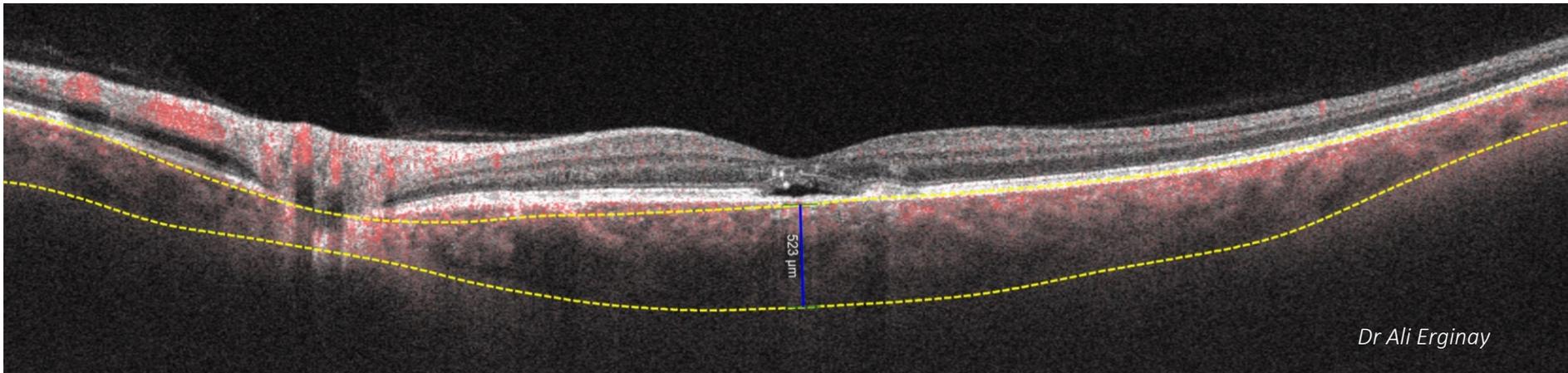
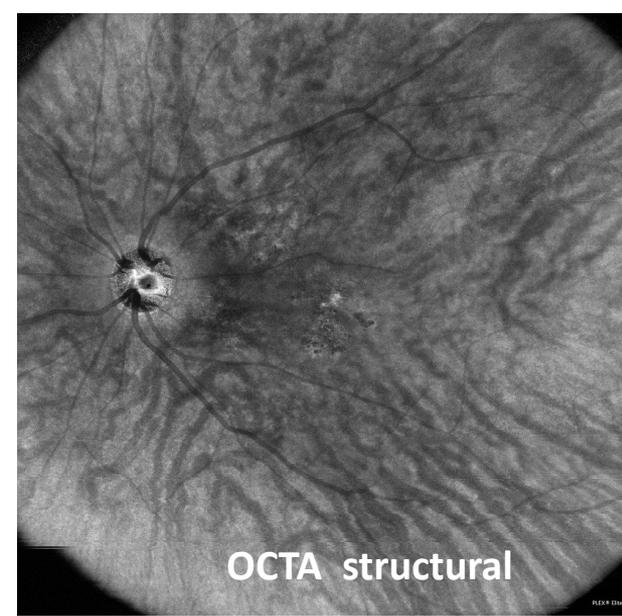
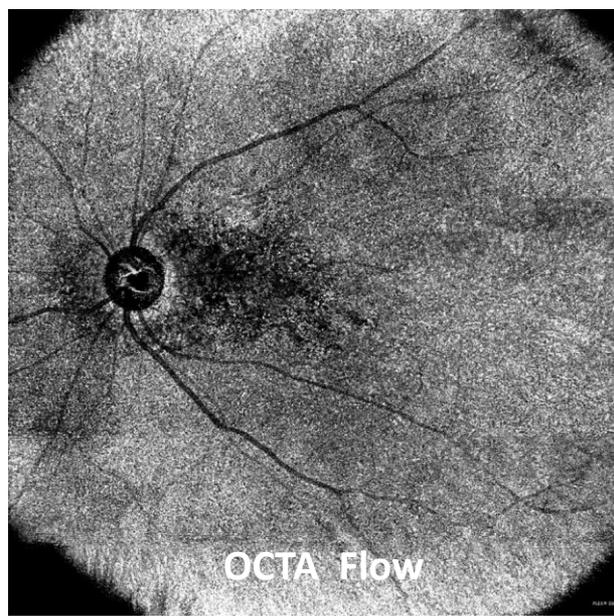
Les différentes couches vasculaires du FO



OCTA et Choroïde

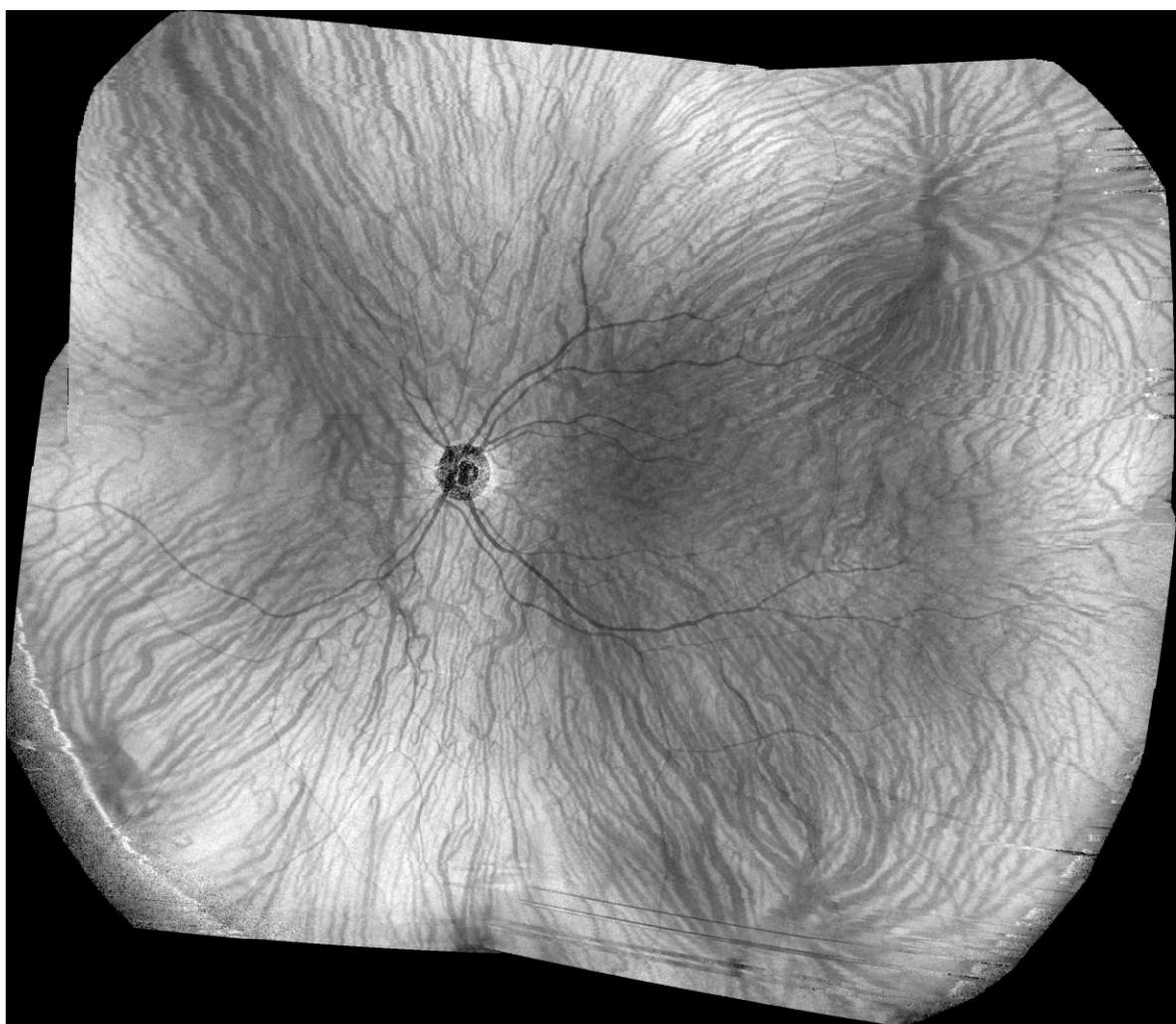
La choroïde

- L'analyse du flux dans les gros vaisseaux est décevante.



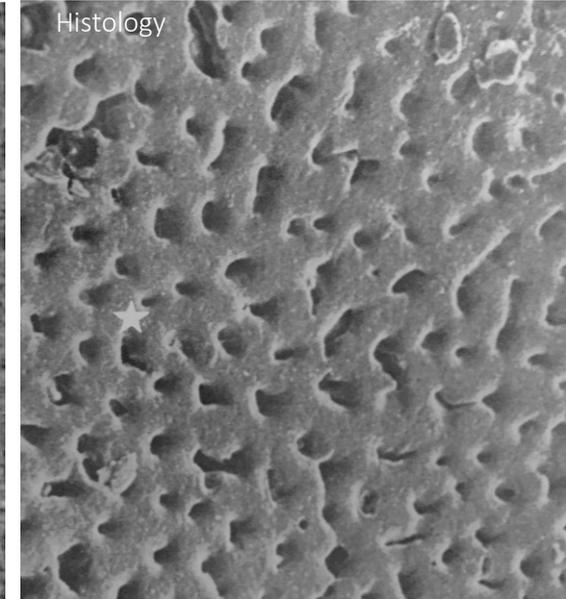
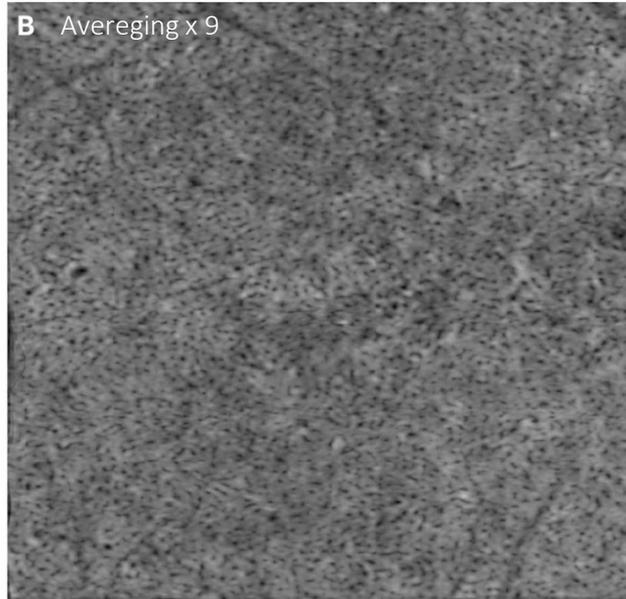
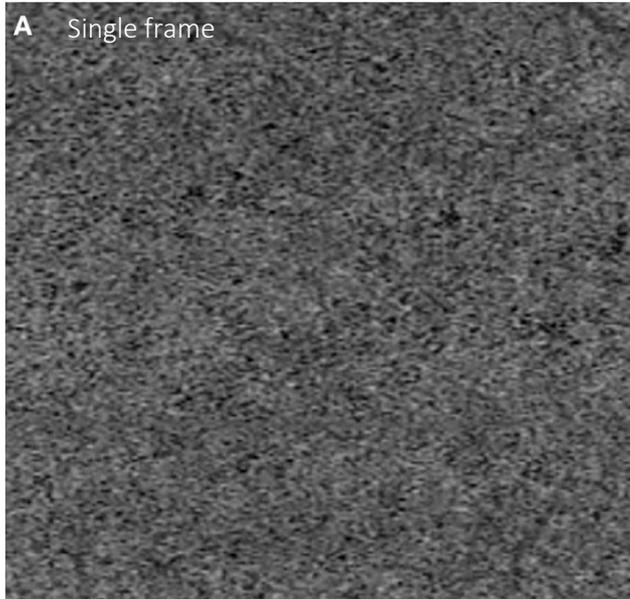
La choroïde

- L'analyse du flux dans les gros vaisseaux est décevante.
- Par contre il est possible de reconstituer assez fidèlement le réseau principalement veineux sur l'image structurelle



Choriocapillaris

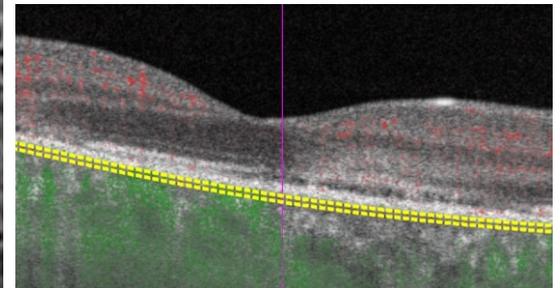
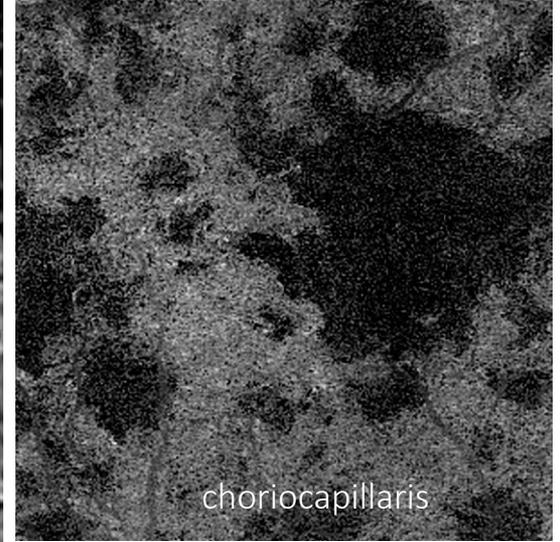
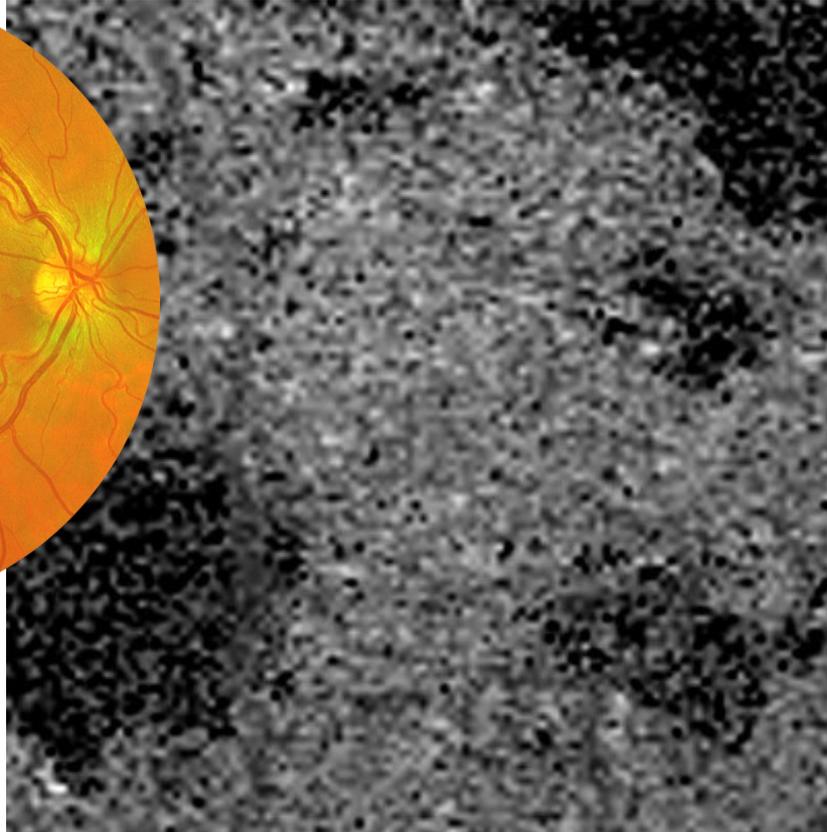
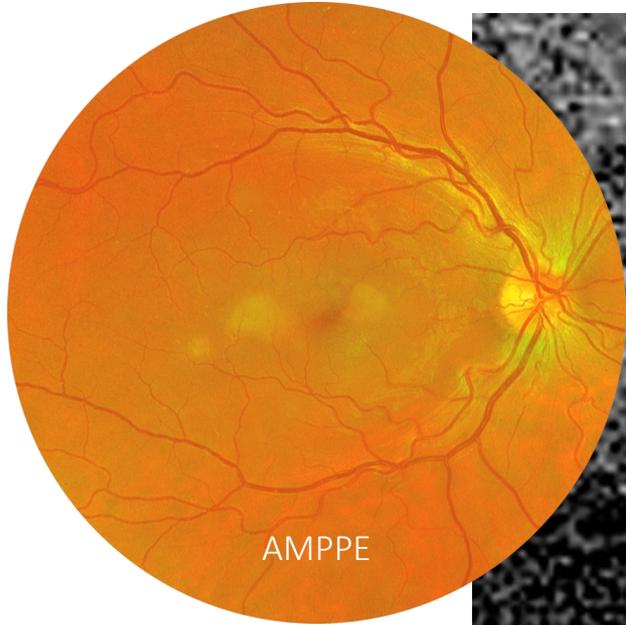
- Imaging of the choriocapillaris remains difficult



Borrelli, E., Sarraf, D., Freund, K. B., & Sadda, S. R. (2018). OCT angiography and evaluation of the choroid and choroidal vascular disorders. *Progress in Retinal and Eye Research*, 67, 30–55.

Shimizu K, Ujje K, Structure of Ocular vessels . Ikaku-Shoin Tokyo 1978

Choriocapillaris



Controversies

Choriocapillaris Flow Features Follow a Power Law Distribution: Implications for Characterization and Mechanisms of Disease Progression

RICHARD F. SPAIDE *Am J Ophthalmol 2016*

When the innermost thickness of the choroid is sampled with OCT angiography, a granular image is obtained that is suggestive of the choriocapillaris.⁵ The resultant image shows a pattern of bright areas, thought to represent flow. The granularity of the choriocapillaris image is created not only by the bright regions, but also by many small dark regions in the image. The anatomic structure of the choriocapillaris does not appear to explain the dark areas, but there has to be a relative decrease in local flow signal for the dark areas to be imaged. As such, these small areas are called flow voids.⁵

Lorsque l'on échantillonne l'épaisseur de la partie la plus interne de la choroïde par OCTA, on obtient une image granulaire qui évoque le choriocapillaire. L'image résultante présente un motif de zones claires, censées représenter le flux. La granularité de l'image de choriocapillaire est créée non seulement par les régions claires, mais aussi par de nombreuses petites régions sombres dans l'image. La structure anatomique de choriocapillaire ne semble pas expliquer les zones sombres, mais il doit y avoir une diminution relative du signal de flux local pour que les zones sombres apparaissent. En tant que telles, ces petites zones sont appelées "flow voids" (absence de flux)

Ces "flow voids ne représentent pas les espaces intercapillaires pour 2 raisons :

- 1: l'épaisseur du "slab" choriocapillaire intègre une partie de la choroïde interne
- 2 : la résolution latérale de l'OCT/OCTA excède la dimension des espaces intercapillaires

Controverses

- Le signal de la choriocapillaire donné par l'OCTA est très sensible aux anomalies et opacités de l'EP sus-jacent .
 - des algorithmes ont été développés pour les effacer , et sont contestés

A Novel Strategy for Quantifying Choriocapillaris Flow Voids Using Swept-Source OCT Angiography *IOVS 2018*

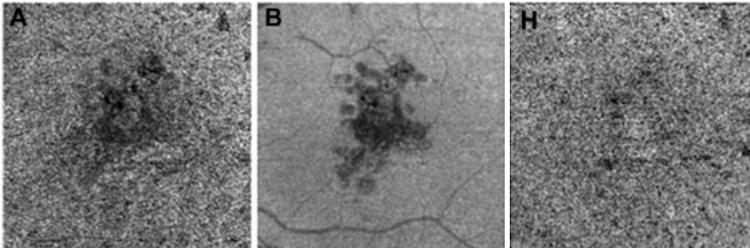
Qinqin Zhang,¹ Fang Zheng,² Elie H. Motulsky,² Giovanni Gregori,² Zhongdi Chu,¹ Chieh-Li Chen,¹ Chunxia Li,¹ Luis de Sisternes,³ Mary Durbin,³ Philip J. Rosenfeld,² and Ruikang K. Wang^{1,4}

Correlations Between Different Choriocapillaris Flow Deficit Parameters in Normal Eyes Using Swept Source OCT Angiography



Am J Ophthalmol 2020

YINGYING SHI, QINQIN ZHANG, FANG ZHENG, JONATHAN F. RUSSELL, ELIE H. MOTULSKY, JAMES T. BANTA, ZHONGDI CHU, HAO ZHOU, NIMESH A. PATEL, LUIS DE SISTERNES, MARY K. DURBIN, WILLIAM FEUER, GIOVANNI GREGORI, RUIKANG K. WANG, AND PHILIP J. ROSENFELD



SWEPT-SOURCE OPTICAL COHERENCE TOMOGRAPHY ANGIOGRAPHY IMAGE COMPENSATION OF THE CHORIOCAPILLARIS INDUCES ARTIFACTS

RETINA 2020

GERARDO LEDESMA-GIL, MD, PEDRO FERNANDEZ-AVELLANEDA, MD, RICHARD F. SPAIDE, MD

- Il faut donc interpréter avec sens critique les articles sur la densité de la choriocapillaire

Néovaisseaux choroïdiens

- Le grand succès de l'OCTA a été le diagnostic des NVC, qui a fait pratiquement disparaître les indications de l'angiographie à la fluorescéine dans la DMLA

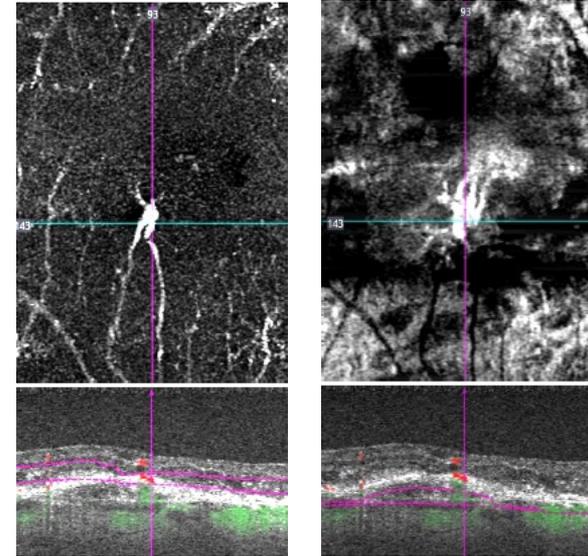
Special Issue

A Comparison Between Optical Coherence Tomography Angiography and Fluorescein Angiography for the Imaging of Type 1 Neovascularization

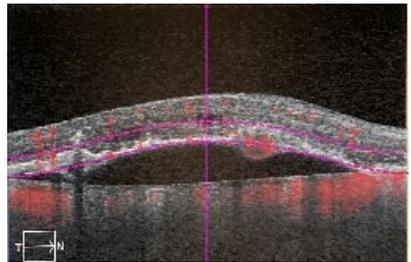
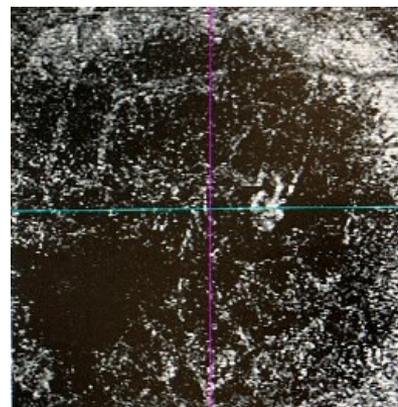
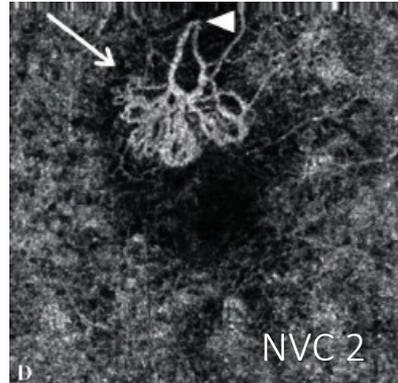
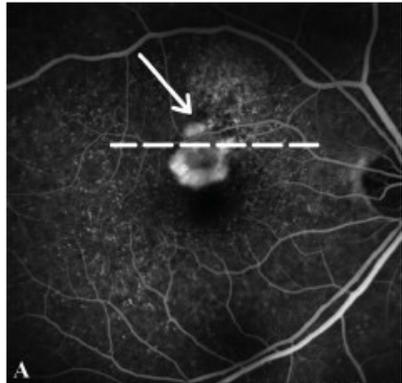
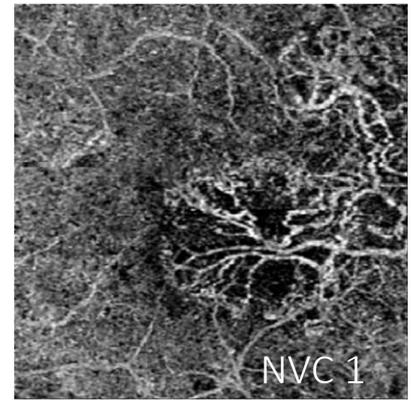
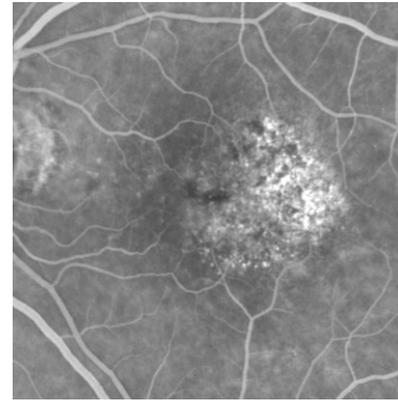
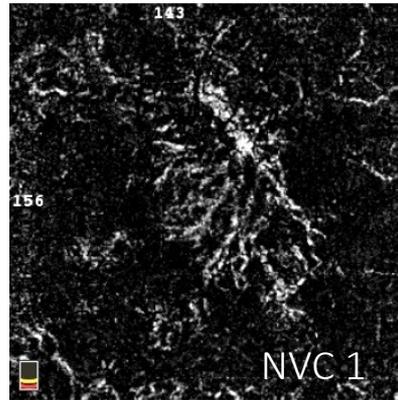
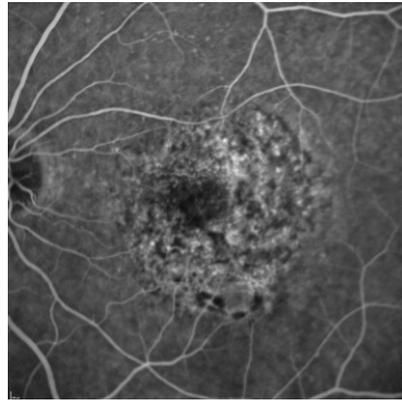
Maiko Inoue,¹⁻³ Jesse J. Jung,^{1,2,4,5} Chandrakumar Balaratnasingam,^{1,2} Kunal K. Dansingani,^{1,2} Elona Dhrami-Gavazi,^{1,2,4} Mihoko Suzuki,^{1,2} Talisa E. de Carlo,^{6,7} Abtin Shahlaee,⁸ Michael A. Klufas,^{9,10} Adil El Maftouhi,¹¹ Jay S. Duker,⁶ Allen C. Ho,⁸ Maddalena Quaranta-El Maftouhi,¹¹ David Sarraf,^{9,10} and K. Bailey Freund^{1,2,12}; for the COFT-1 Study Group

Investigative Ophthalmology Vis Sci. 2016;57(9):OCT314.

CONCLUSIONS. L'OCTA en face et l'OCT structurel ont permis de mieux détecter les NV de type 1 que l'AF seule ou l'OCTA en face seule. La combinaison des informations de l'OCTA en face et de l'OCT structurel peut donc être un moyen utile de diagnostiquer de manière non invasive et de suivre le traitement des NV de type 1.

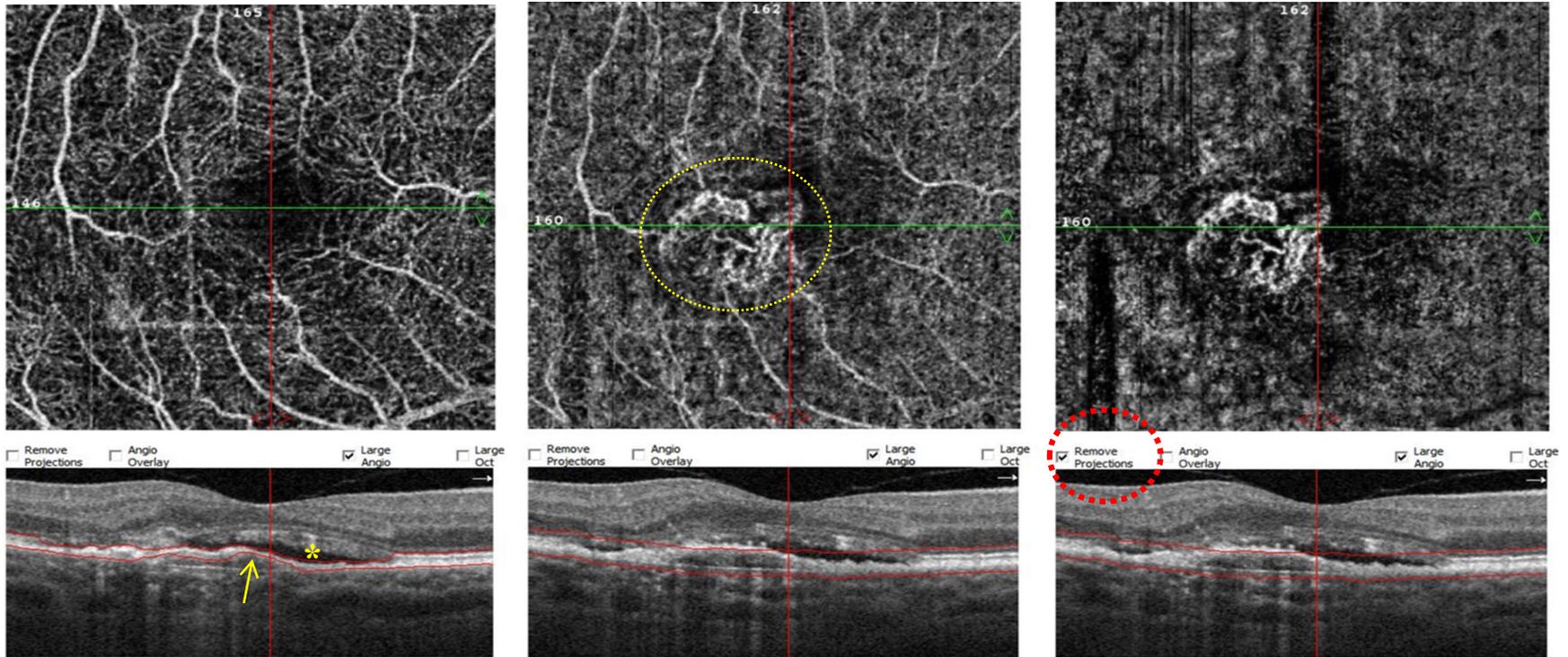


L'OCTA diagnostique tout type de NVC



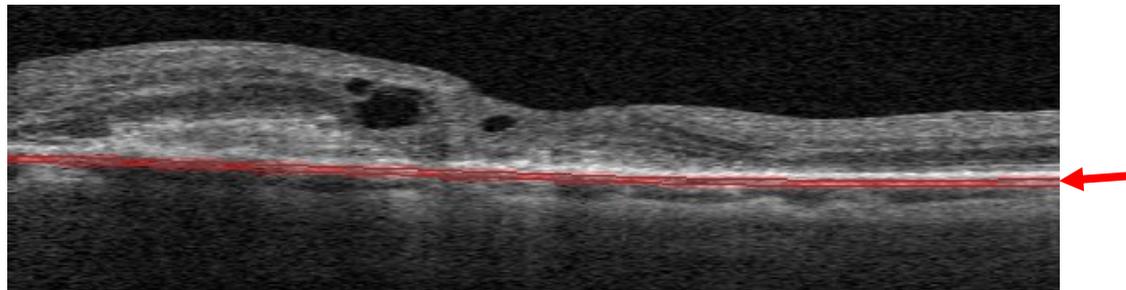
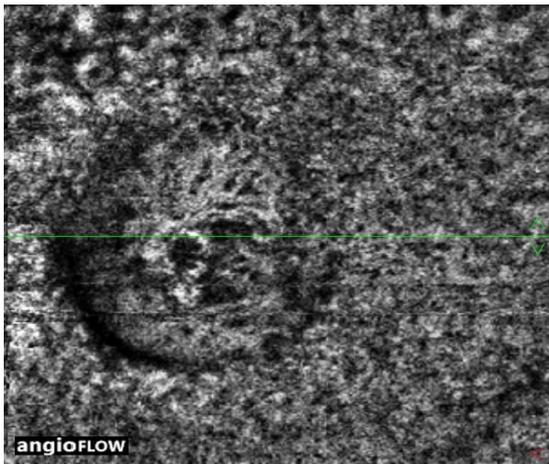
NVC 3

Artefacts de segmentation

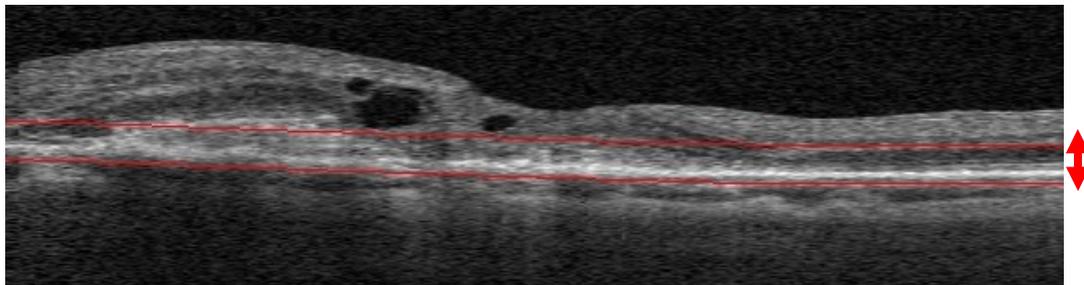
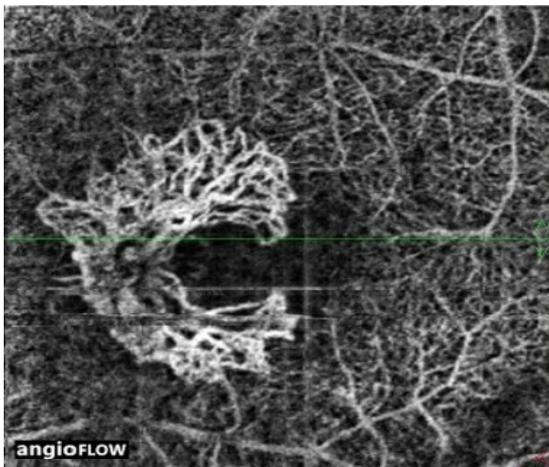


La correction des artefacts de segmentation et l'élimination des projections fait apparaître les NVC

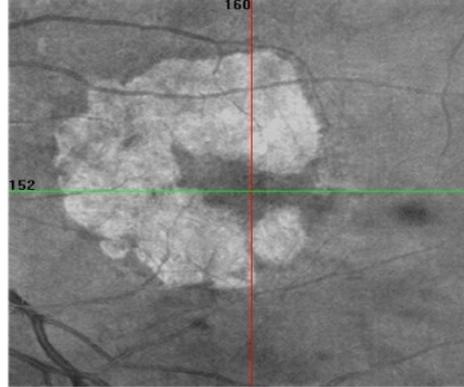
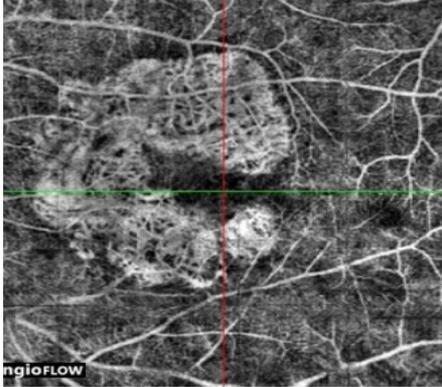
Ajustement de la segmentation



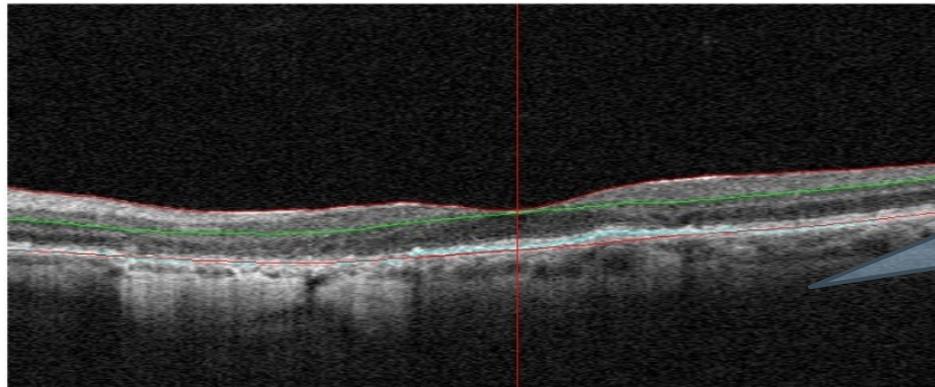
adjustment of slab boundaries



Confusion avec atrophie choroïdienne



Toujours regarder l'image en face structurelle, et le B-scan

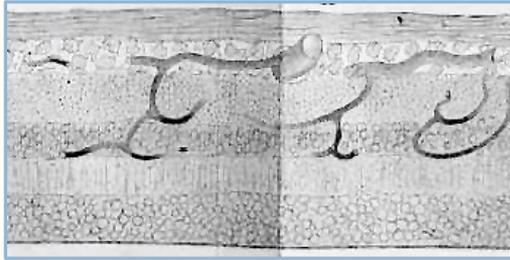


Pas de DSR
Pas de DEP
Hypertransmission dans la choroïde

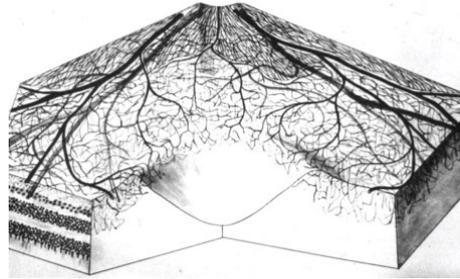
OCTA et circulation rétinienne

Schematization of retinal capillaries

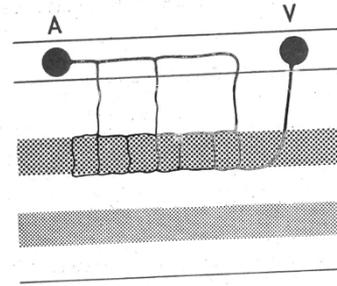
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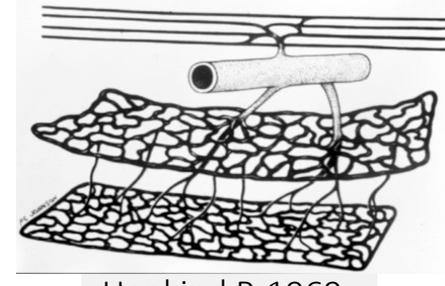
His W 1880



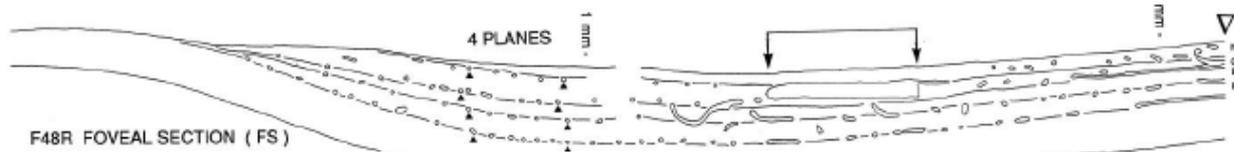
Toussaint D, 1961



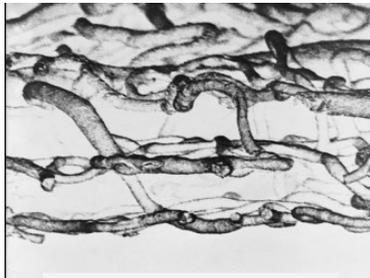
Cunha-Vaz J, 1967



Henkind P, 1969

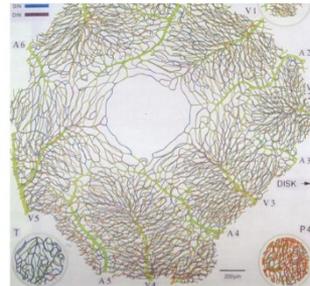


Snodderly DM, 1992

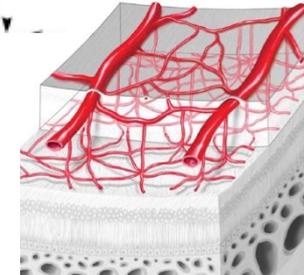


Shimizu K, 1978

Hôpital Lariboisière



Paques M, 2003

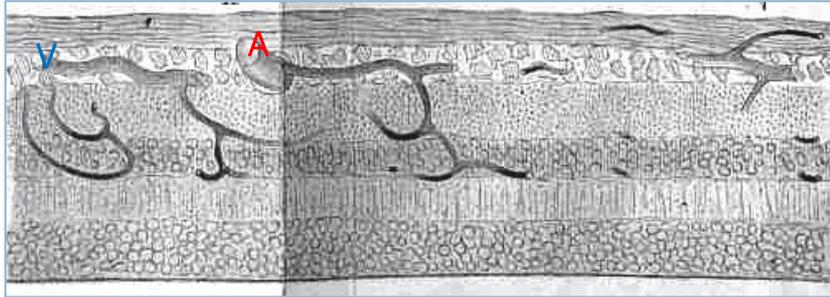


Savastano MC, 2015

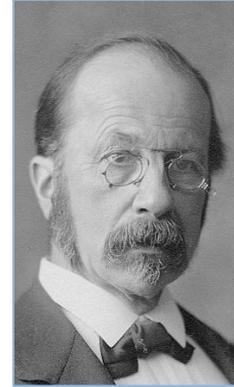
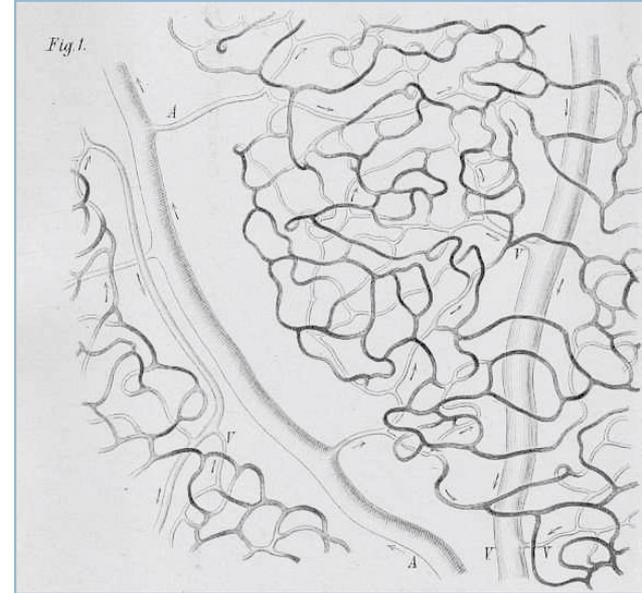
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Schematization of retinal capillaries

Abbildungen über das Gefässsystem der menschlichen
Netzhaut und derjenigen des Kaninchens.
Von
Wilhelm His.



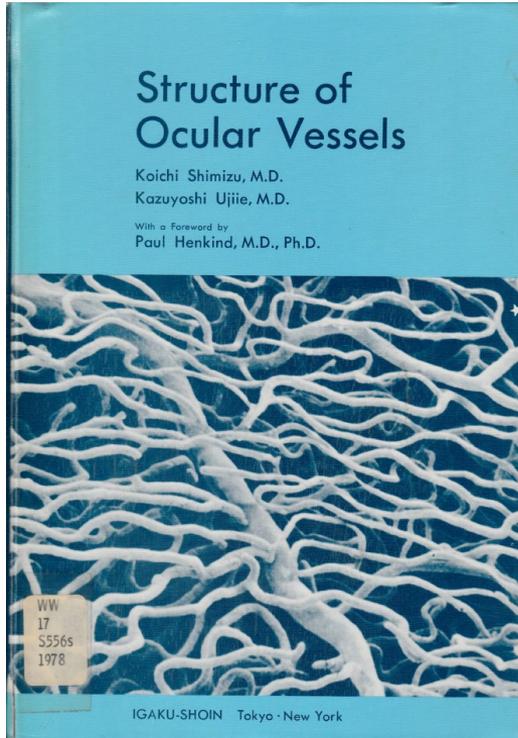
W His , Arch Anat Entwicklungsgn5:224, 1880



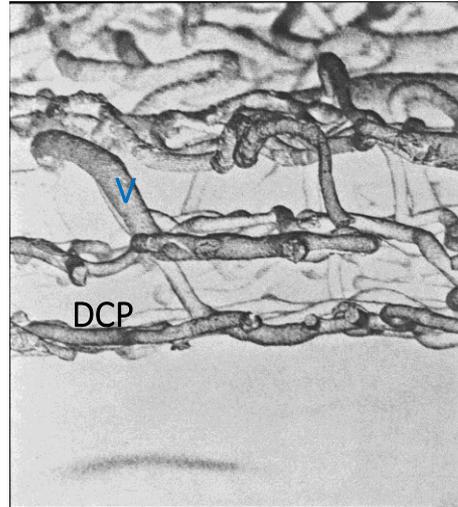
Wilhelm His Sr

- First description of 3 retinal capillary levels and direct drainage of the DCP in superficial venules

Schematization of retinal capillaries



Shimizu, K., & Ujiie, K. (1978). *Structure of ocular vessels*. Igaku-Shoin Medical Publishers.



Koichi Shimizu

- In intravascular casts, K. Shimizu showed the presence of direct capillary drainage of the DCP into superficial veins in monkey eyes. (1978)

Schematization of retinal capillaries

Neural-Vascular Relationships in Central Retina of Macaque Monkeys (*Macaca fascicularis*)

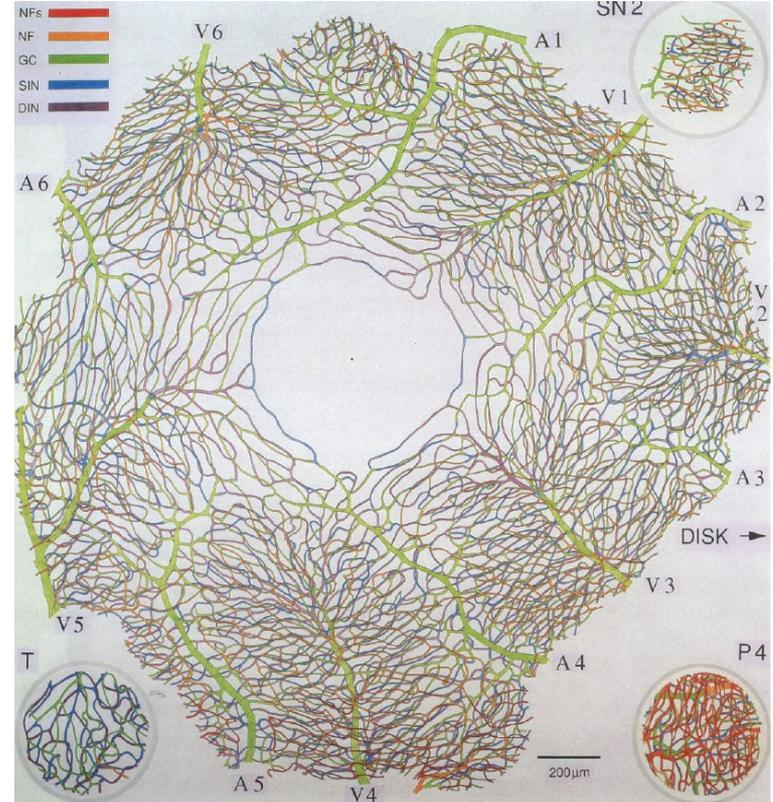
D. Max Snodderly,^{1,2,3} Richard S. Weinhaus,^{1,2,a} and John C. Choi^{1,b}

The Journal of neuroscience 1992;12(4):1169-1193.

« Les affluents veineux ont une distribution et une géométrie très différentes.[. des artères..]

Du côté veineux de la circulation, les vaisseaux de chaque plan capillaire convergent habituellement vers des affluents qui qui se jettent ensuite dans le tronc veineux principal.

Il existe également de nombreux cas de capillaires individuels se drainant directement dans le tronc veineux principal »

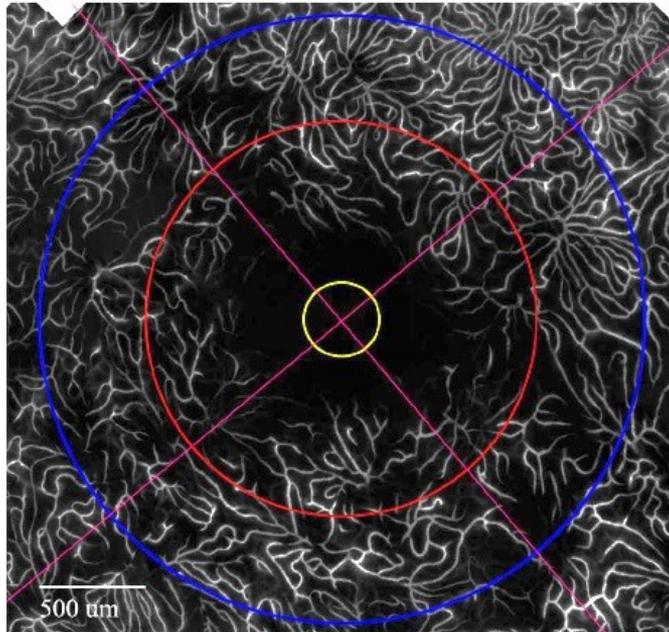


Confocal histology of the retinal capillaries

72

Quantitative Study of the Macular Microvasculature in Human Donor Eyes

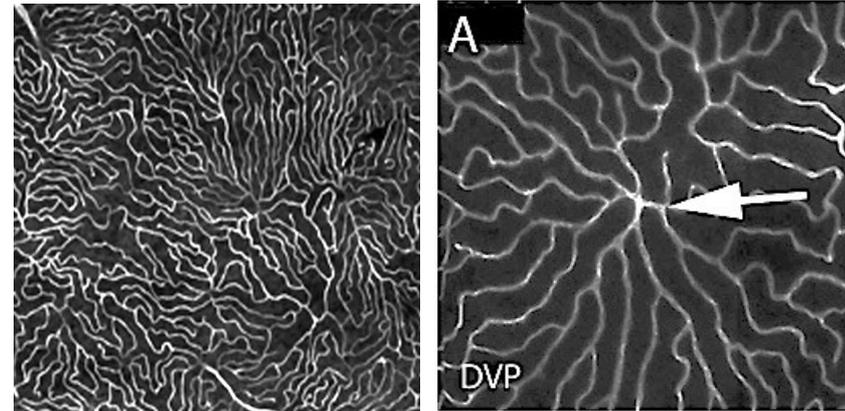
Paula K. Yu,^{1,2} Zaid Mammo,³ Chandrakumar Balaratnasingam,^{1,2,4} and Dao-Yi Yu^{1,2}



Invest Ophthalmol & Vis Sci. 2018;59(1):108-116.

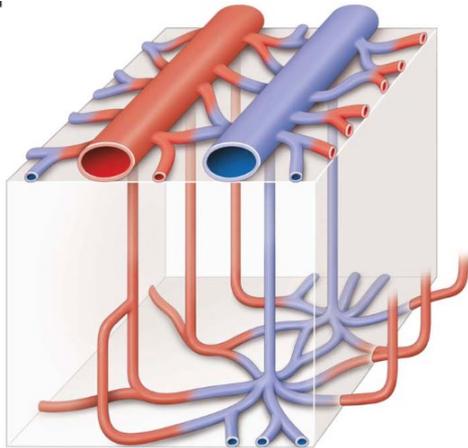
The 3D Retinal Capillary Circulation in Pigs Reveals a Predominant Serial Organization

Stéphane Fouquet,¹ Ophélie Vacca,¹ Florian Sennlaub,¹ and Michel Paques^{1,2}



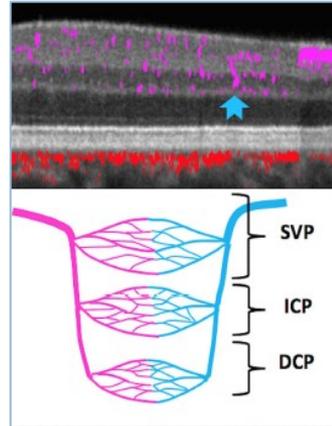
Fouquet S, Vacca O, Sennlaub F, Paques M. Invest Ophthalmol Vis Sci. 2017;58(13):5754-5763.

Structure of capillary plexuses



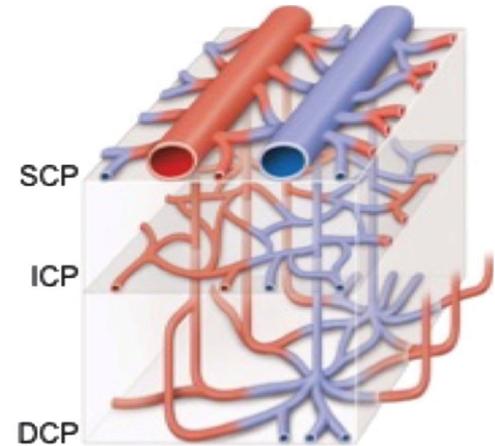
Bonnin 2015

Bonnin S, Mané V, Couturier A, Gaudric A . New Insight Into The Macular Deep Vascular Plexus Imaged By Optical Coherence Tomography Angiography. Retina. 2015;35(11):2347-2352.



Campbell 2017

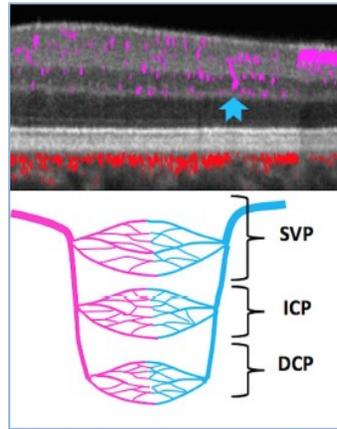
Campbell JP, Zhang M, Hwang TS, et al. Detailed Vascular Anatomy of the Human Retina by Projection-Resolved Optical Coherence Tomography Angiography. Sci Rep. 2017;7:42201.



Garrity 2017

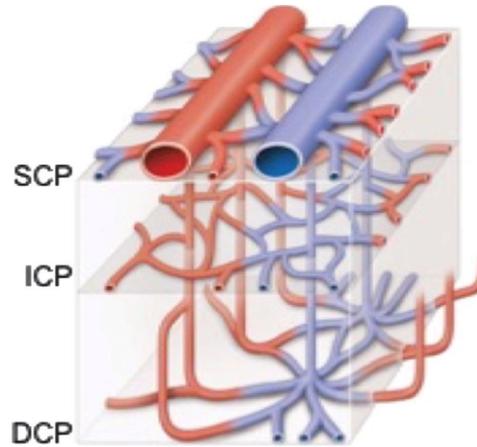
Garrity ST, Paques M, Gaudric A, Freund KB, Sarraf D. Considerations in the Understanding of Venous Outflow in the Retinal Capillary Plexus. Retina 2017;37(10):1809-1812.

Structure of capillary plexuses



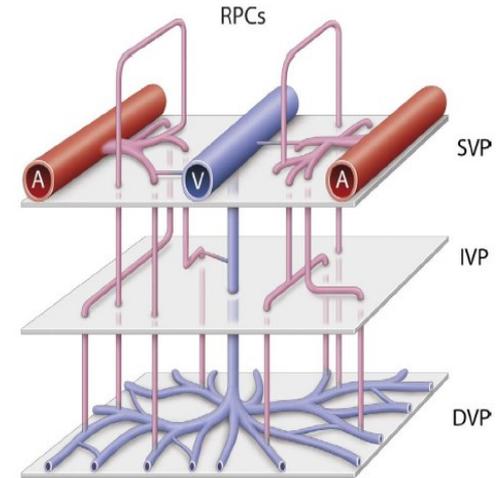
Campbell 2017

Campbell JP, Zhang M, Hwang TS, et al. Detailed Vascular Anatomy of the Human Retina by Projection-Resolved Optical Coherence Tomography Angiography. *Sci Rep.* 2017;7:42201.



Garrity 2017

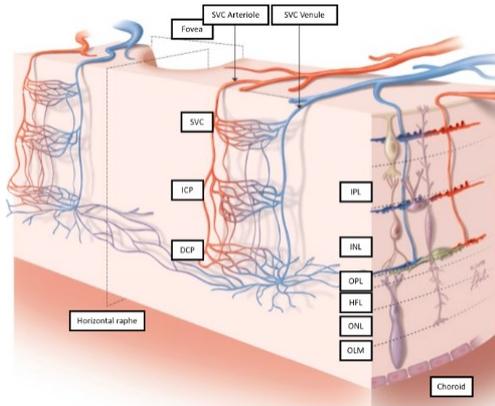
Garrity ST, Paques M, Gaudric A, Freund KB, Sarraf D. Considerations in the Understanding of Venous Outflow in the Retinal Capillary Plexus. *Retina* 2017;37(10):1809-1812.



Paques 2017

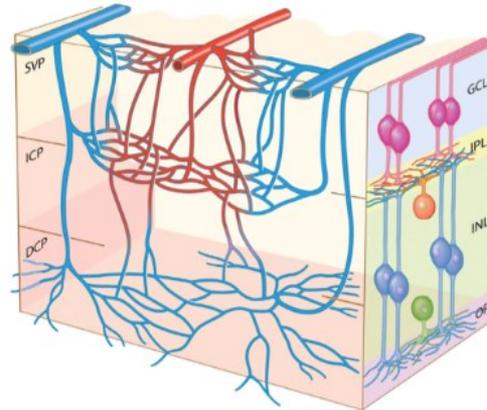
Fouquet S, Vacca O, Sennlaub F, Paques M. The 3D Retinal Capillary Circulation in Pigs Reveals a Predominant Serial Organization. *Investigative Ophthalmology & Visual Science.* 2017;58(13):5754-5763.

Structure of capillary plexuses



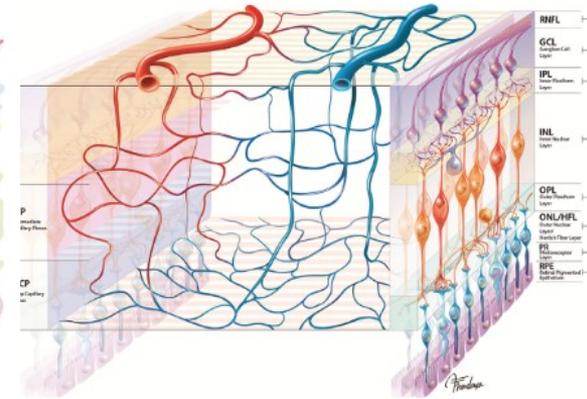
Nesper 2018

Nesper PL, Fawzi AA. Human Parafoveal Capillary Vascular Anatomy and Connectivity Revealed by Optical Coherence Tomography Angiography. *Invest Ophth Vis Sci.* 2018;59(10):3858-3867.



An 2020

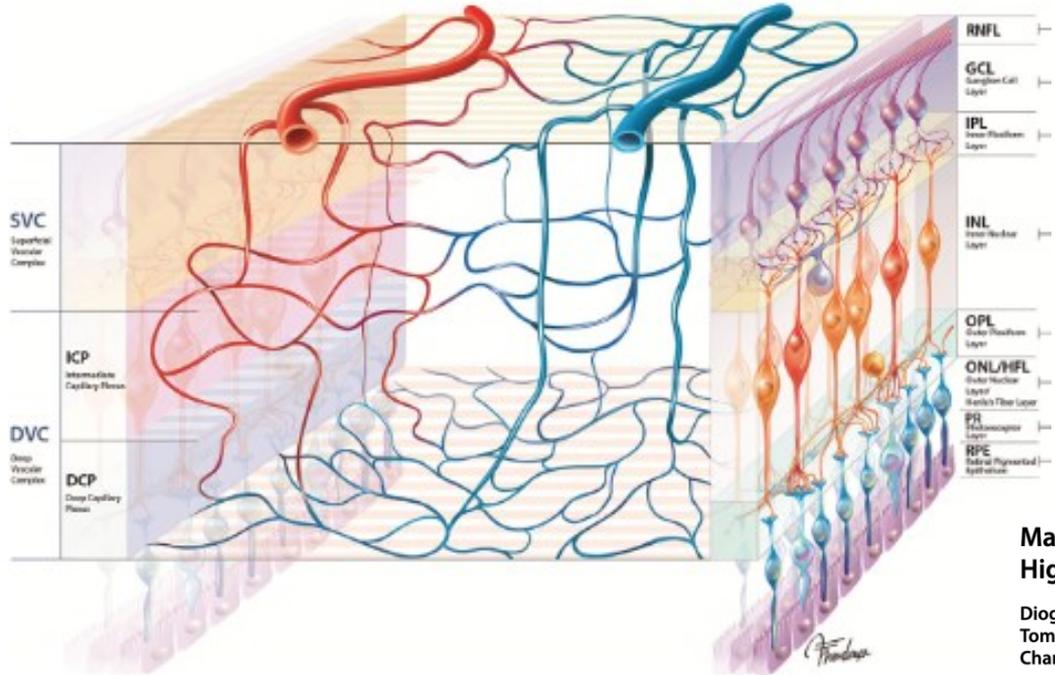
An D, Yu P, Freund KB, Yu DY, Balaratnasingam C. Three-Dimensional Characterization of the Normal Human Parafoveal Microvasculature Using Structural Criteria and High-Resolution Confocal Microscopy. *Investig Ophthalmol Vis Sci.* 2020;61(10):3.



Cabral 2022

Cabral D, Fradinho AC, Pereira T, et al. Macular Vascular Imaging and Connectivity Analysis Using High-Resolution Optical Coherence Tomography. *Transl Vis Sci Technology.* 2022;11(6):2.

Structure of capillary plexuses



■ Hybrid circuitry

- Direct connection of arteries to SVP and ICP
- Small arterial branches from the ICP irrigate the DCP
- Direct venous drainage from the DCP in venules

Macular Vascular Imaging and Connectivity Analysis Using High-Resolution Optical Coherence Tomography

Diogo Cabral^{1,2}, Ana C. Fradinho², Telmo Pereira², Meera S. Ramakrishnan¹, Tommaso Bacci¹, Dong An^{3,4}, Sandra Tenreiro², Miguel C. Seabra^{2,5}, Chandrakumar Balaratnasingam^{3,4}, and K. Bailey Freund^{1,6}

Transl Vis Sci Technology. 2022;11(6):2.

Nomenclature

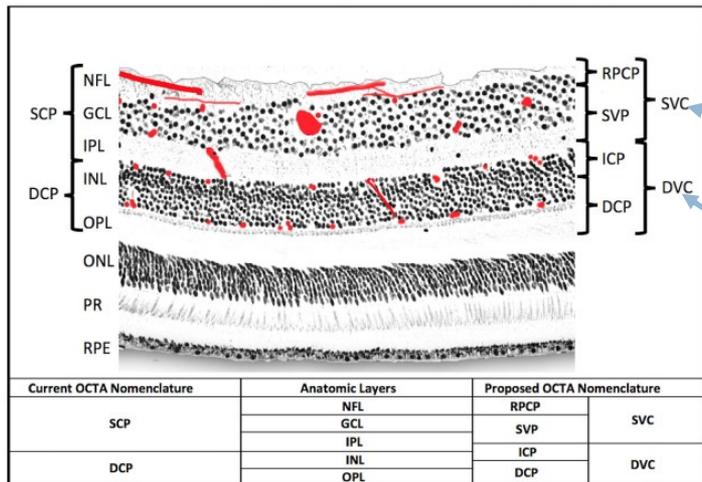
SCIENTIFIC REPORTS

OPEN

Detailed Vascular Anatomy of the Human Retina by Projection-Resolved Optical Coherence Tomography Angiography

Received: 25 September 2016
Accepted: 06 January 2017
Published: 10 February 2017

J. P. Campbell¹, M. Zhang¹, T. S. Hwang, S. T. Bailey, D. J. Wilson, Y. Jia & D. Huang



- To name the retinal capillary layers we used the terminology proposed by Campbell et al

SUPERFICIAL VASCULAR COMPLEX =

Radial Peripapillary Capillary plexus

+ Superficial Vascular Plexus

DEEP VASCULAR COMPLEX =

Intermediate Capillary plexus

+ Deep Capillary Plexus

Campbell JP, Zhang M, Hwang TS, et al. Sci Rep. 2017;7:42201.
Casey Eye Institute, Oregon Health & Science University

Retinal capillaries : nomenclature

78

Based on

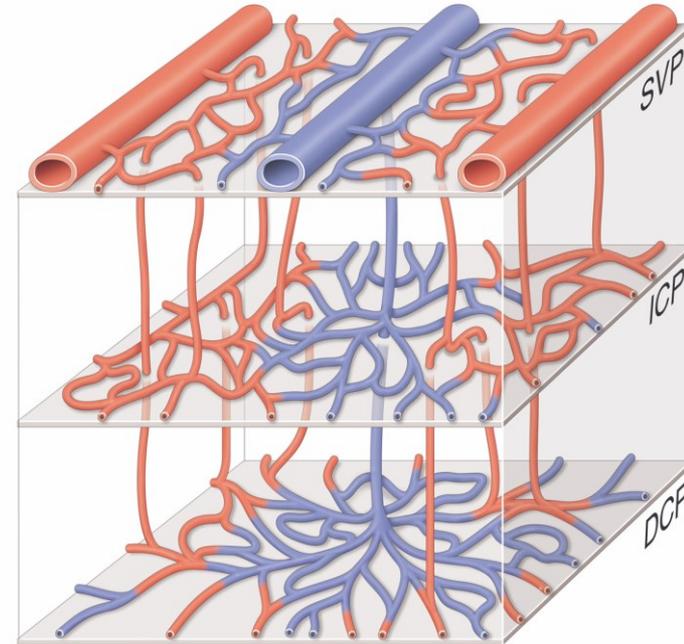
- Campbell JP, Zhang M, Hwang TS, et al. Detailed Vascular Anatomy of the Human Retina by Projection-Resolved Optical Coherence Tomography Angiography. Sci Rep. 2017;7:42201.

Deep
Vascular
Complex
DVC

Superficial
Vascular Plexus
SVP

Intermediate
Capillary Plexus
ICP

Deep Capillary
Plexus
DCP

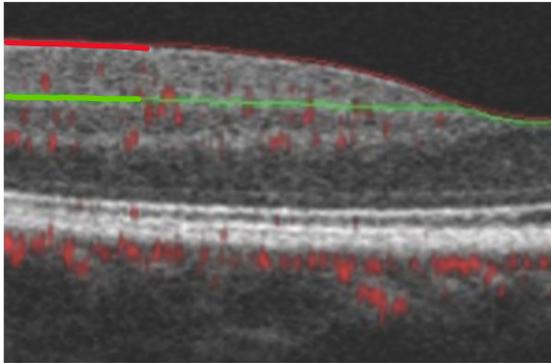


Segmentation

- An accurate segmentation of the capillary layers + Projection artifact removal
- are essential for a reliable density measurement

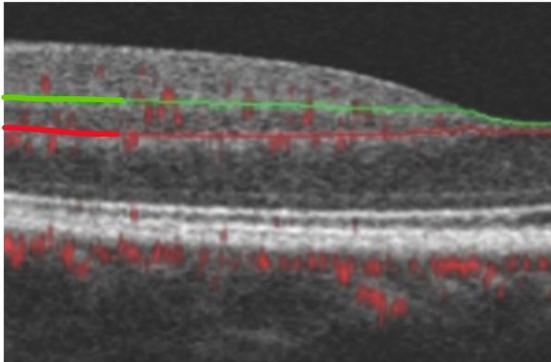
Superficial Vascular Plexus

From ILM
To 9 μm over
IPL-INL junction



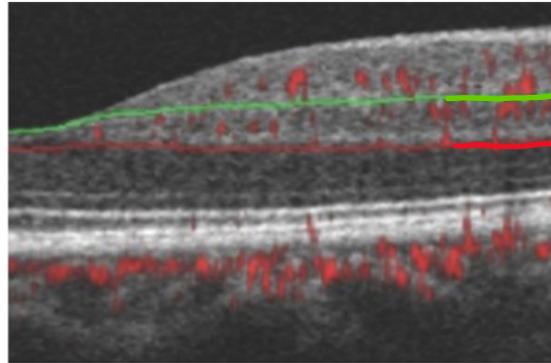
Intermediate Capillary Plexus

From 9 μm over
IPL-INL junction
To 6 μm below
the INL-OPL
junction



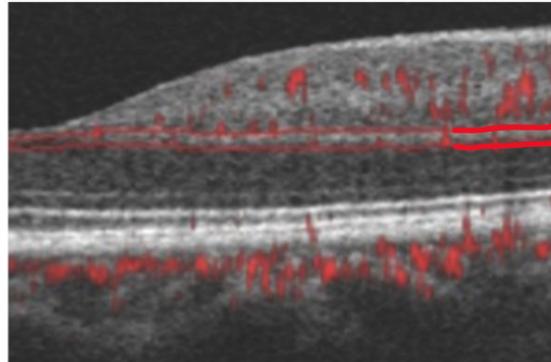
Deep Vascular Complex

From 9 μm over
IPL-INL junction
To 9 μm below
the OPL-ONL
junction

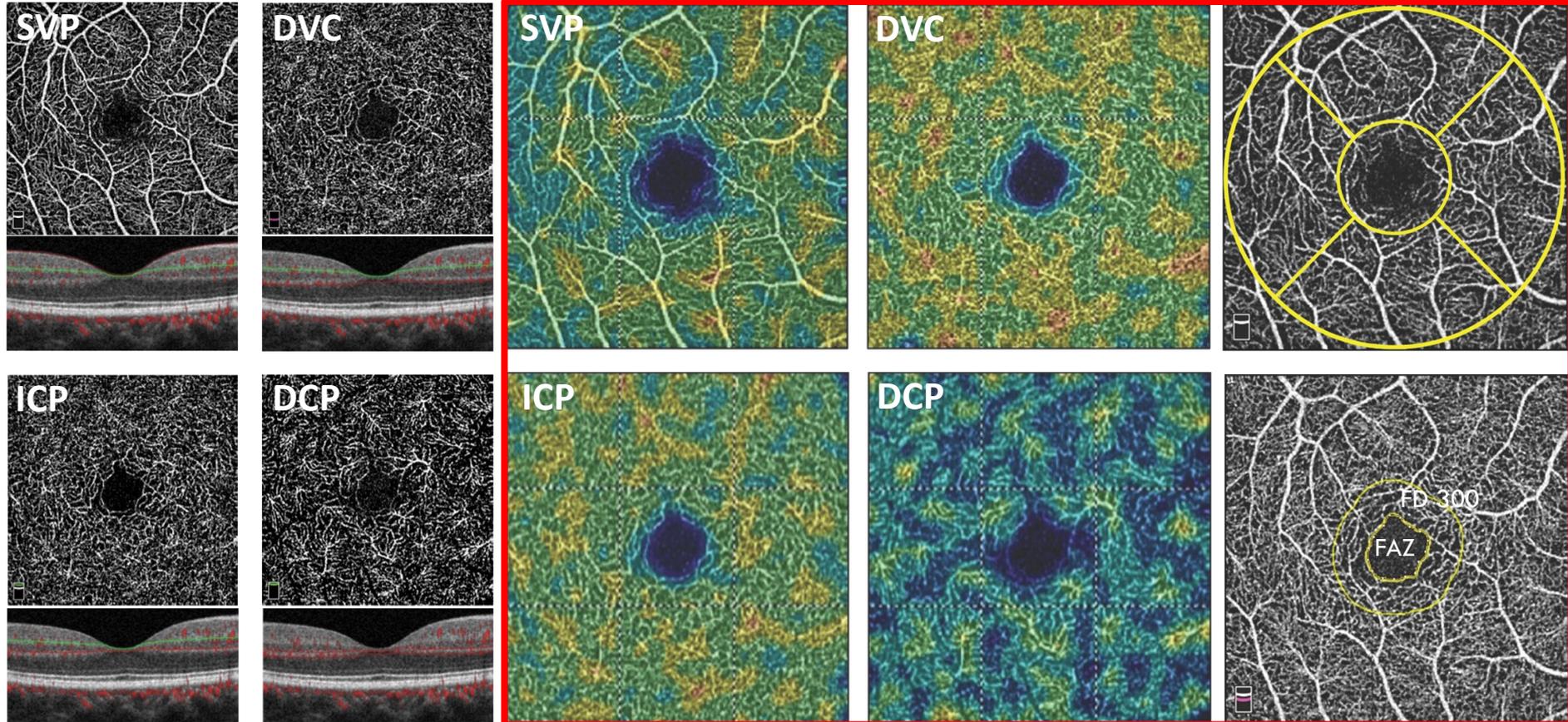


Deep Capillary Plexus

From 6 μm
below the INL-
OPL junction
To 9 μm below
the OPL-ONL
junction

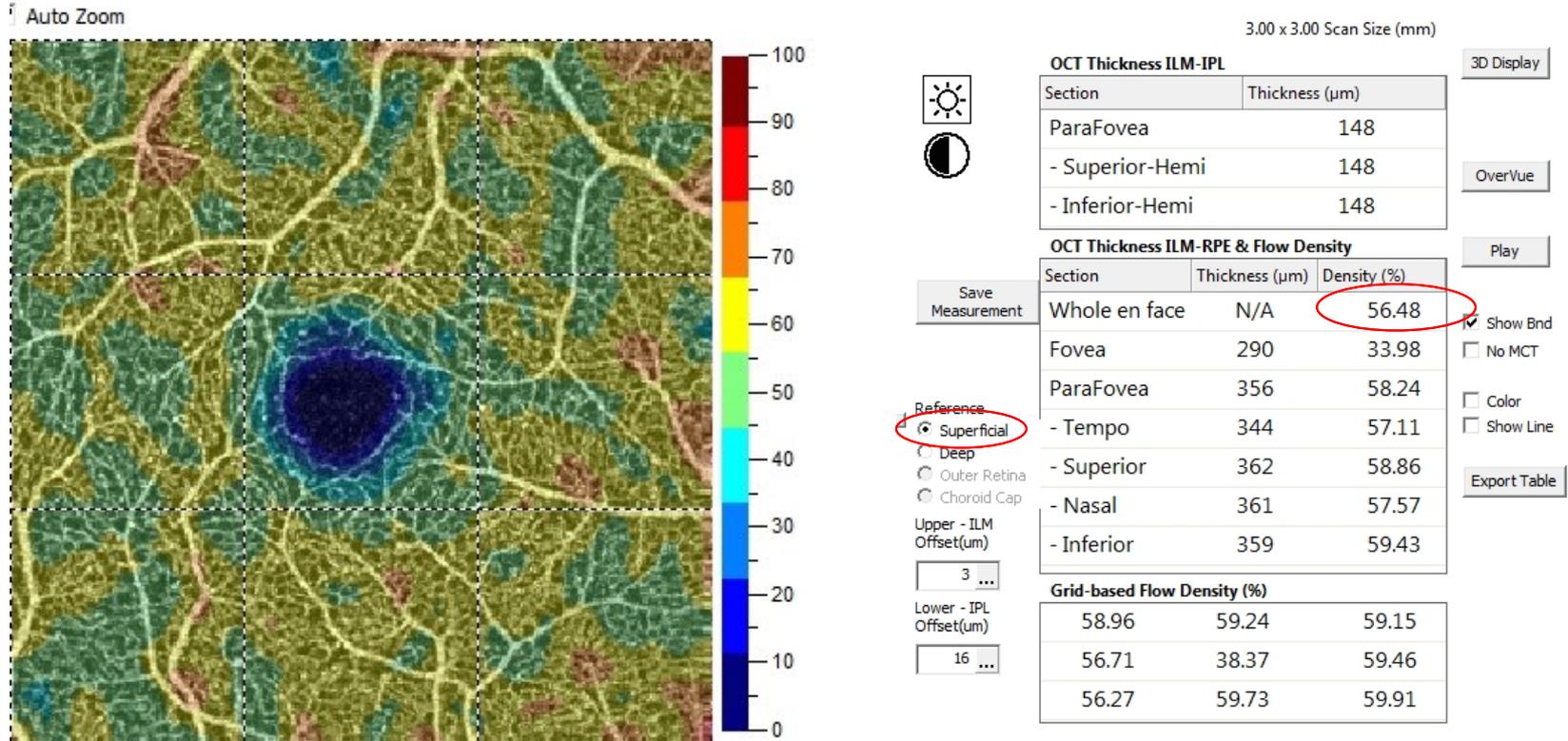


Capillary density measurement (3x3 mm)



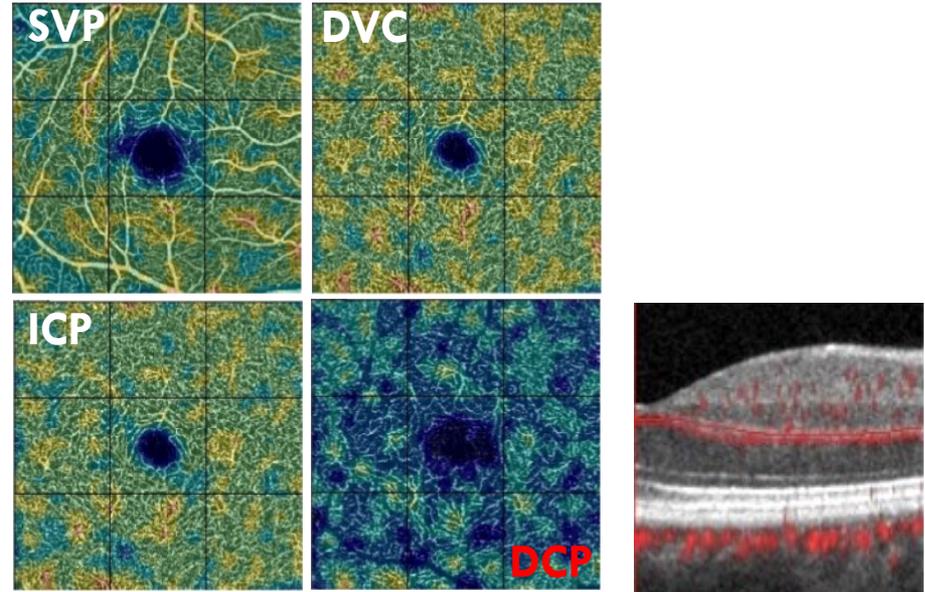
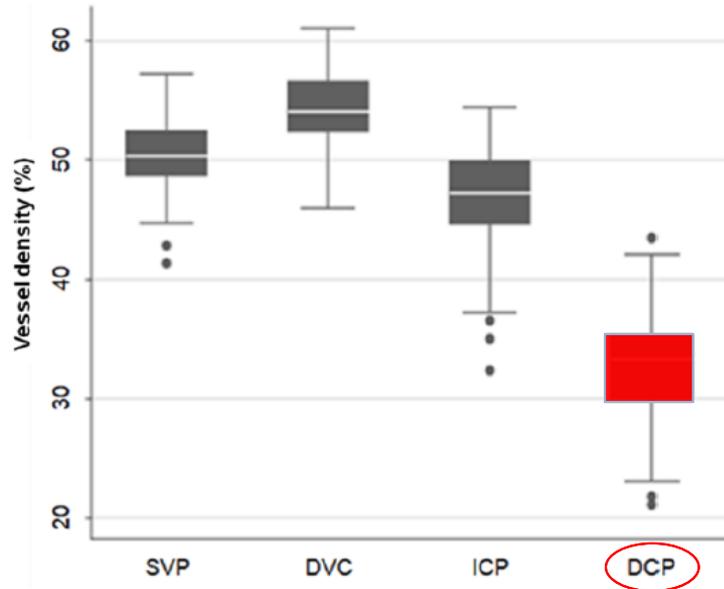
Capillary density measurement

- The AngioVue software (Optovue®) is based on a modified binarization.
- Results expressed in %



Results . Vessel density

- The fact that DCP is a monoplanar capillary network may explain that its density was the lowest of all plexuses.



Normal macular capillary density

148 eyes of normal subjects	Whole Image (3x3mm) %	Parafovea %
SVP	47,7 ± 2,8	50,5 ± 2,8
DVC	52,7 ± 3,3	54,2 ± 3,2
ICP	45,4 ± 4,2	46,9 ± 4,2
DCP	31,6 ± 4,4	32,7 ± 4,3
FAZ area	0,25 ± 0,11	
FAZ acircularity	1,14 ± 0,05	
FD 300 area	50,8 ± 3,4	

Vascular density decreases with age in all plexuses

- 0.064% per year in the SVP
- 0.076% per year in the DCP

Vascular density is sensitive to the image quality (Signal Strength Index)

Vascular density is not related to gender

VESSEL DENSITY OF SUPERFICIAL, INTERMEDIATE, AND DEEP CAPILLARY PLEXUSES USING OPTICAL COHERENCE TOMOGRAPHY ANGIOGRAPHY

CARLO LAVIA, MD,*† SOPHIE BONNIN, MD,* MILENA MAULE, PhD,‡ ALI ERGINAY, MD,* RAMIN TADAYONI, MD, PhD,* ALAIN GAUDRIC, MD*

Editorial

Cristine Curcio

Commentary on Lavia et al: Progress of Optical Coherence Tomography Angiography for Visualizing Human Retinal Vasculature

RETINA Ahead of pub
2018

Différences de valeurs entre les appareils

- Les fabricants d'appareils d'OCT ont développé des algorithmes propriétaires pour générer l'image des vaisseaux obtenus par contraste de mouvement et gérer les artéfacts .
- Les résultats de mesure de densité ne sont pas comparables d'un appareil à l'autre

Manufacturer	Device Name	OCT Modality	Algorithm	Scanning Speed (A-scans/sec)
Carl Zeiss Meditech	Cirrus HD-OCT Angioplex	Spectral domain	OMAG	68,000
	PLEX Elite 9000	Swept source	OMAG	100,000
Canon	OCT-HS100	Spectral domain	Modified FSADA	70,000
Heidelberg Engineering	Spectralis OCT Angiography	Spectral domain	FSADA	85,000
Nidek	RS-3000 Advance Angioscan	Spectral domain	CODAA	53,000
OPTOPOL	REVO NX OCTA	Spectral domain	SOA	110,000
Optovue	RTVue XR Avanti Angiovue	Spectral domain	SSADA	70,000
Topcon	DRI OCT Triton	Swept source	OCTARA	100,000

Densité capillaire en OCTA et réalité

Visualization of micro-capillaries using optical coherence tomography angiography with and without adaptive optics

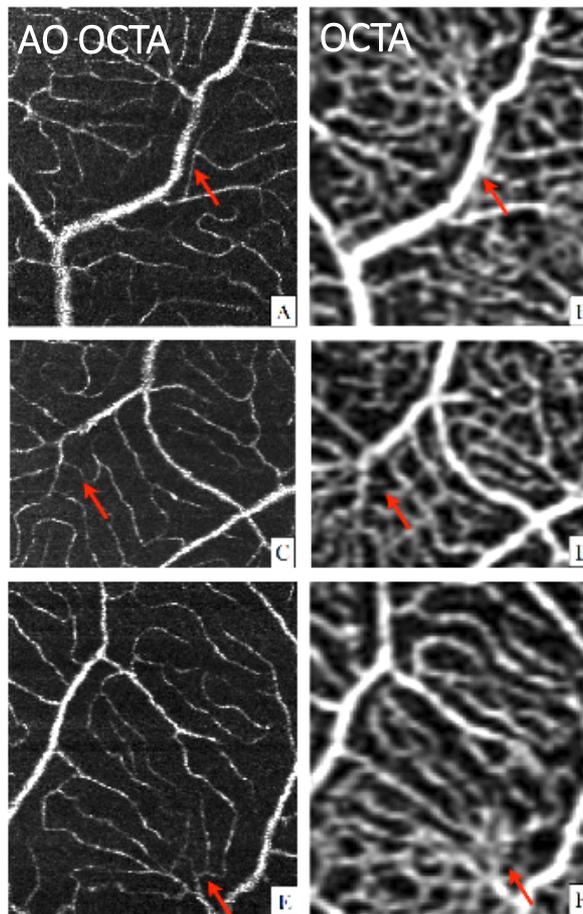
MATTHIAS SALAS^{1*}, MARCO AUGUSTIN¹, LAURIN GINNER^{1,3}, ABHISHEK KUMAR¹, BERNHARD BAUMANN¹, RAINER LEITGEB^{1,3}, WOLFGANG DREXLER,¹ SONJA PRAGER,² JULIA HAFNER,² URSULA SCHMIDT-ERFURTH,² AND MICHAEL PIRCHER¹

Salas M, Augustin M, Ginner L, et al. Visualization of micro-capillaries using optical coherence tomography angiography with and without adaptive optics. 2017;8(1):207-222. doi:10.1364/boe.8.000207

La résolution latérale de l'OCTA est d'environ 15 μ alors que le diamètre réel des capillaires réiniens est de 5 à 7 μ .

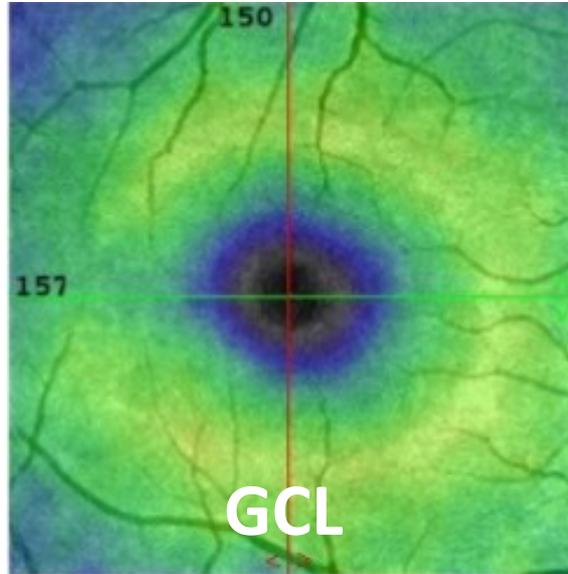
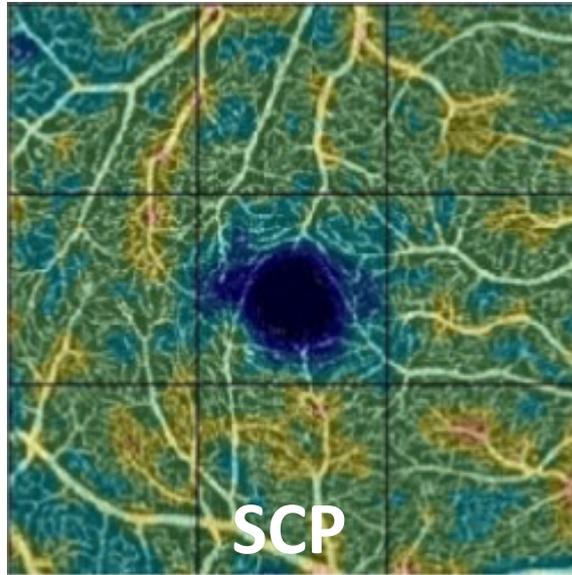
A chaque fois qu'un mouvement d'hématie est enregistré il est transformé en une unité élémentaire de 15 μ de large, c'est à dire sans lien avec la réalité anatomique .

L'adjonction d'un système d'OA permet d'améliorer fortement la résolution au niveau de 1 à 3 μ et donc de donner une représentation plus fidèle du diamètre capillaire et des espaces intercapillaires

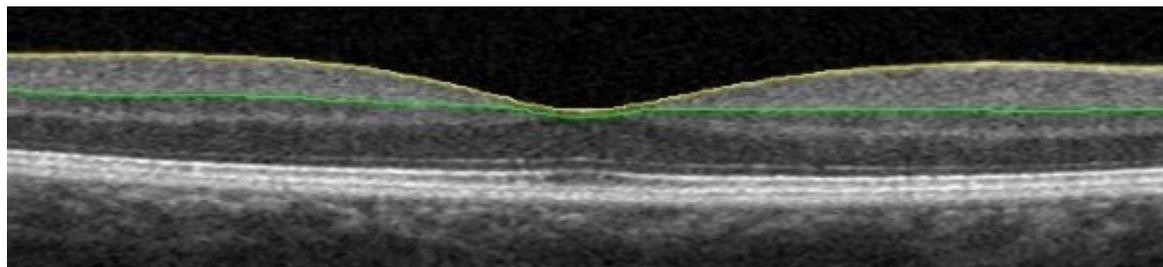
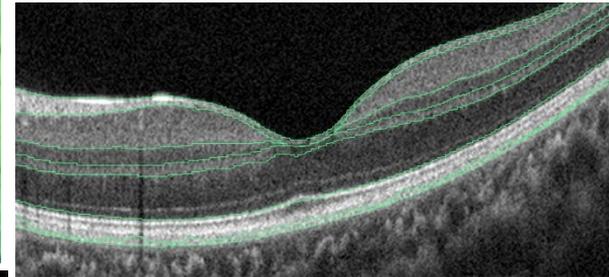


Capillary density and retinal layer thickness

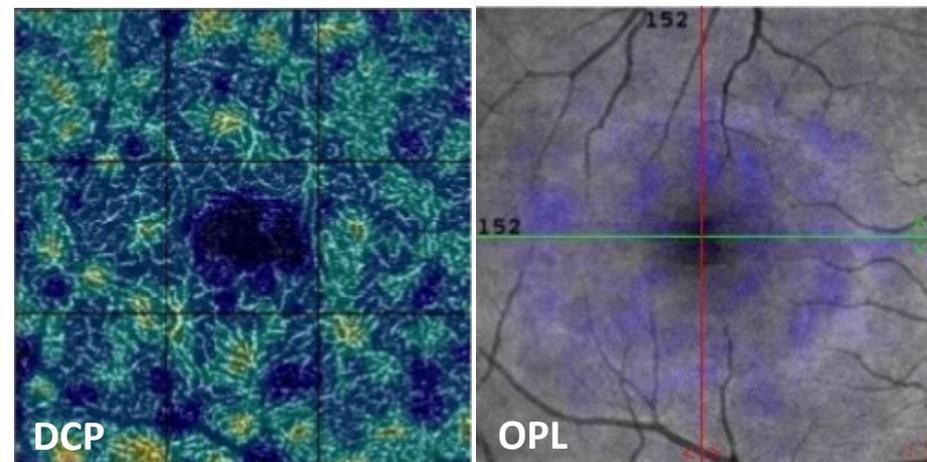
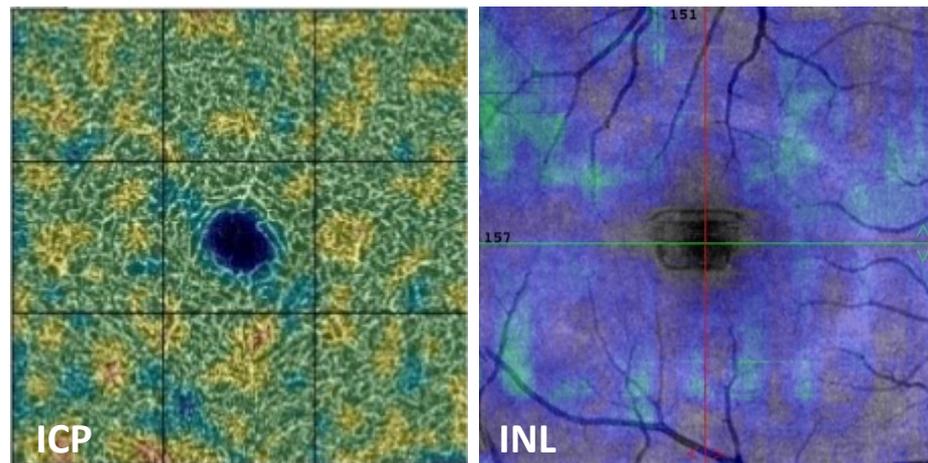
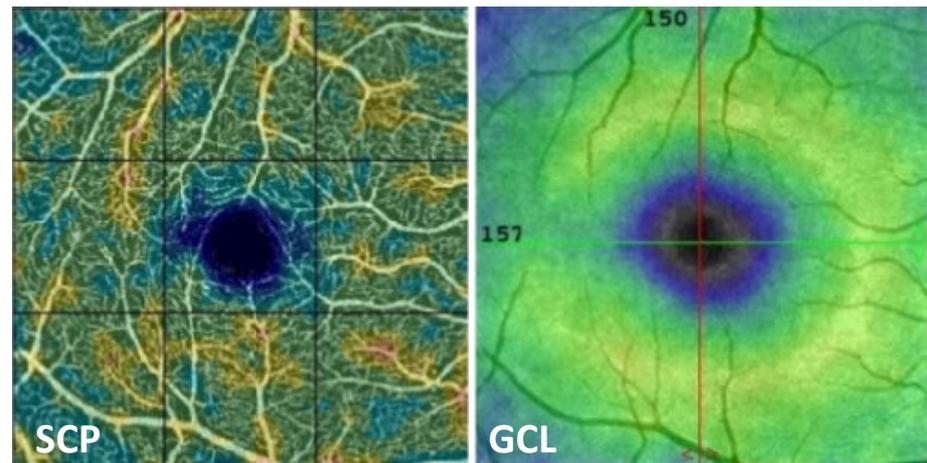
86



- More accurate segmentation allows measuring the depth of each retinal layer



← Ganglion cell layer



- La densité des différents plexus capillaires est corrélée à l'épaisseur des couches cellulaires qu'ils irriguent

Snodderly, D. J of Neurosci: 1992

Chan, G. IOVS 2012

Yu, J. IOVs 2016

Reduced vessel density in the superficial and deep plexuses in diabetic retinopathy is associated with structural changes in corresponding retinal layers

Carlo Lavia, Aude Couturier, Ali Erginay, Bénédicte Dupas, Ramin Tadayoni, Alain Gaudric*

Plos One. 2019;14(7):e0219164.

In summary,

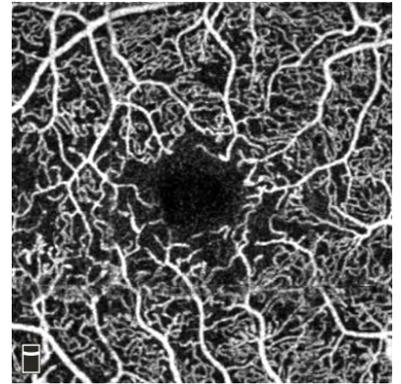
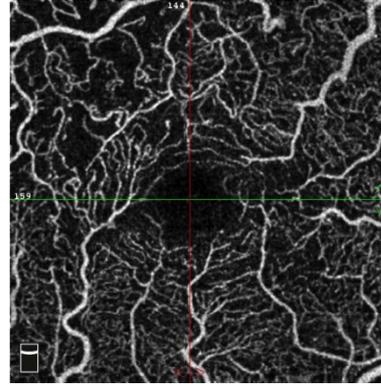
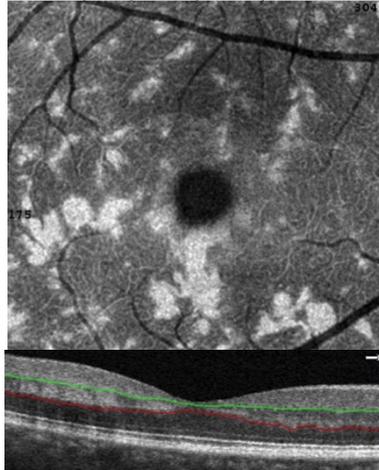
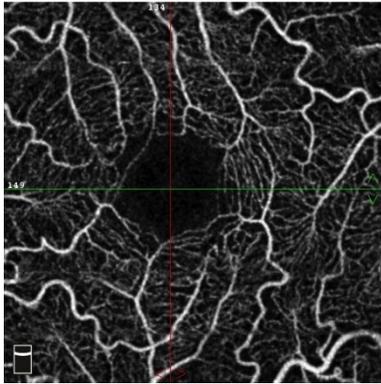
88

- Retinal capillary network has a laminated 3D configuration
- Each layer corresponds to a specific cellular region
 - RPPC : Optic Nerve Fiber Layer
 - SCP : Ganglion Cell Layer
 - DVC : Inner Nuclear Layer
 - ICP : Inner Plexiform Layer
 - DCP: Outer Plexiform Layer
- DCP is on the "venous side" of the retinal capillary network

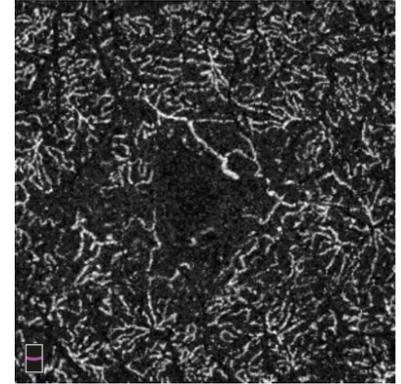
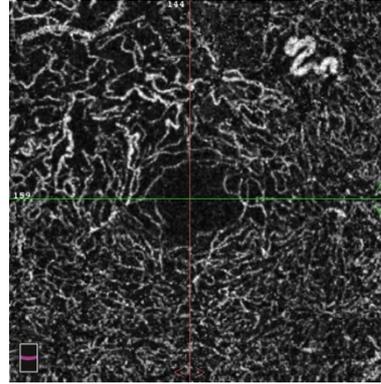
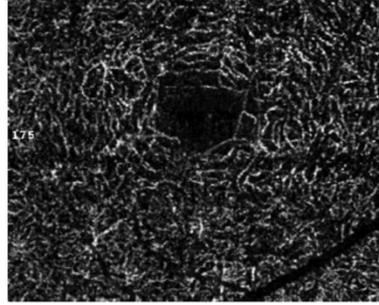
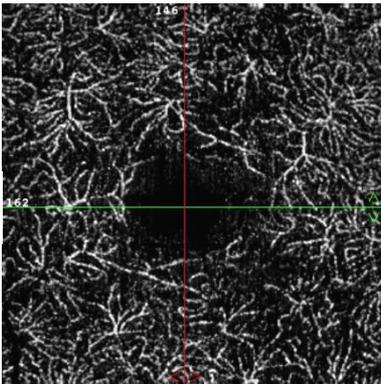
Clinical consequences

89

SCP



DCP



Retinal Arterial
Tortuosity

PAMM

collaterals in BRVO

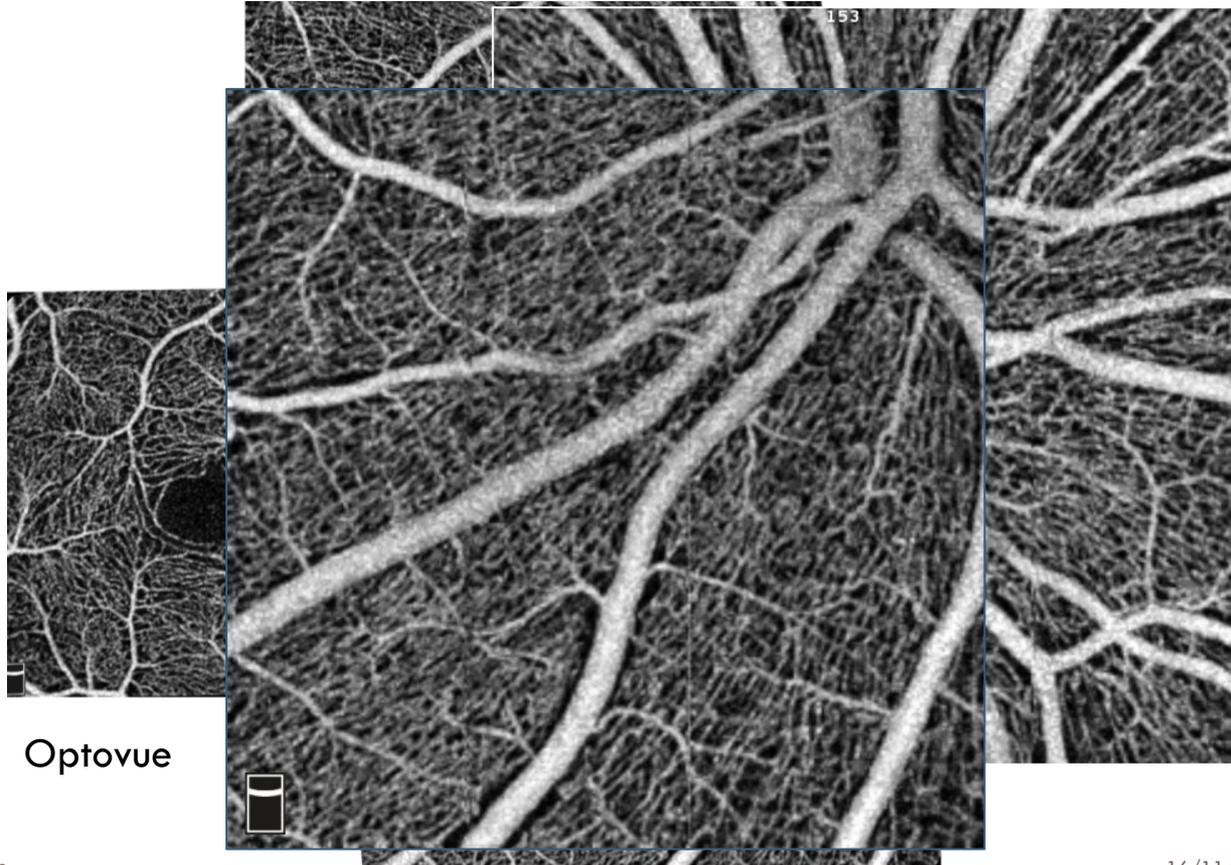
Diabetic maculopathy

ris

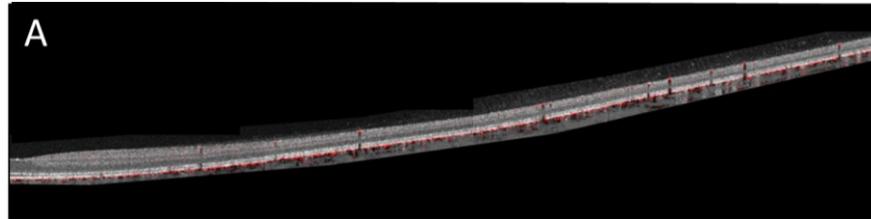
16/11/2023 18:55

Capillaires radiaires péripapillaires

Une couche supplémentaire de capillaires pour les fibres optiques



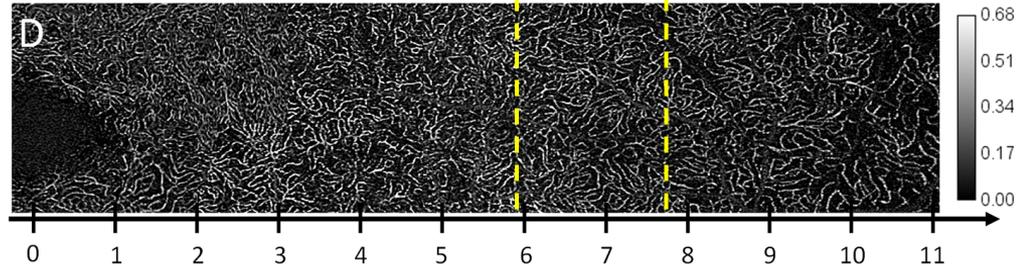
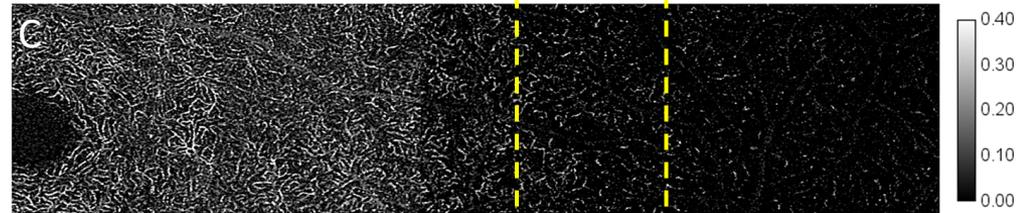
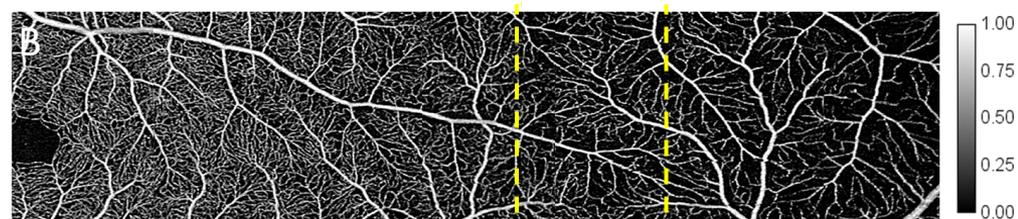
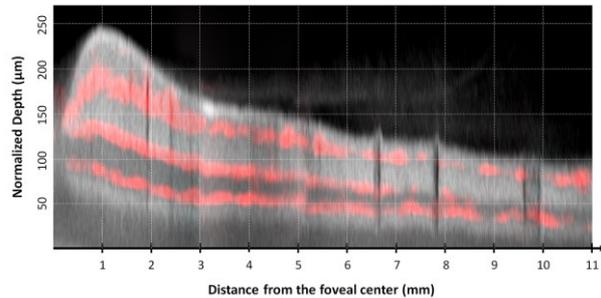
WF OCTA : vascularisation périphérique



Le SCP devient progressivement moins dense en périphérie

L'ICP disparaît progressivement à partir de 6mm du centre

Le DCP reste relativement stable

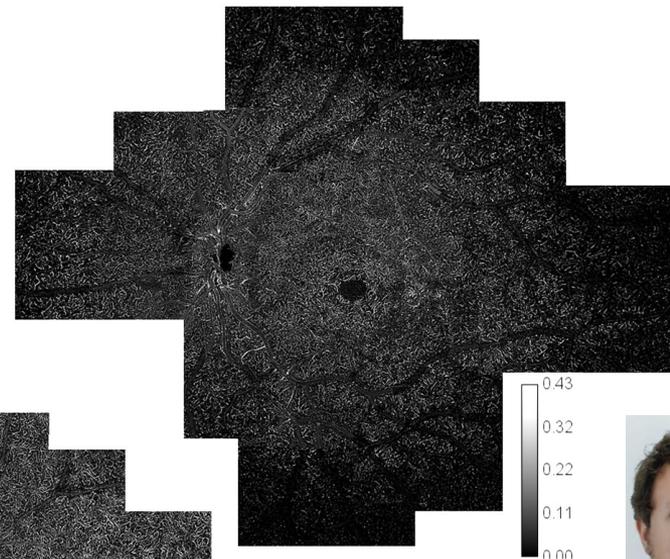
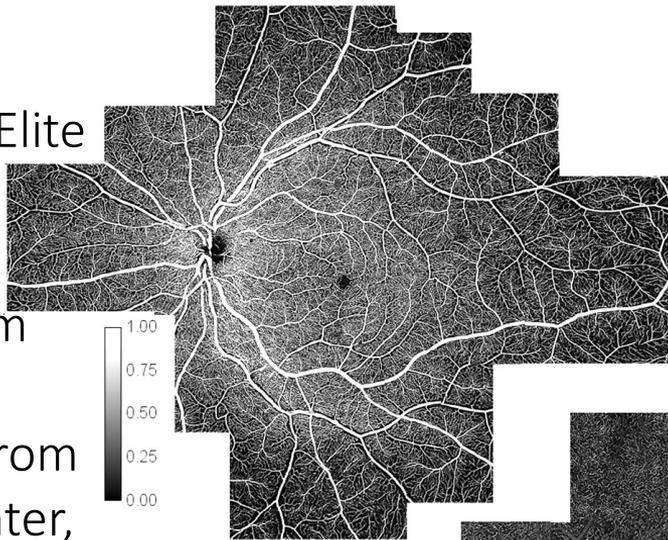


Distance from the foveal center (mm)

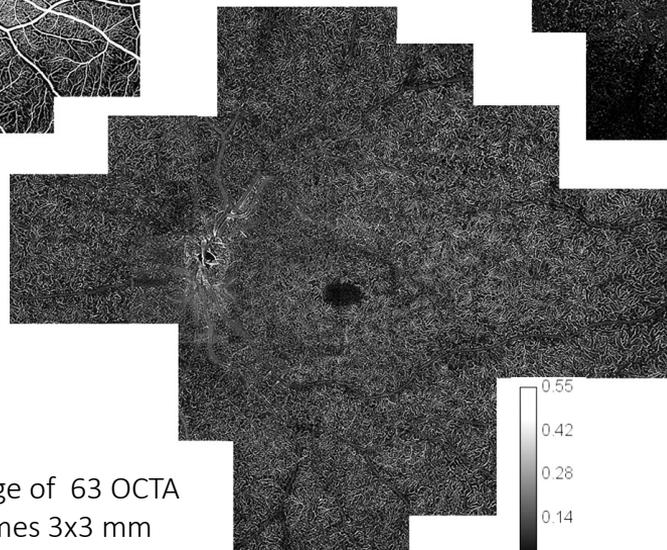
SUPERFICIAL VASCULAR PLEXUS

INTERMEDIATE CAPILLARY PLEXUS

- Because PlexElite have also the possibility to record 3x3 mm OCTA volume until 12 mm from the foveal center,



- We performed a montage of 3x3mm C-scans to obtain the best capillary resolution as possible



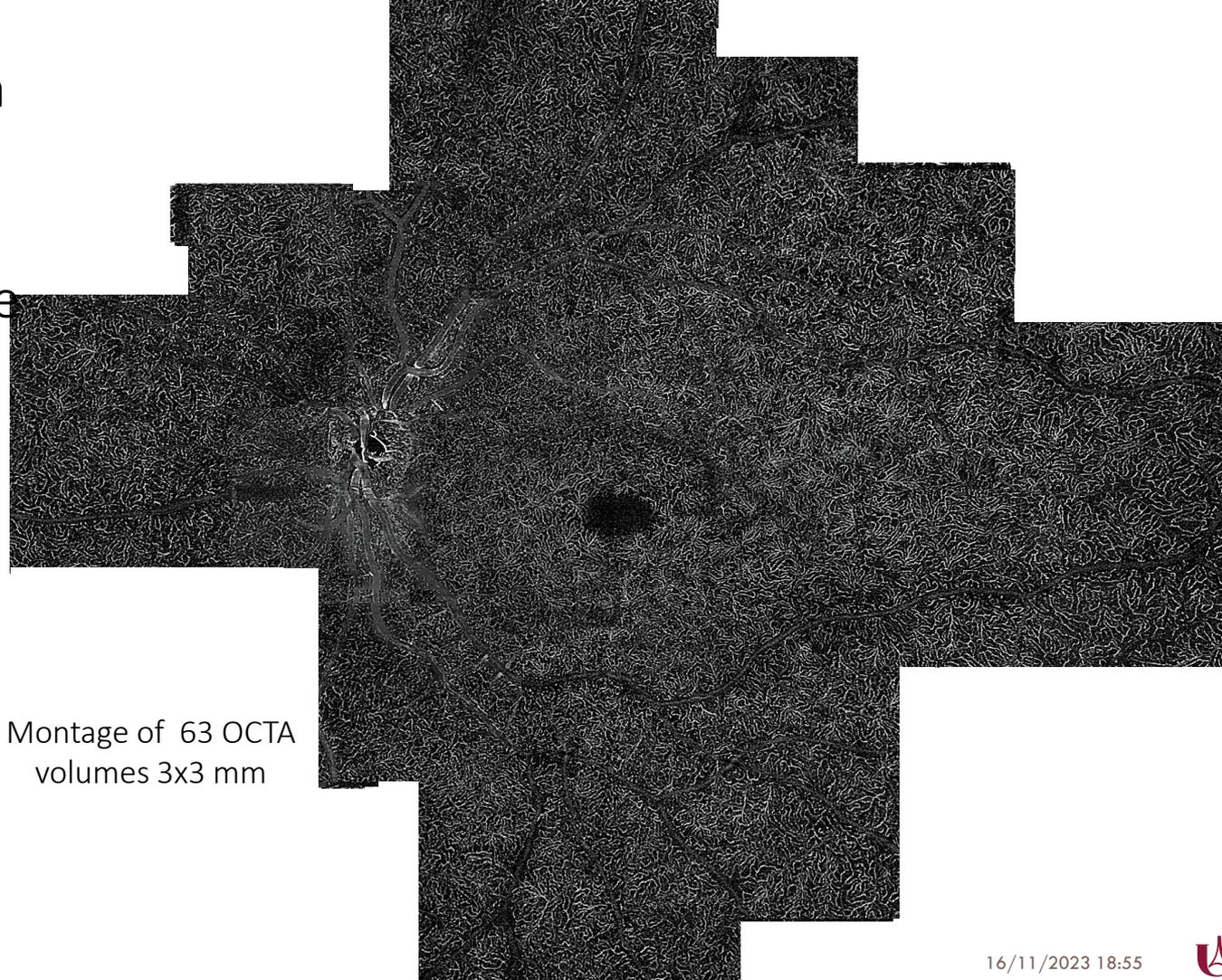
Montage of 63 OCTA volumes 3x3 mm

DEEP CAPILLARY PLEXUS



Carlo Lavia

■ The pattern of the 3 capillary plexuses are different from each other in periphery



Montage of 63 OCTA volumes 3x3 mm

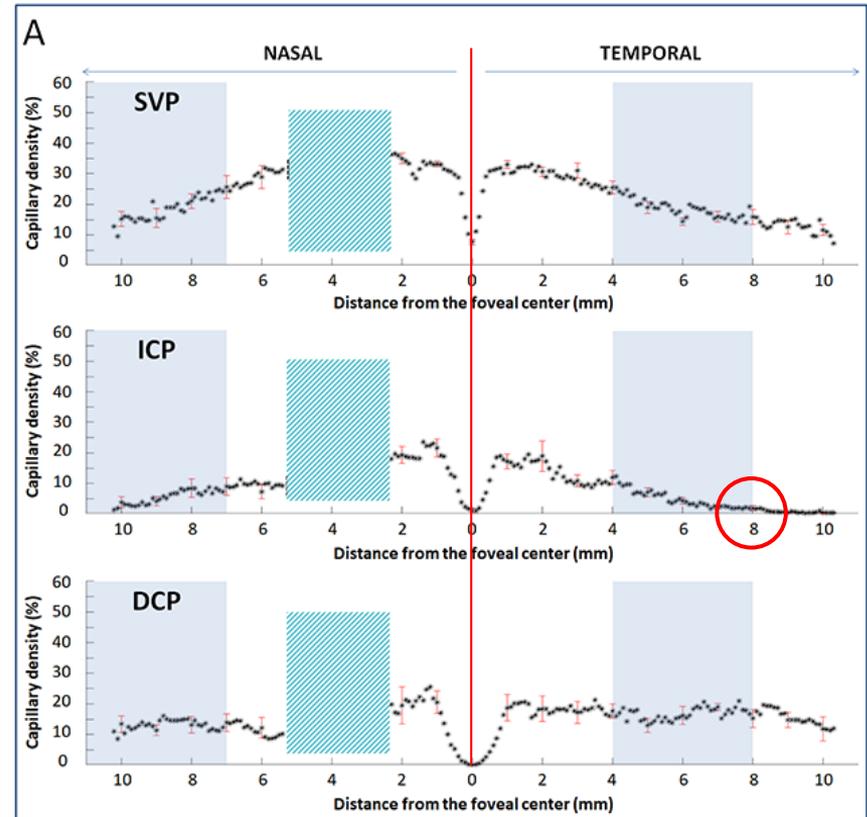
Changes in capillary density from the fovea to the periphery

- Capillary density decreases in the 3 capillary plexuses from the fovea to the periphery,
 - More rapidly in the SVP than in the DCP
- ICP vanishes around 8 mm temporally and 10 mm nasally

Retinal Capillary Plexus Pattern and Density from Fovea to Periphery Measured in Healthy Eyes with Swept-Source Optical Coherence Tomography Angiography

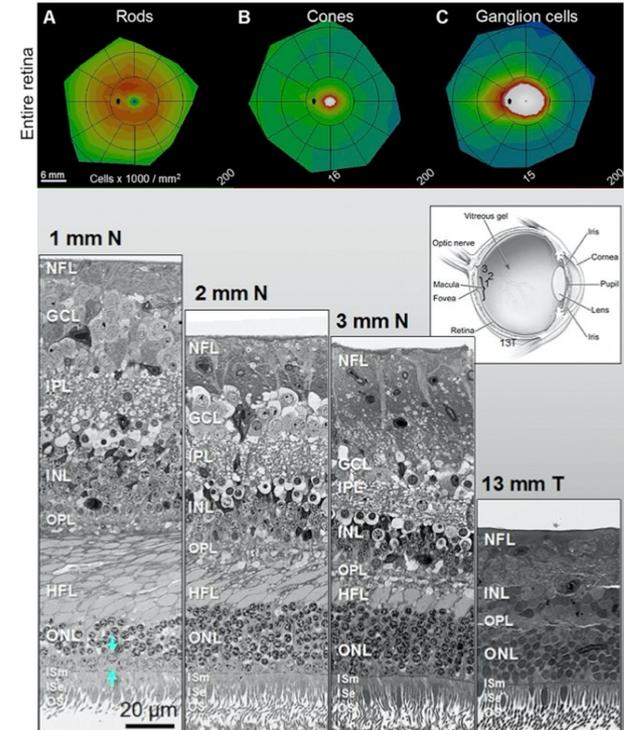
Carlo Lavia¹, Pedro Mecê², Marco Nassisi^{3,4}, Sophie Bonnin^{1,5}, Jennifer Marie-Louise¹, Aude Couturier², Ali Erginay¹, Ramin Tadayoni¹ & Alain Gaudric^{1*}

January 22, 2020:1-11



In summary,

- La densité des 3 plexus capillaires rétiniens varie de façon différente du bord de la fovéa à la périphérie
 - La densité du SVP diminue progressivement et a perdu 50 % de sa densité à 8 mm du centre de la fovéa
 - La densité de ICP diminue rapidement et a perdu 90 % de sa densité à 8 mm du centre de la fovéa et n'est plus détectable au-delà..
 - La densité du DCP reste relativement stable jusqu'à 8 mm, puis diminue de 40 % à 10 mm.
 - La distance entre le DCP et le plexus immédiatement supérieur augmente au-delà de 8 mm..
- Ces changements suivent la diminution de la densité neuronale dans la rétine interne, et en particulier des cellules ganglionnaires.

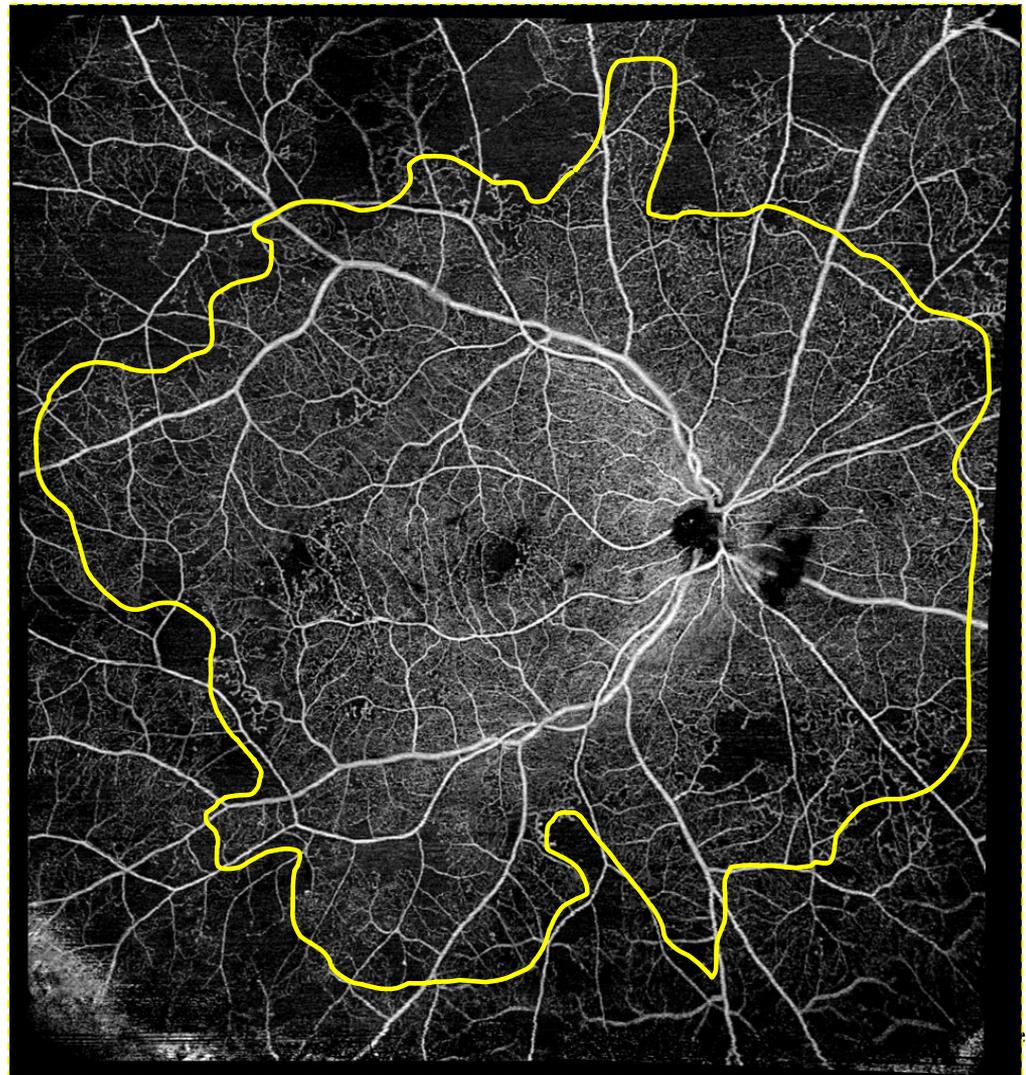


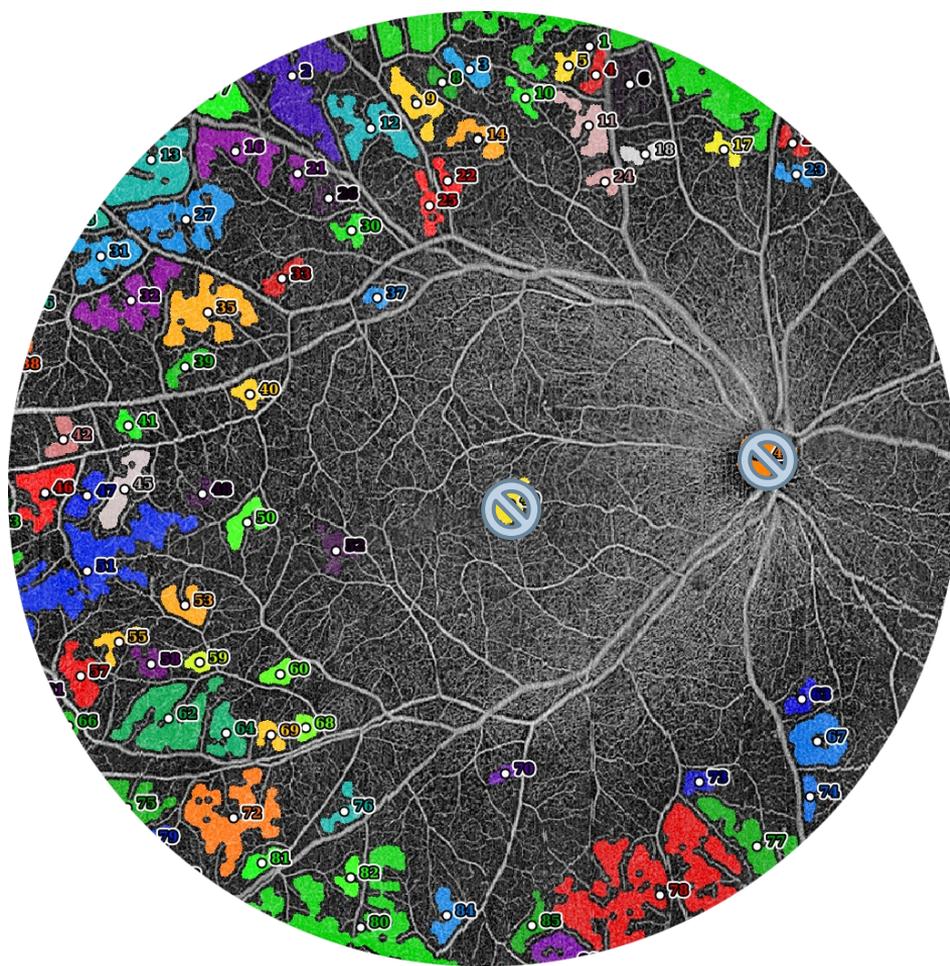
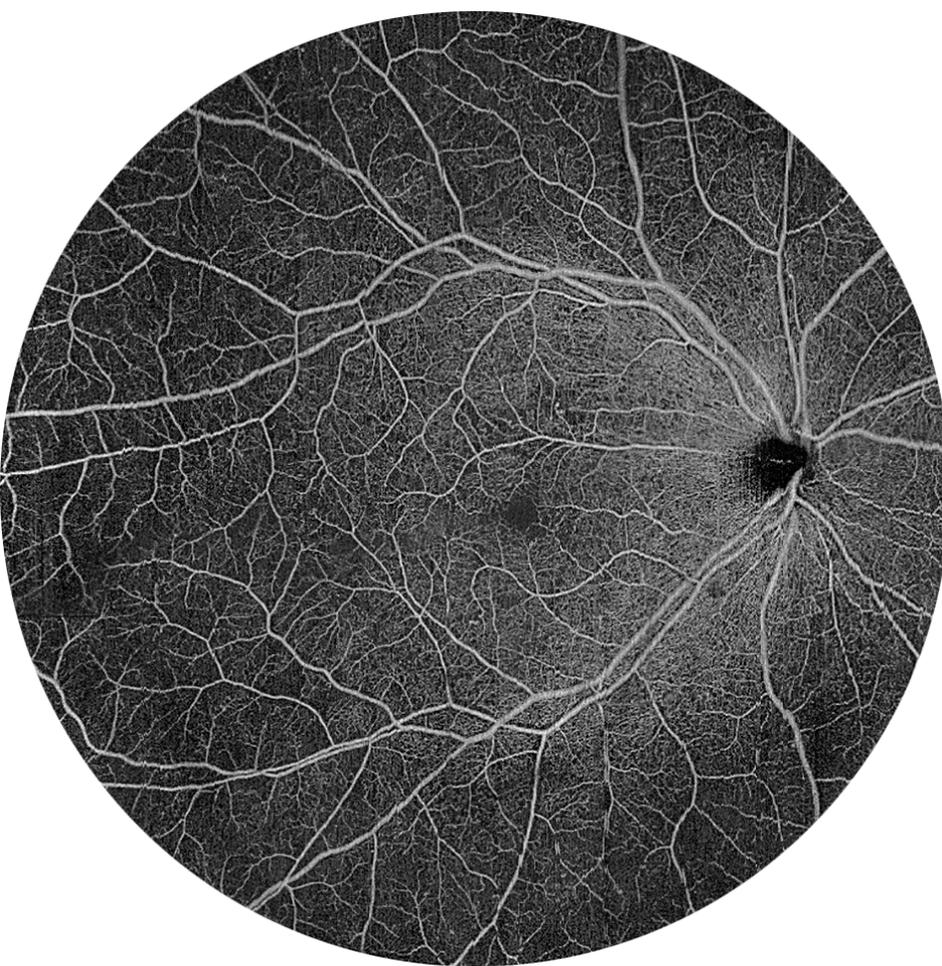
Quinn N, et al. The clinical relevance of visualising the peripheral retina. *Prog Retin Eye Res.* 2019;68:83-109.

Consequences for diabetic retinopathy

- In DR peripheral capillary density assessment should be based on the normal decrease of capillary density in healthy eyes.
- The usefulness of studying separately the 3 capillary plexuses is unclear
- However it is striking to note that, in DR, non-perfusion often starts in mid-periphery, beyond 7 to 8 mm from the foveal center, in an area where the ICP is normally absent.

All retina slab





PlexElite montage : all retina slab

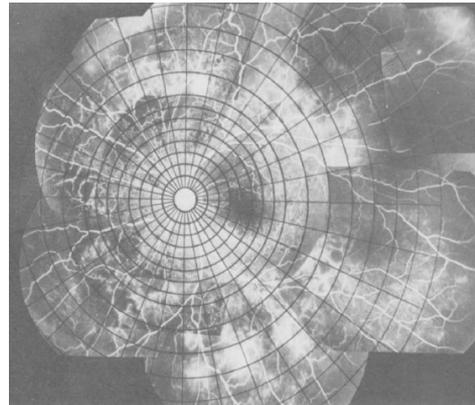
Onset of capillary NP in DR

- The onset of capillary non-perfusion in mid-periphery was already known from fluorescein angiography montages.
- The prevalent distribution of NP in mid-periphery has also be found with WF-OCTA despite the limitations of the present technology

Midperipheral Fundus Involvement in Diabetic Retinopathy

KOICHI SHIMIZU, MD, YOSHIHARU KOBAYASHI, MD, KANEMITSU MURAOKA, MD

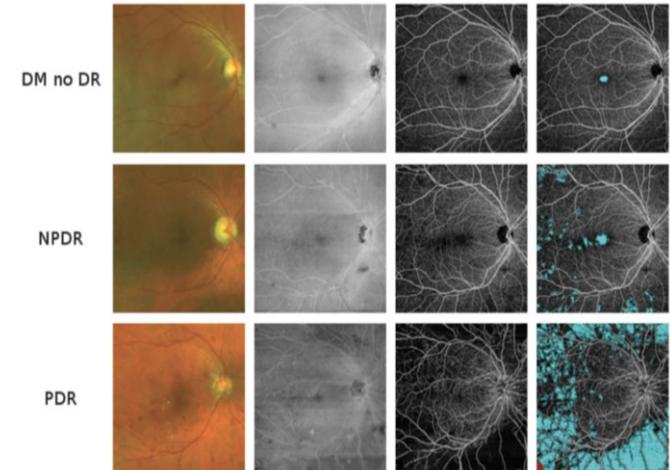
Ophthalmology 1981;88(7):601-612..



QUANTIFICATION OF RETINAL CAPILLARY NONPERFUSION IN DIABETICS USING WIDE-FIELD OPTICAL COHERENCE TOMOGRAPHY ANGIOGRAPHY

A. YASIN ALIBHAI, MD,* LUCAS R. DE PRETTO, MS,†† ERIC M. MOULT, BS,† CHRIS OR, MD,* MALVIKA ARYA, BSC,* MITCHELL MCGOWAN, BS,* OSCAR CARRASCO-ZEVALLOS, PhD,† BYUNGKUN LEE, MS,† SIYU CHEN, PhD,† CAROLINE R. BAUMAL, MD,* ANDRE J. WITKIN, MD,* ELIAS REICHEL, MD,* ANDERSON ZANARDI DE FREITAS, PhD,‡ JAY S. DUKER, MD,* JAMES G. FUJIMOTO, PhD,† NADIA K. WAHEED, MD, MPH*

RETINA. December 2018;1.



Onset of capillary NP in DR

Ultra-wide optical coherence tomography angiography in diabetic retinopathy

Qinqin Zhang¹, Kasra A. Rezaei², Steven S. Saraf², Zhongdi Chu¹, Fupeng Wang¹, Ruikang K. Wang^{1,2}

Quant Imaging Med Surg. 2018;8(8):743-753.

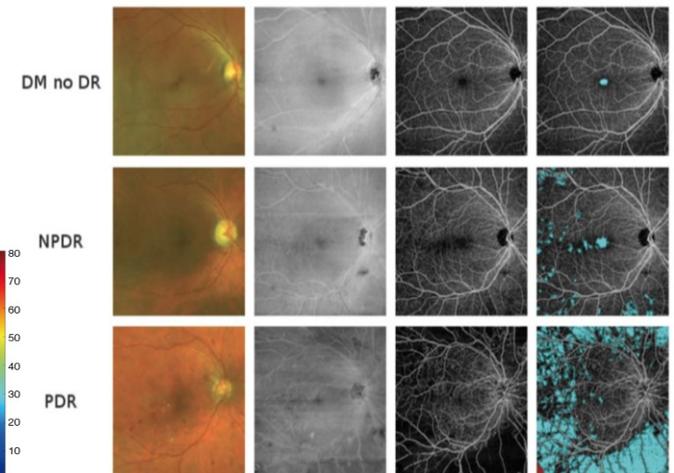
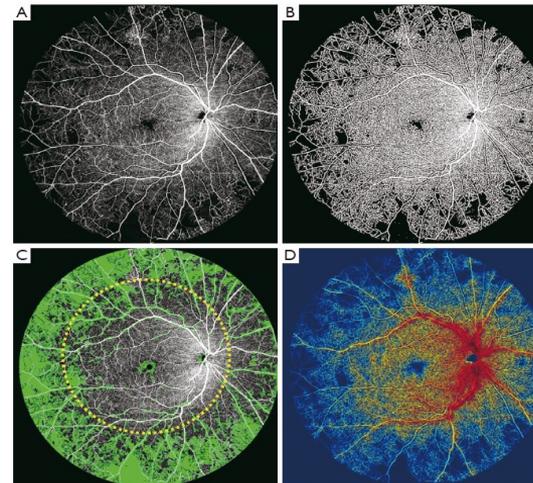
QUANTIFICATION OF RETINAL CAPILLARY NONPERFUSION IN DIABETICS USING WIDE-FIELD OPTICAL COHERENCE TOMOGRAPHY ANGIOGRAPHY

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RETINA. December 2018;1.

■ The onset of capillary non-perfusion in mid-periphery was already known from fluorescein angiography montages.

■ The prevalent distribution of NP in mid-periphery has also be found with WF-OCTA despite the limitations of the present technology



Standardization of OCT Angiography Nomenclature in Retinal Vascular Diseases: First Survey Results

Ophthalmology Retina 2022

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Pas d'accord sur la définition de l'OCT grand champ
Pas d'accord sur la définition d'une maculopathie ischémique
Pas d'accord sur le seuil de NP critique dans la RD

- Diminution importante du flux
 - $\geq 30\%$ de la surface absolue imagée.
- Changement sévère du pourcentage de flux sur l'OCTA à grand champ
 - augmentation ou diminution $\geq 30\%$.
- Inclure l'OCTA dans l'évaluation de la sévérité et de la progression de la RD.
 - L'évaluation des anomalies microvasculaires intrarétiniennes et de la densité des vaisseaux devrait être ajoutée aux paramètres déjà recommandés,
 - à savoir "présence de néovascularisation", "paramètres de la zone avasculaire fovéale" et "présence et quantité de zones d'absence de flux".

Recommandations pour l'interprétation de l'OCTA

1. Examiner les couches vasculaires de la rétine et de la choroïde pour identifier les anomalies et déterminer si elles diffèrent de la vascularisation normale.
2. Lorsqu'une anomalie est identifiée, déterminer quelle segmentation est sélectionnée
3. Évaluer si la segmentation est correcte.
 - En présence d'une maladie, la segmentation automatisée peut être imprécise et créer des artefacts qui peuvent être interprétés à tort comme une maladie. Les lignes de segmentation peuvent être corrigées manuellement sur certaines machines d'OCTA.
4. Identifier l'emplacement de l'anomalie.
5. Éliminer les artefacts en corrélant les résultats avec l'OCT B-scan enregistré (avec superposition du flux) ou l'OCT structurel en face.
6. Déterminer la nature de la structure vasculaire et l'état du flux
 - La meilleure façon d'y parvenir est d'établir des références croisées entre l'angiographie OCT de face, la superposition de flux de l'OCT B-scan en coupe, et/ou d'autres résultats d'imagerie multimodale (par exemple, FA ou ICGA).

D'après Optical Coherence Tomography. Kirk K. Hou, Adrian Au, Giulia Corradetti, Srinivas R. Sadda, David Sarraf. RYAN'S Retina , 7th Ed 2022, Vol 1 , Chapt 4

Merci de votre attention



