
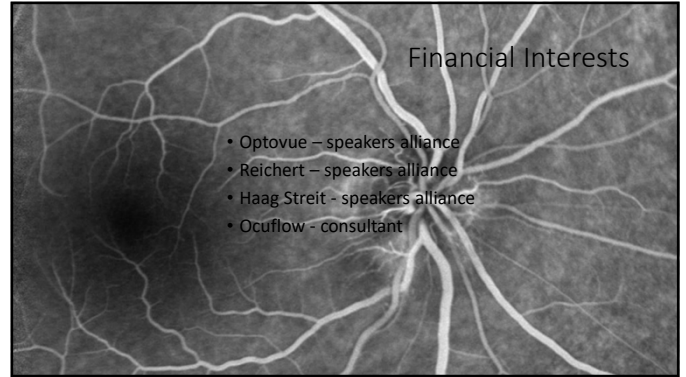


Ocular Blood Flow
IOP's Ignored Sibling



Elliot M. Kirstein, OD, FAAO
Harper's Point Eye Associates
Glaucoma and Diabetes Eye Institute
Cincinnati, Ohio

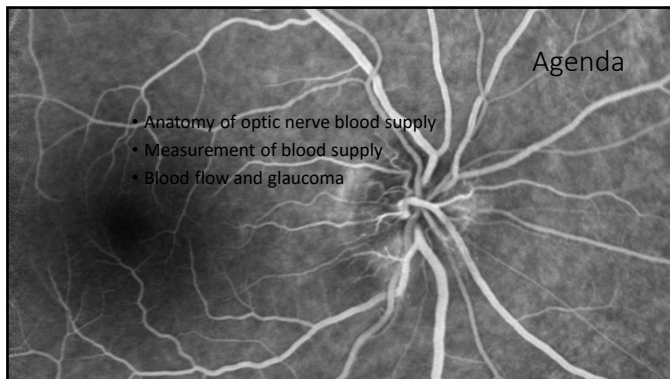
1



Financial Interests

- Optovue – speakers alliance
- Reichert – speakers alliance
- Haag Streit - speakers alliance
- Ocuflow - consultant

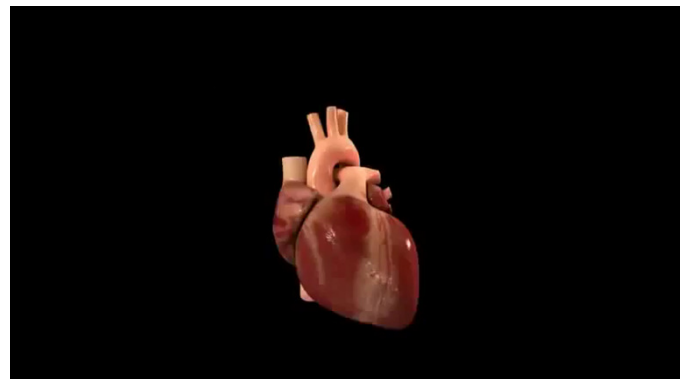
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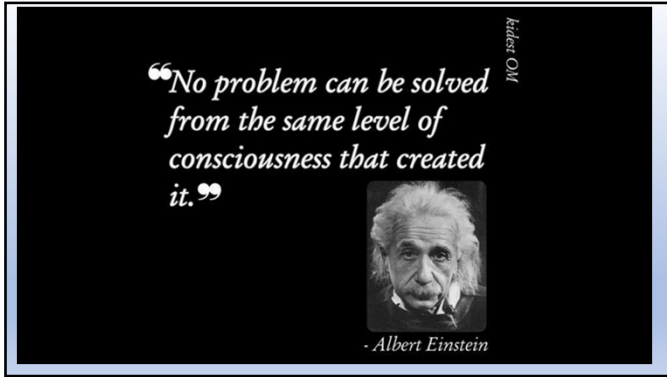
Agenda

- Anatomy of optic nerve blood supply
- Measurement of blood supply
- Blood flow and glaucoma

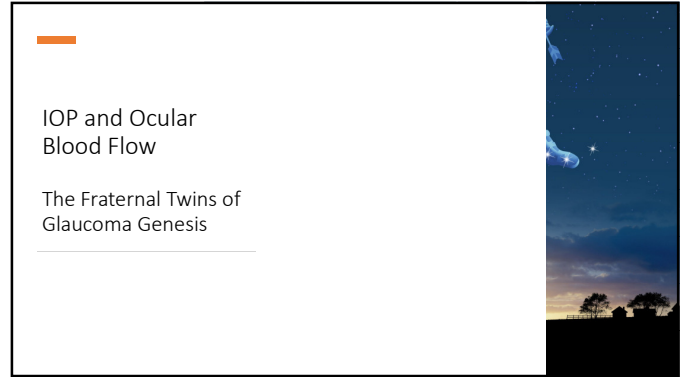
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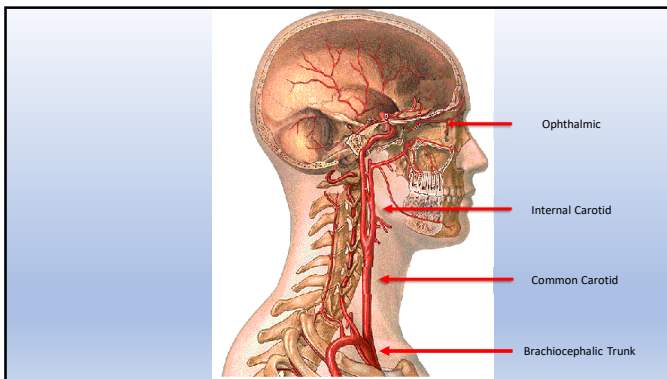
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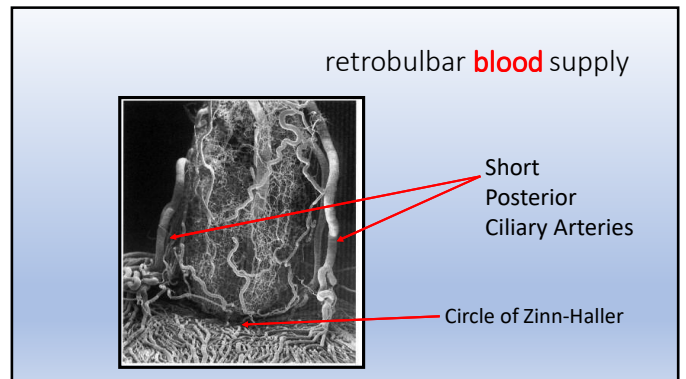
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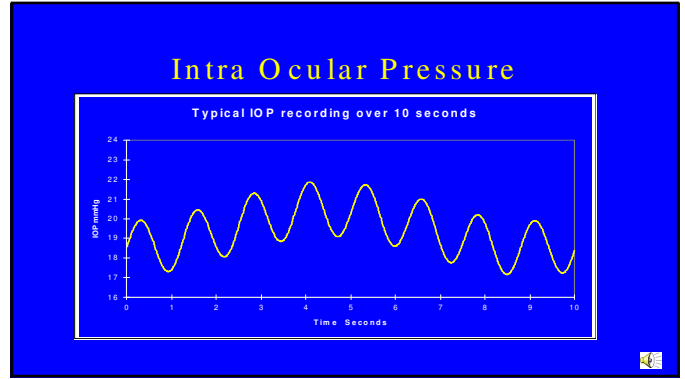
7



8

Measuring Ocular Blood Flow

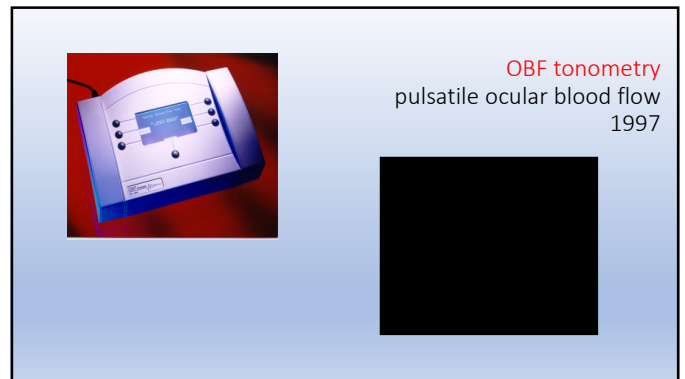
9



10



11



12

236 patients with NTG and 109 with suspicious discs (red) compared to 777 normal controls (yellow)

(1998 Investigative Ophthalmology – R A Hitchings, Moorfields Eye Hospital)

13

95% of the axonal blood supply is derived from the short posterior ciliary arteries

Source	% OF TOTAL
CILIARY	95
CRA	5
OTHER	0

14


Heidelberg Doppler Flowmetry (late 1990's)

15

Dynamic Contour Tonometry
Ocular Pulse Amplitude
2003

16

The Clinical Utility of Dynamic Contour Tonometry and Ocular Pulse Amplitude
 Weizer, Jennifer S. MD; Asrani, Sanjay MD; Stinnett, Sandra S. DrPH; Herndon, Leon W. MD
 Journal of Glaucoma: December 2007 - Volume 16 - Issue 8 - pp 700-703

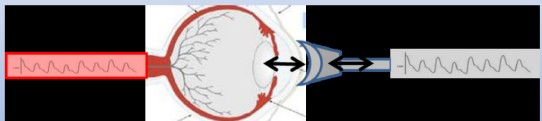


Purpose: To determine if Ocular Pulse Amplitude (OPA) as measured by Dynamic Contour Tonometry is related to severity of glaucoma...

Conclusions: Increased OPA seems to correlate with less severe glaucoma....

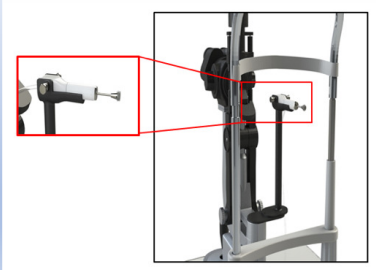
17

Composite Ocular Blood Flow Analyzer 2019



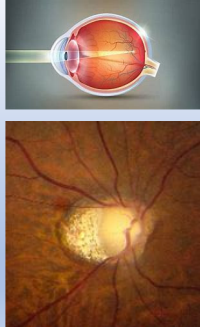
18

Composite Ocular Blood Flow Analyzer 2019



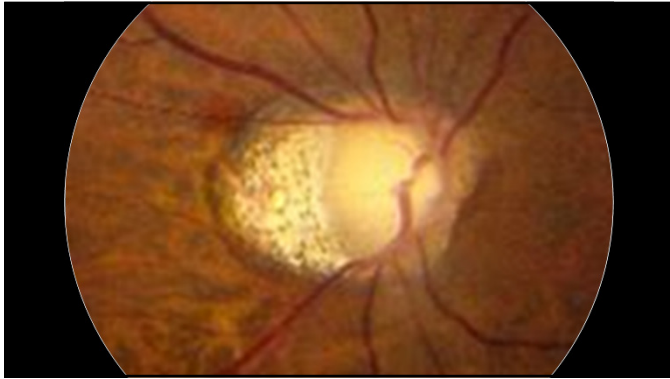
19

Myopia and Glaucoma



- Poor architecture - more vulnerable to IOP challenge
- Eye size
- Low pulsatile ocular blood flow
- Low pulse amplitudes
- Challenge to perfusion

20



21

auto-regulation

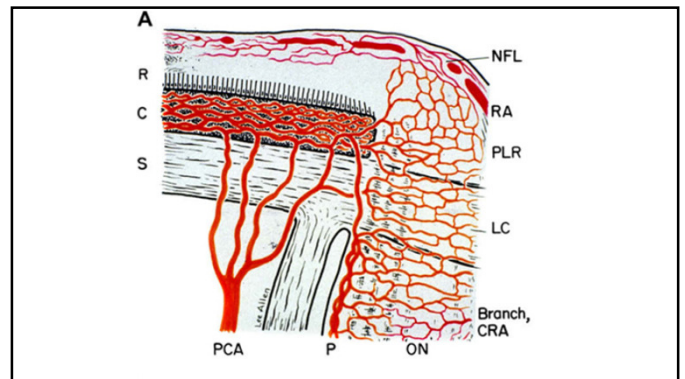
The system which attempts to mitigate variations in intraocular pressure and systemic blood pressure to meet the metabolic requirements of the axonal bed.

22

auto-regulation

 A grayscale micrograph showing a complex, dense network of blood vessels, likely representing the choriocapillary bed or a similar vascular structure. The vessels are highly branched and interconnected.

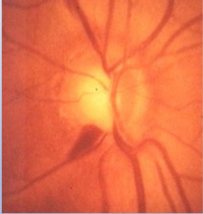
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24

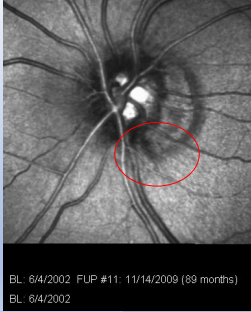
Drance Hemorrhage

- 13% POAG / 20% NTG
- 84% are missed
- 100% with 2 disc hemorrhages will have field loss
- 81% with 1 disc hemorrhage will have field loss
- 3 fold progression risk – even under treatment



Liebmann et al

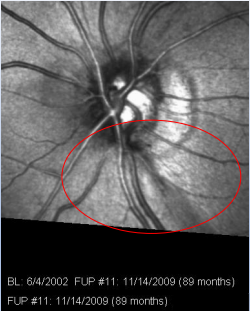
25



Drance Hemorrhage kills axons

BL: 6/4/2002 FUP #11: 11/14/2009 (89 months)
BL: 6/4/2002

26



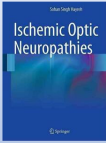
Drance Hemorrhage

BL: 6/4/2002 FUP #11: 11/14/2009 (89 months)
FUP #11: 11/14/2009 (89 months)


27

Nocturnal Systemic Hypotension

- Circadian cycle
- Beta blockers
- ACE inhibitors
- Anti-depressants
- Above taken at bedtime
- Physical fitness



Sohan Singh Hayreh
Professor of Ophthalmology
University of Iowa
Iowa City



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Nocturnal Systemic Hypotension Increases the Risk of Glaucoma Progression

Mary E. Charlson, MD, Carlos Gustavo de Moraes, MD, Alissa Link, MPH, Martin T. Wells, PhD, Gregory Hammond, MD, Nancy C. Peterson, EdD, Robert Ritch, MD, and Jeffrey M. Liebmann, MD
Ophthalmology, 2014 Oct; 121(10): 2004-2012

Conclusions:

Cumulative nocturnal hypotension predicted VF loss in this cohort. Our data suggest that the duration and magnitude of decrease in nocturnal blood pressure below the daytime MAP, especially pressures that are 10 mmHg lower than daytime MAP, predict progression of NTG. Low nocturnal blood pressure, whether occurring spontaneously or as a result of medications, may lead to worsening of VF defects.

29

NTG: The Nocturnal Blood Pressure Factor Red Flags for Clinicians

- Postural hypotension
- Cold hands and feet
- Migraines
- Myopia
- Systemic beta blocker use

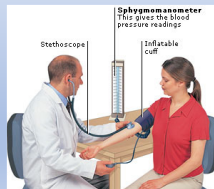


Carlos G. De Moraes, MD, New York City
 Published 10 February 2014

30

Diastolic Perfusion Pressure (DPP)

- Diastolic Blood pressure – IOP = DPP
- Risk increases 6X below 55



31

Progressing case despite controlled IOP (DPP=50 mmHg), cold hands (+)

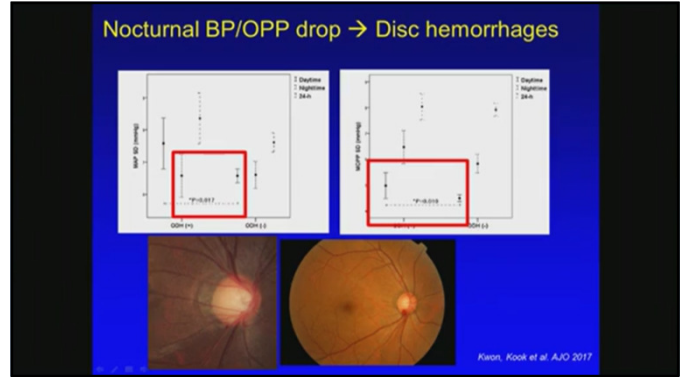
Time	BP	IOP (OD) (Ta/Tp)	IOP (OS) (Ta/Tp)
10 am	109/65	14/15	14/15
M.D	106/68	13/15	13/14
2 pm	115/74	12/13	11/12
4 pm	113/77	11/12	12/12
6pm	102/62	13/14	13/13
8pm	96/61	11/13	11/13
10pm	105/64	12/14	12/14
M.N	96/61	11/13 (15) *	10/12 (14) *
3am	96/54	9/12 (15) *	9/12 (14) *
6am	97/54	10/11 (14) *	11/11 (13) *
8am	107/64	11/12	12/13

32

Progressing patient with CAD & (+)antihypertensive medications

Time	BP	IOP (OD) (Ta/Tp)	IOP (OS) (Ta/Tp)
10am	129/85	14/15	14/15
M.D	126/78	15/16	15/16
2 pm	125/74	14/15	15/16
4 pm	133/77	13/14	14/15
6pm	122/72	14/16	16/17
8pm	126/81	13/15	13/14
10pm	125/74	15/16	14/15
M.N	103/59	14/15 (18) *	14/16 (17) *
3am	98/56	13/15 (18) *	14/15 (17) *
6am	97/60	13/14 (17) *	13/15 (16) *
8am	127/74	14/14	13/14

33



34



35



36

When to consider OPP clinically?

- Progressing glaucoma despite well-controlled IOP
- Normal-tension glaucoma
- Patients with nocturnal hypotension
- History or symptoms of low BP, systemic antihypertensive medications, orthostasis
- Patients with optic disc hemorrhages

37

Clinical Interventions to improve OPP

- Measure BP to identify those with low OPP
- Consider 24-h BP/IOP monitoring
- Modify systemic antihypertensive medication schedule or dose (pm → am, reduce dose to ½)
- Avoid topical beta-blockers for IOP reduction
- Reduce nocturnal IOP with topical PGAs or CAs
- Consider salty diet or salt tablets at night



38

Reduced Cerebral Blood Flow in the Visual Cortex and Its Correlation With Glaucomatous Structural Damage to the Retina in Patients With Mild to Moderate Primary Open-angle Glaucoma

Wang, Qian, MD^{*}; Chen, Weiwei, PhD^{*}; Qu, Xiaoxia, PhD^{*}; Wang, Huaizhou, MD^{*}; Wang, Ying, MD^{*}; Zhang, Xun, MD^{*}; Li, Ting, MD^{*}; Wang, Ningli, MD, PhD^{*}; Xian, Junfang, MD, PhD^{*}
 Journal of Glaucoma: [September 2018 - Volume 27 - Issue 9 - p 816-822](#)

Conclusions: The complex pathologic progress of POAG includes abnormal cerebral perfusion within the visual cortex in mild to moderate disease stages. The association of cerebral perfusion changes with alterations of the optic disc and the retina may contribute to the early diagnosis of POAG.



39

Primary Vascular Dysregulation

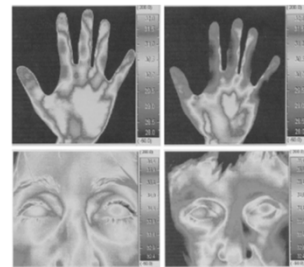
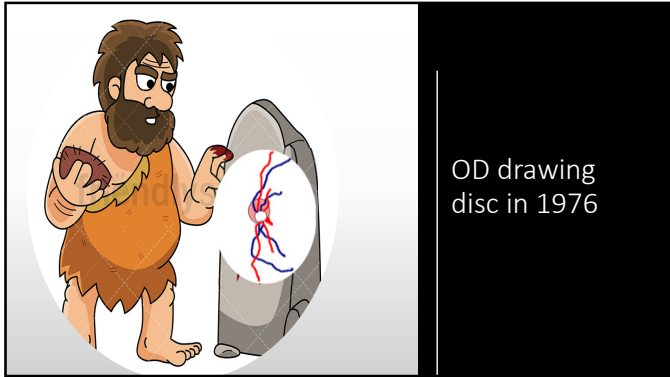


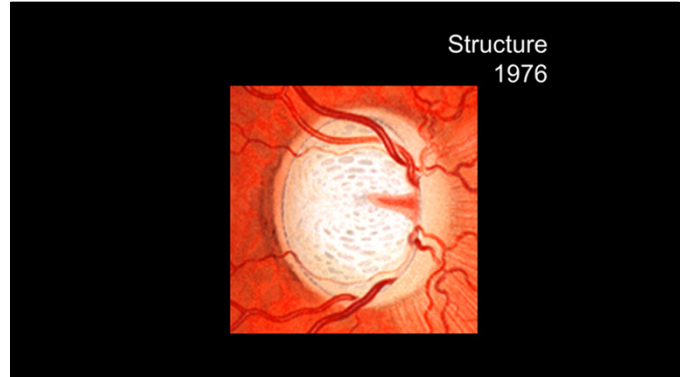
Fig. 2. Photographic Comparison between a subject without POAG (left) and with POAG (right) depicts a cold face and hand in POAG and a warm glow in a subject without POAG.

40



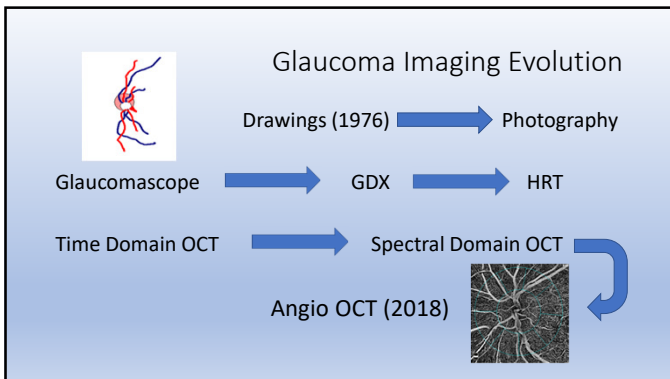
OD drawing
disc in 1976

41

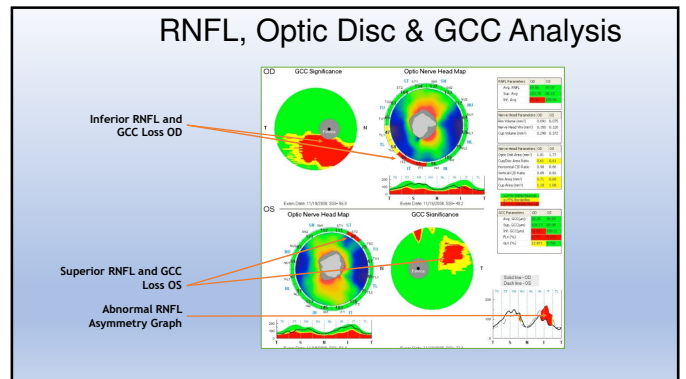


Structure
1976

42



43




44

OCT best for early and moderate disease

- Plasticity of fields with early loss
- OCT “Floor Effect” at about 50 microns

45

Angio OCT
OCTA



46



AngioVue OCT
Optovue



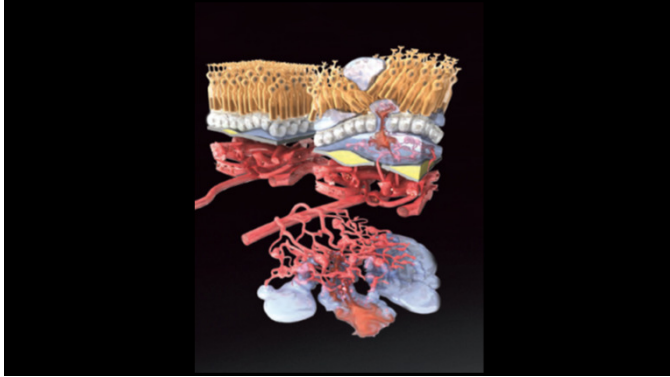
AngioPlex OCT
Ziess

47

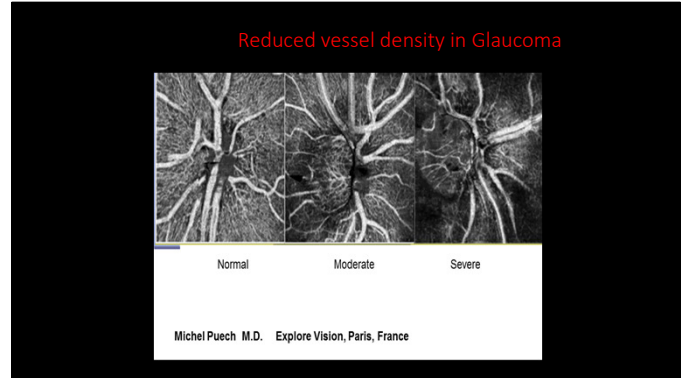


Heidelberg OCTA
September 2018

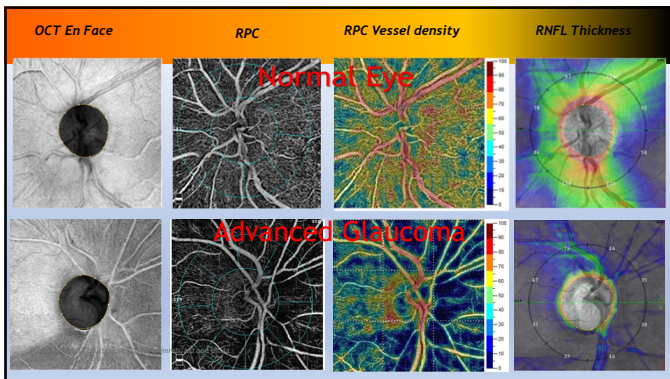
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49



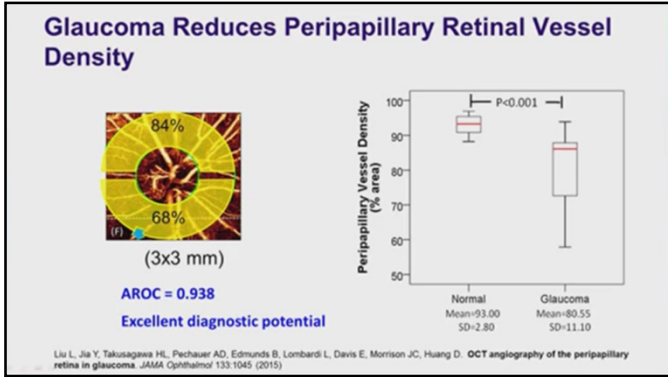
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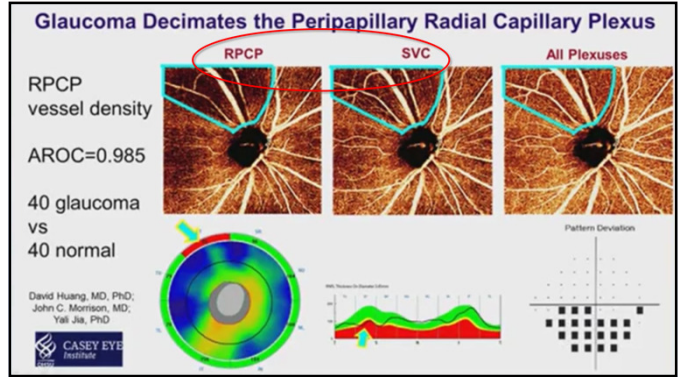
51



52



53



54

Decreased Vessel Density cause or effect?

- **Theory 1**
Axonal loss causes reduced demand of blood (ie. decrease in VEG-F), so vessels recede as the result of decrease in signal.
- **Theory 2**
Axonal loss secondary to acute or chronic ischemia

55

Optical Coherence Tomography Angiography of Optic Disc in Eyes With Primary Open-angle Glaucoma and Normal-tension Glaucoma

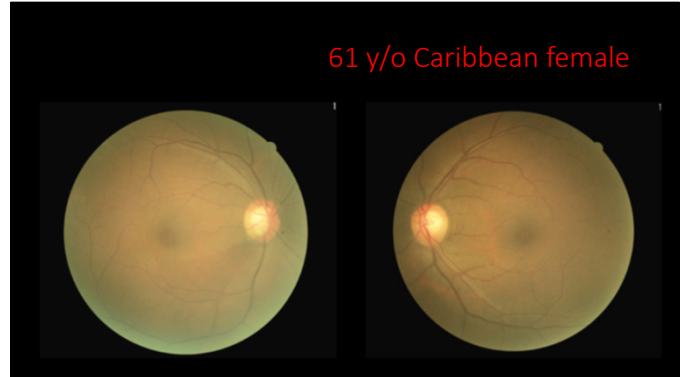
Toshev, Anani P, MD¹; Schuster, Alexander Karl-Georg, MD, MSc¹; ul Hassan, Shahzada N., MD^{1,2}; Pfeiffer, Norbert, MD¹; Hoffmann, Esther M, MD¹
Journal of Glaucoma: March 2019 - Volume 28 - Issue 3 - p 243-251

Conclusions: Overall, glaucomatous eyes had lower peripapillary Vessel Density compared with normal and OHT eyes. There is a strong relationship between the peripapillary structure of RNFL and its vasculature.

56

Clinical Examples

57

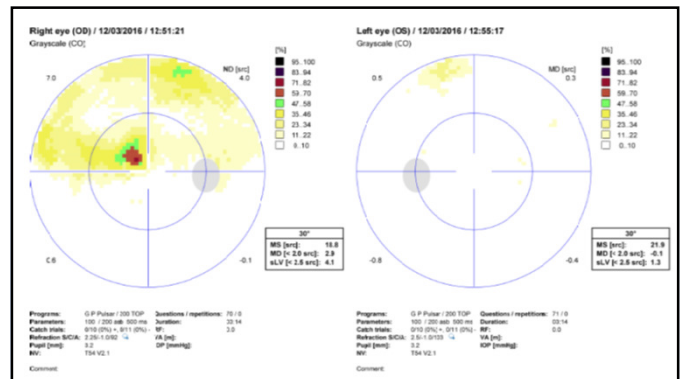


58

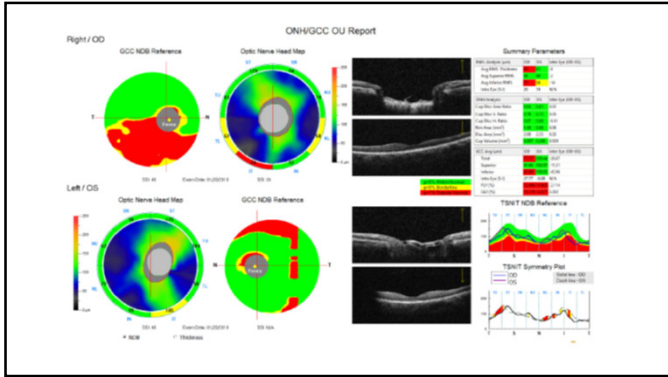
history

- Positive family glaucoma History
- 5 years treatment latanoprost monotherapy
- IOP's with medication 20 mm OU
- OD loss approaching fixation
- OD wedge NFL defect

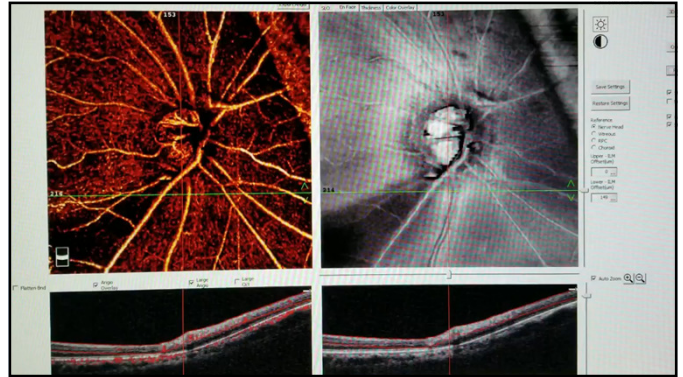
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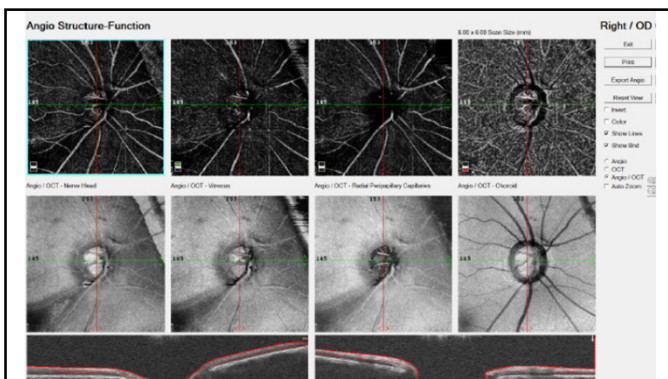
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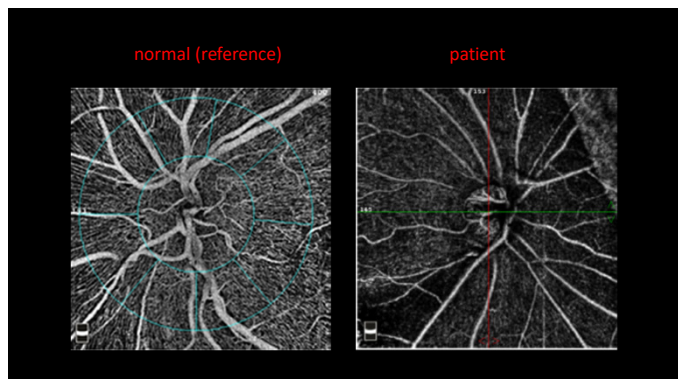
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62



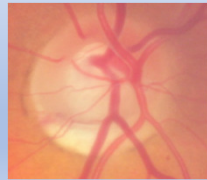
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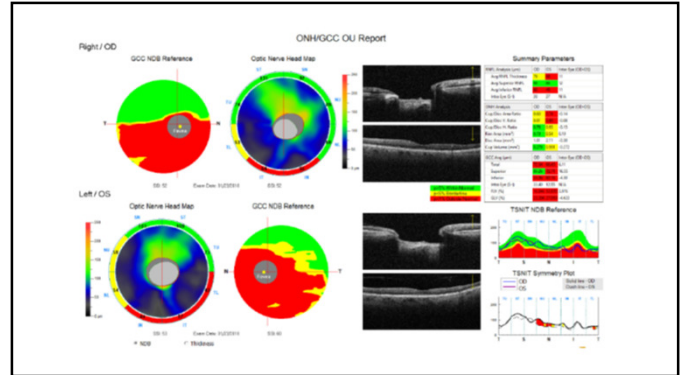
64

76 y/o Caucasian female

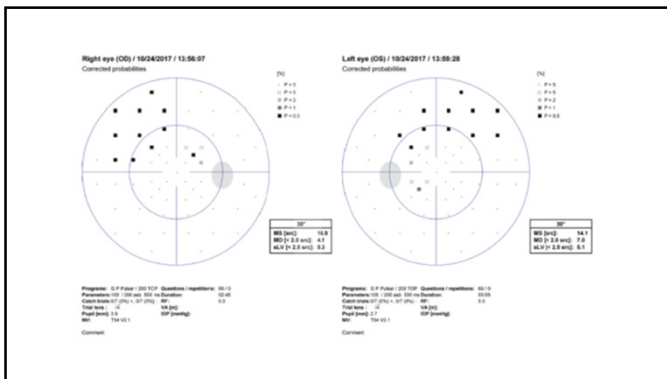
- Chronic Drance hemorrhage
- 4 topical medicines
- Superior and paracentral field loss
- “controlled” IOP’s in high teens



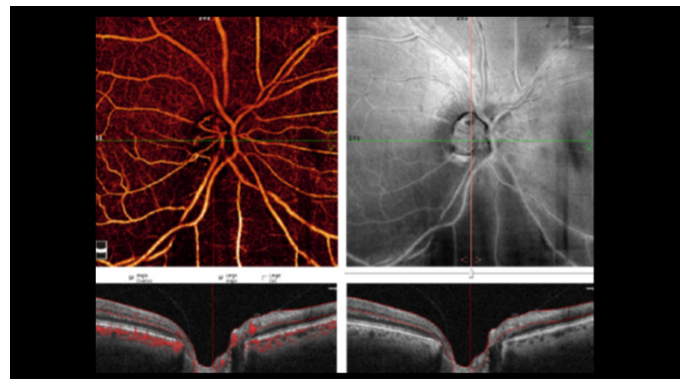
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66



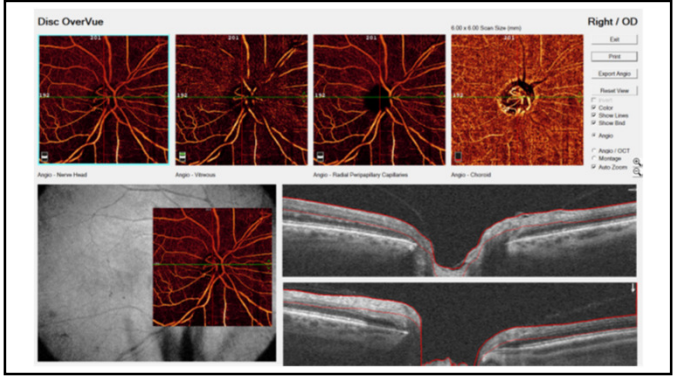
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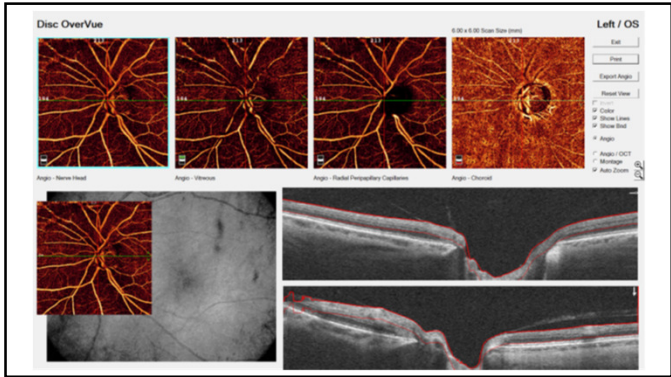
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69



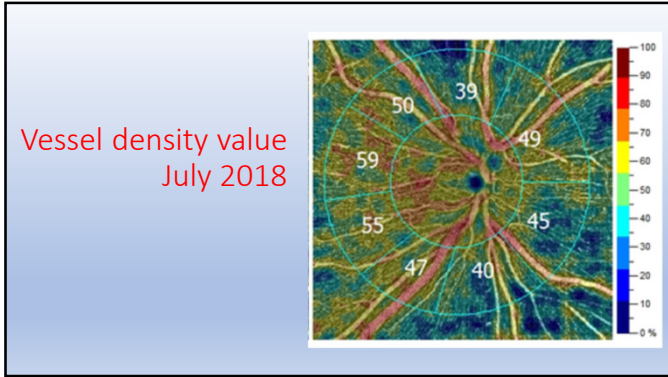
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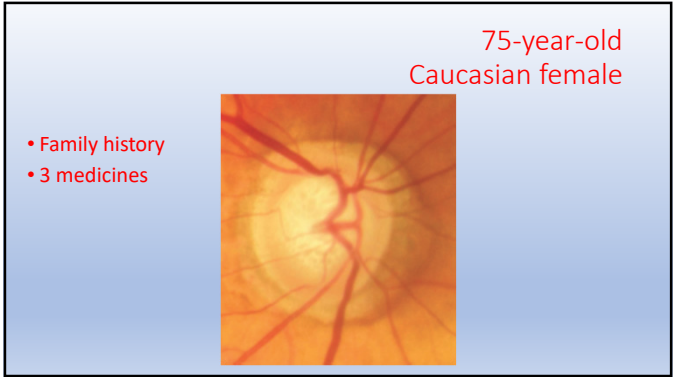
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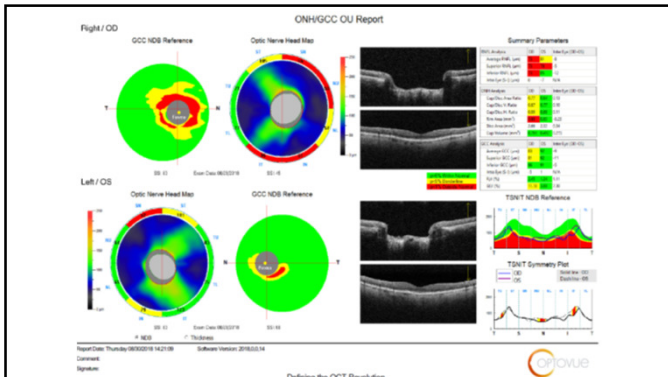
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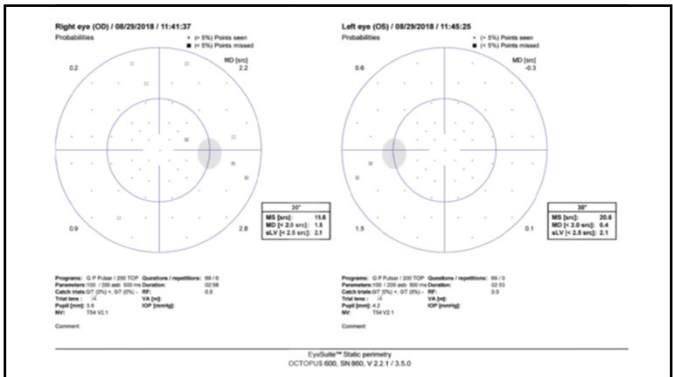
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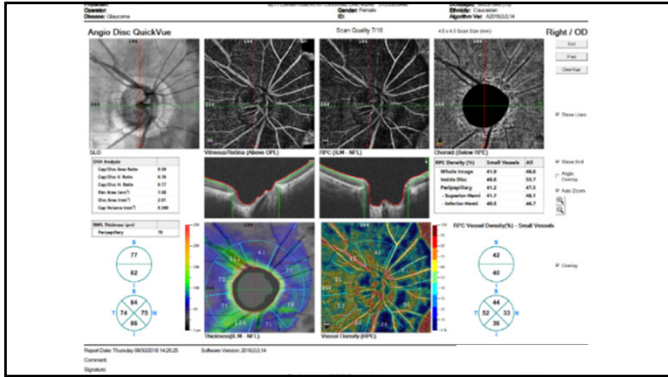
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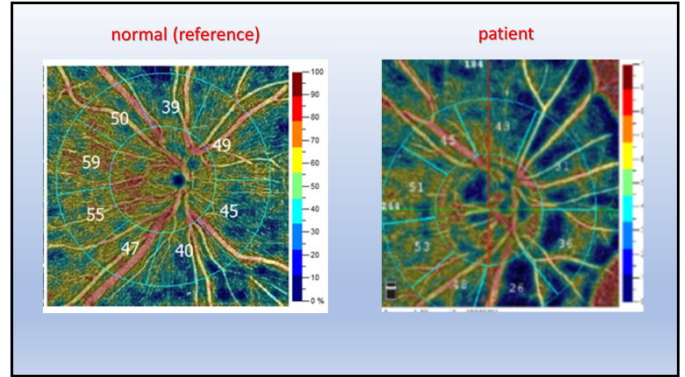
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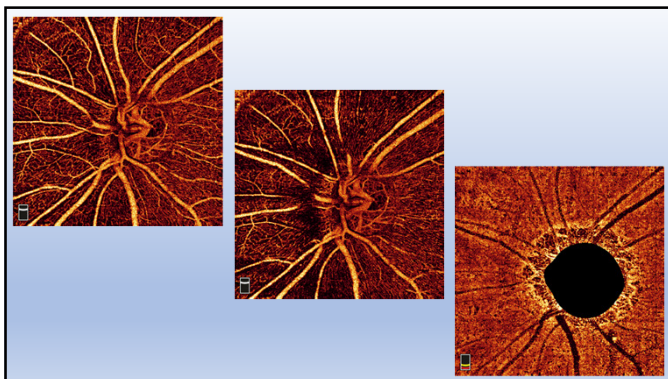
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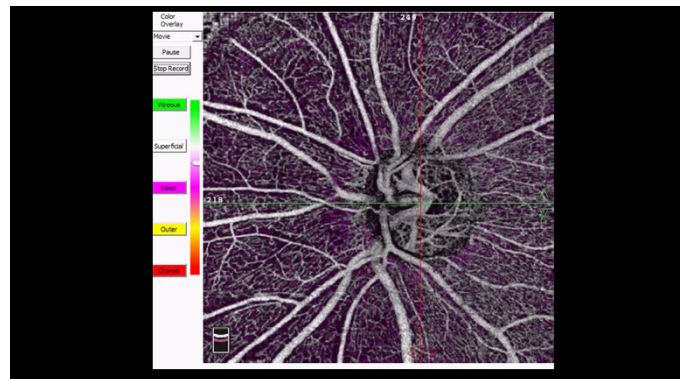
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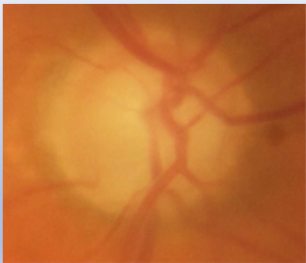
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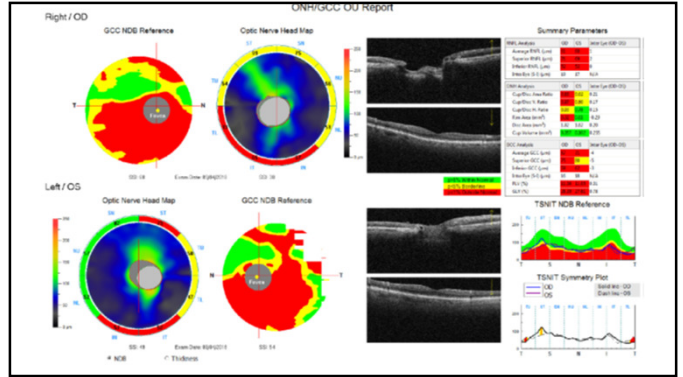
80

80 y/o Caucasian male

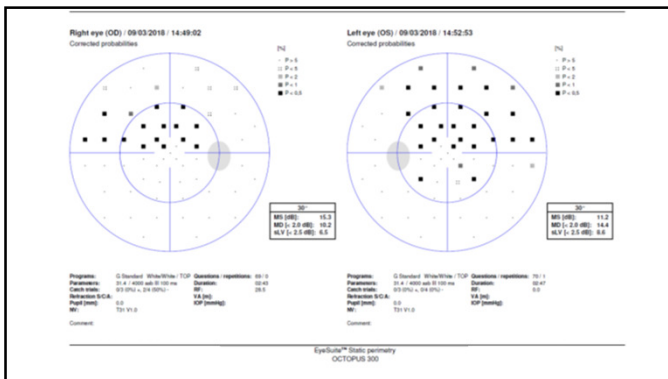
- IOP never exceeded 20 mm
- Dx normal tension glaucoma
- Current meds – Latanoprost, Simbrinza, Rhoпресса



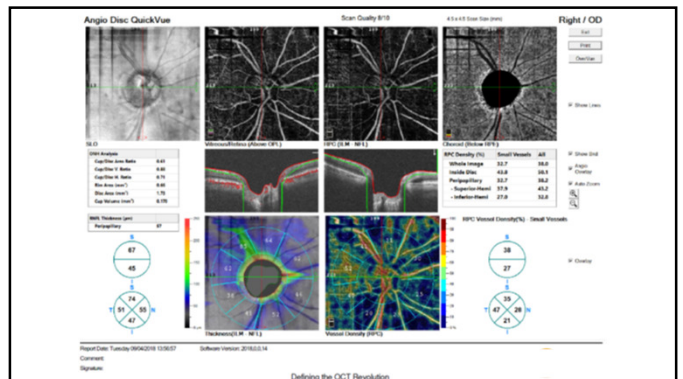
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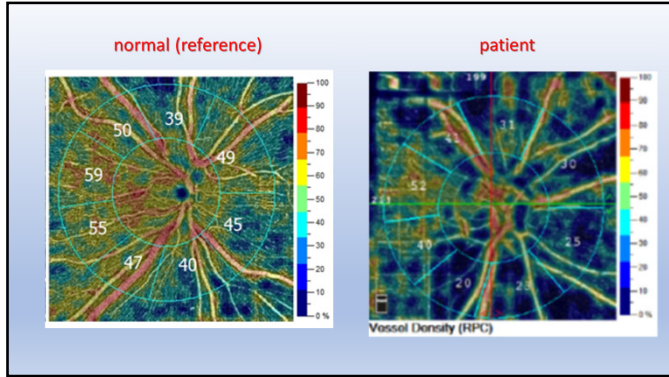
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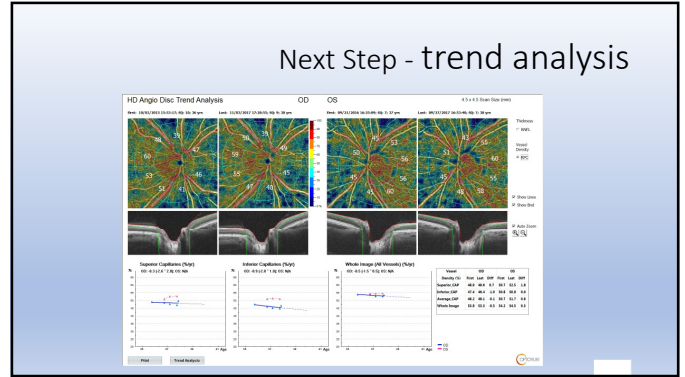
83



84



85



86



87

Decrease IOP significantly

- Small changes in IOP seldom alter blood flow significantly because of the mitigating effect of autoregulation
- Dramatic IOP decreases overwhelm autoregulation and increase ocular perfusion

88

Calculate Diastolic Perfusion Pressure

- Be more aggressive in treating individuals with DPP below 55



89

Look for over treatment of high blood pressure

- Avoid nighttime systemic beta blockers
- Communicate with prescribing MD's to share your concern

90

Counsel hydration / salt intake / lifestyle

- Encourage electrolyte drinks
- Encourage hydration at bedtime
- Consider salt tablets at bedtime
- Encourage self monitoring of blood pressure



91

Consider topical medications or treatments which may augment blood flow by dramatically reducing IOP

92

Recent Blood Flow Studies

The Effect of Medical Lowering of Intraocular Pressure on Peripapillary and Macular Blood Flow as Measured by Optical Coherence Tomography Angiography in Treatment-naïve Eyes

Liu, Chang MD*; Umapathi, Retha M. BSc*; Atalay, Eray MD; Schmetterer, Leopold PhD*, S, J, S, K, **, *,*; Husain, Rahat MD(Res), FRCOphth*; Bony, Pui Yi FRCSEdJ*; Aung, Tin FRCSEdJ, PhD*, S, J, J; Nongpiur, Monisha E. MD, PhD*, Author Information

Journal of Glaucoma: June 2021 - Volume 30 - Issue 6 - p 465-472

doi: 10.1097/JG.0000000000001828

https://journals.lww.com/glaucomajournal/Abstract/2021/06000/The_Effect_of_Medical_Lowering_of_Intraocular_Pressure.aspx

Superficial and Deep Macula Vessel Density in Healthy, Glaucoma Suspect, and Glaucoma Eyes

El-Nimri, Nevin W. OD, PhD*; Manalastas, Patricia Isabel C. MD*; Zangwill, Linda M. PhD*; Proudfoot, James A. MSc*; Bowd, Christopher PhD*; Hou, Huiyuan MD, PhD*; Maghini, Sasan MD*; Penzado, Raíella C. MD*; Rezapour, Jamin MD*; Ekici, Eren MD*, J; Shoji, Takuhei MD*, J; Ghahari, Eham MD*, S; Yarmohammadi, Afsah MD*; Weiszb, Robert N. MD* Author Information

Journal of Glaucoma: June 2021 - Volume 30 - Issue 6 - p e276-e284

doi: 10.1097/JG.0000000000001860

https://journals.lww.com/glaucomajournal/Abstract/2021/06000/Superficial_and_Deep_Macula_Vessel_Density_in_Healthy_Suspect_and_Glaucoma_Eyes.aspx

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Prediction of 10-2 Visual Field Loss Using Optical Coherence Tomography and 24-2 Visual Field Data

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Thank YOU

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