NEW IMAGING MODALITIES IN GLAUCOMA

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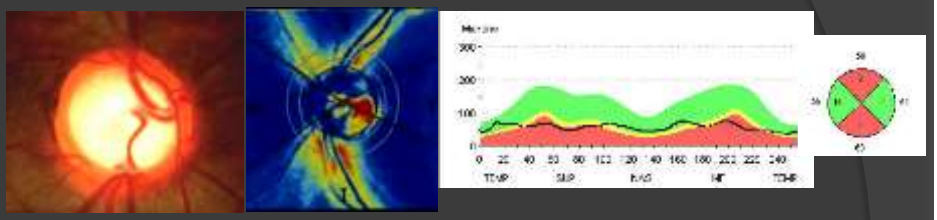
Cairo University

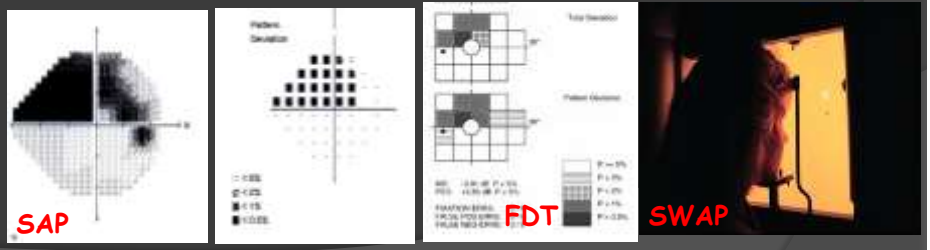
"Life is trying things to see if they work"

Ray Bradbury

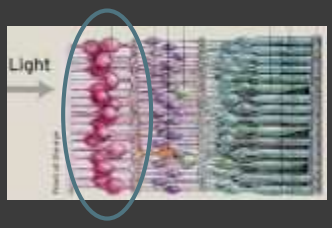
Structure

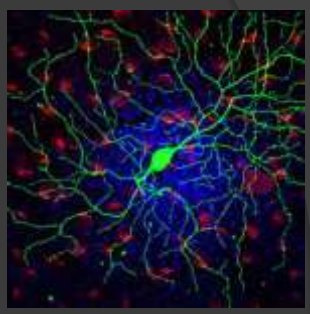


Function



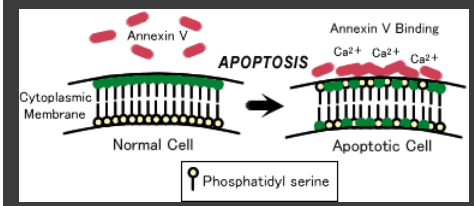
Retinal Ganglion Cells





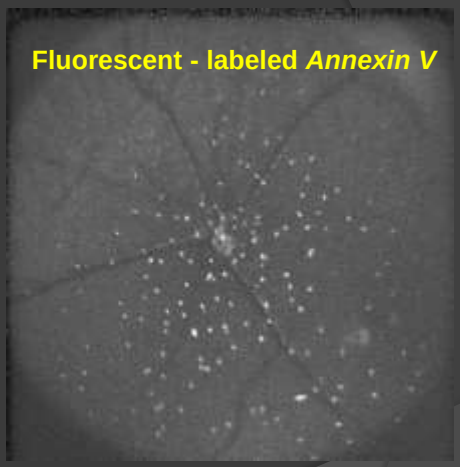
- Key cell type in glaucoma damage.
- 20-40% loss before field defects.
- 10 years delay in diagnosis.

Apoptosis



- Normal aging : 0.4% / Y.
- Glaucoma : 4% / Y.
- Exp glaucoma model :
  2- 4 weeks ⟶
  4-13% apoptosis.

cSLO 488 nm



DARC

(Detection of Apoptosing Retinal Cells)

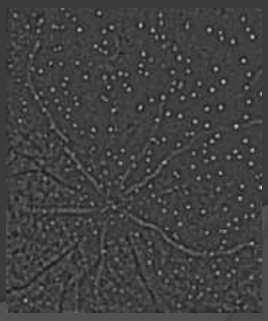
DARC

(Detection of Apoptosing Retinal Cells)

RESEARCH ARTICLE Open Access

A semi-automated technique for labeling and counting of apoptosing retinal cells

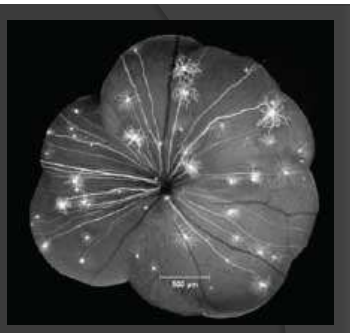
Non-invasive , *in vivo* , real - time Visualization of Single Retinal Cells Undergoing Apoptosis

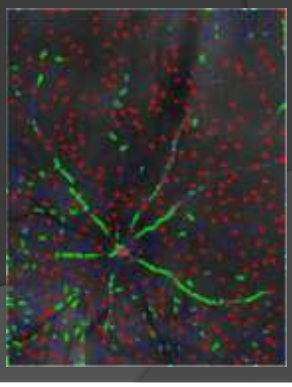


DARC

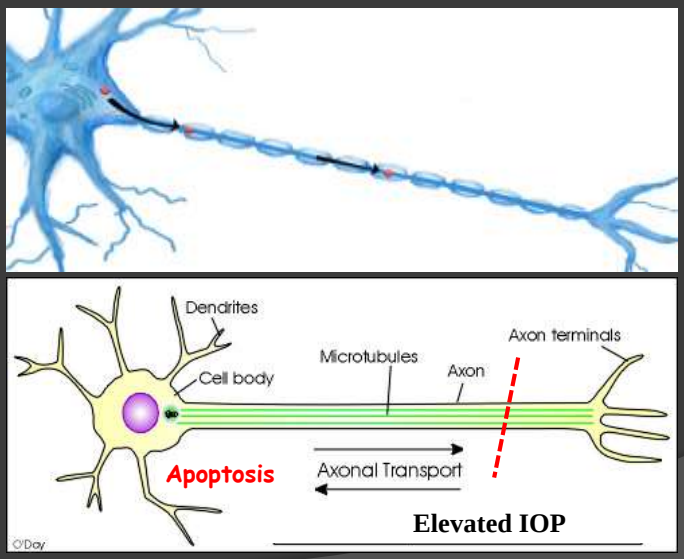
(Detection of Apoptosing Retinal Cells)

- Early Diagnosis , Monitor Progression and Treatment Efficacy.
- Effect of therapy *in days and weeks* (rather than years).
- IOP : insufficient as diagnostic tool or index of control.
- Non-IOP lowering strategies : blockade glutamate activity (NMDA antagonist).
- No human data available so far.





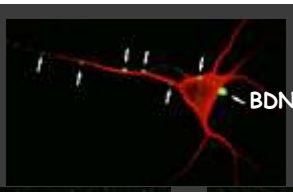
Axonal Transport (BDNF)

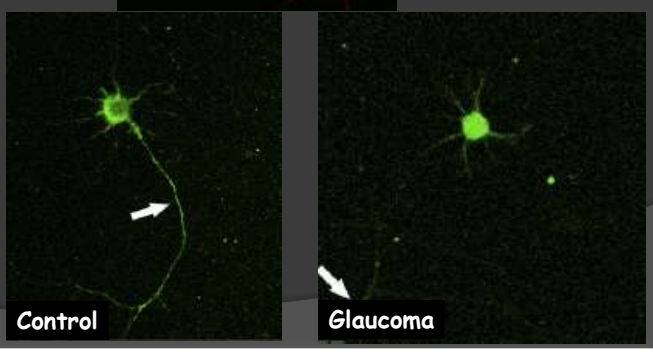


Axonal Transport (BDNF)

Glaucoma

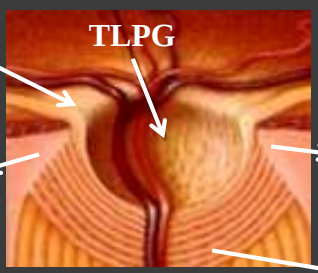
Dynamic Imaging of Axonal Transport in Living Retinal Ganglion Cells In Vitro



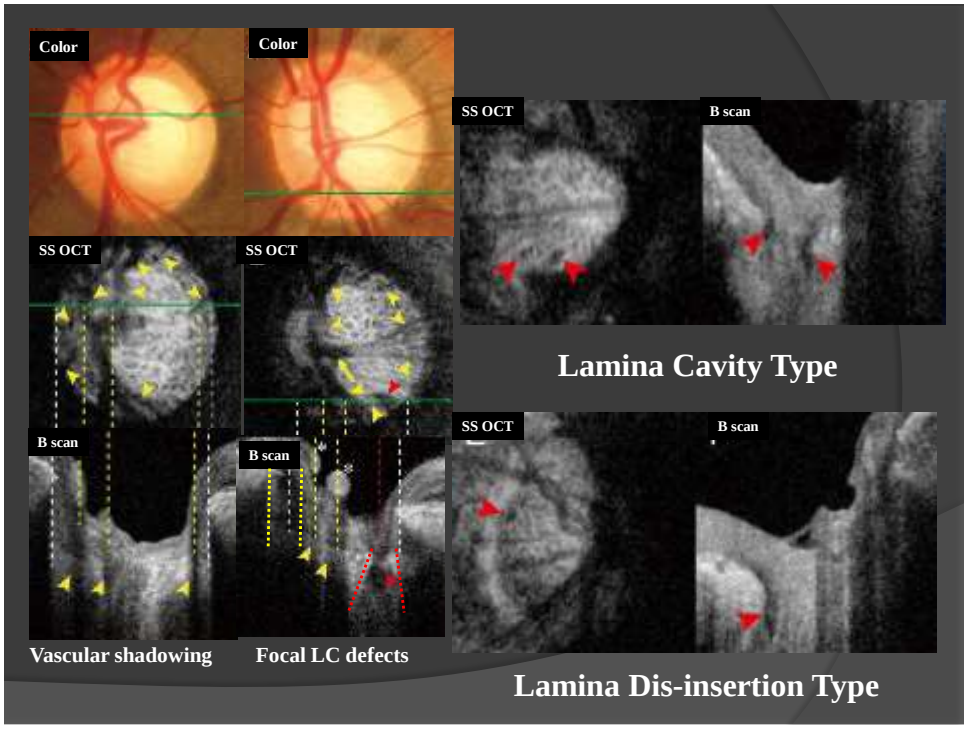


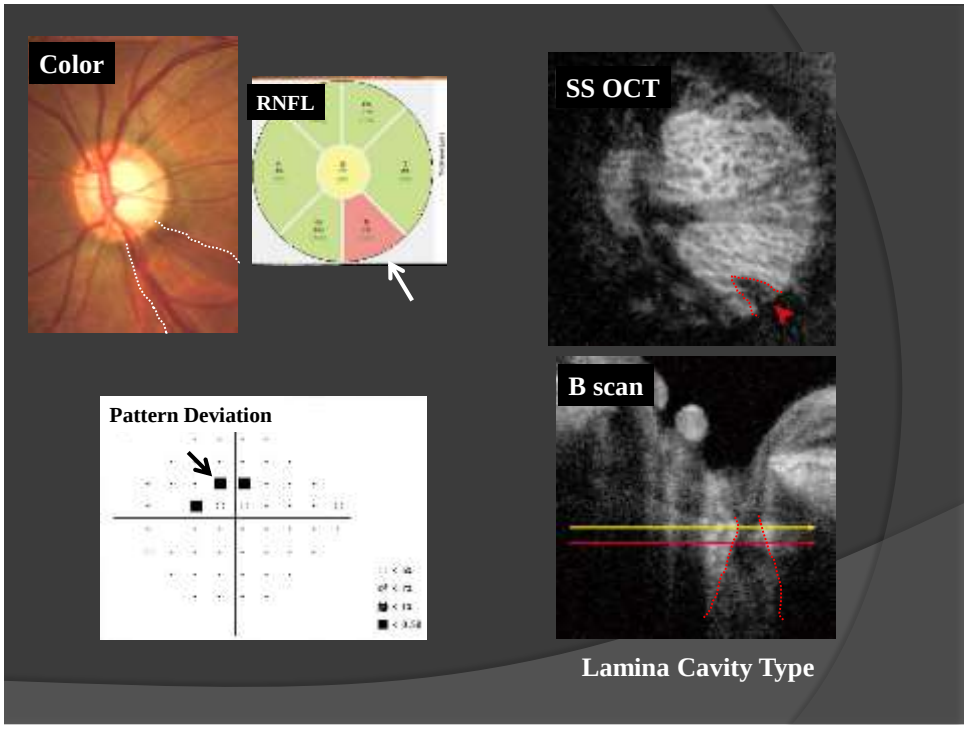
Lamina Cribrosa

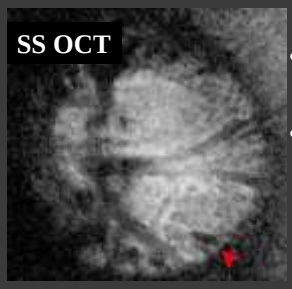
Principal site of RGC axon damage in glaucoma



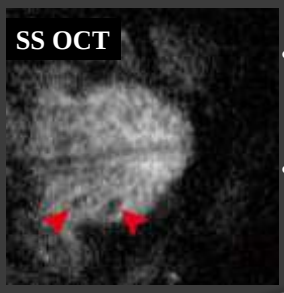
DD Glaucomatous vs. non-glaucomatous cupping


Color
Color
SS OCT
B scan
Lamina Cavity Type
SS OCT
SS OCT
B scan
B scan
SS OCT
B scan
Vascular shadowing
Focal LC defects
Lamina Dis-insertion Type


Color
RNFL
SS OCT
Pattern Deviation
B scan
Lamina Cavity Type



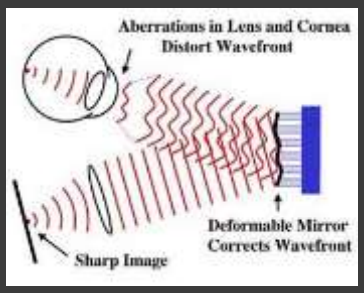
- Peripheral LC.
- Inf .& Sup.Poles :
  - Larger pores.
  - Thinner CT.
  - Less glial tissue.



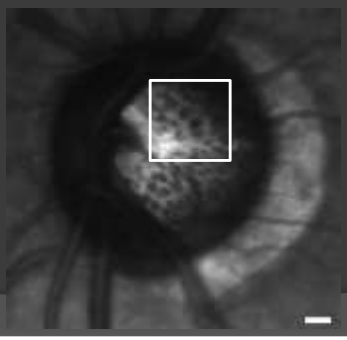
- Early : Precedes clinical findings.
- Damaged LC : more Susceptible to Further Damage.

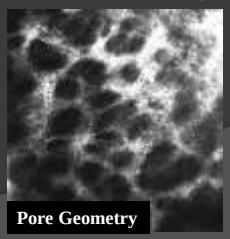
Localized Glaucomatous Damage & Focal Progression

Adaptive Optics



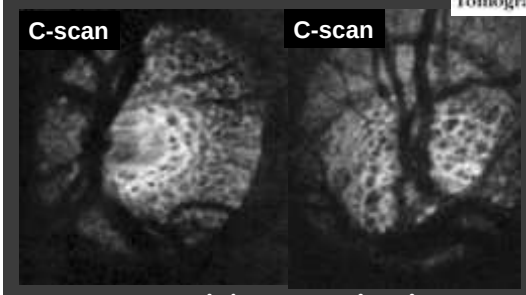
- LC thinner in glaucoma patients.
- Post. Displacement , Compression.
- Dis-insertion.
- Pore deformation (Ax. Flow , Bl. Supply).





LC Micro-Architecture

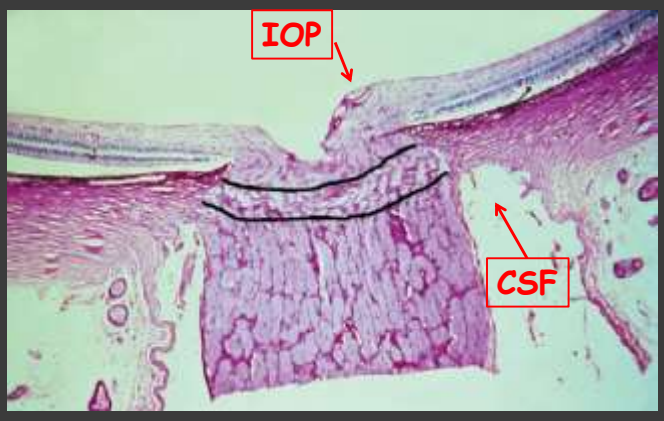
Glaucoma
In Vivo Lamina Cribrosa Micro-Architecture in Healthy and Glaucomatous Eyes as Assessed by Optical Coherence Tomography
Invest Ophthalmol Vis Sci 2013 ; 54 : 8270-8274.



- Increased beam thickness : pore diameter ratio.
- Increased variability of pore diameter.
- Increased pore count.
- Decreased pore diameter.

LC re-modeling : disease severity indicator.

Trans-laminar Pressure Gradient (TLPG) [IOP – CSFp] & LC thickness



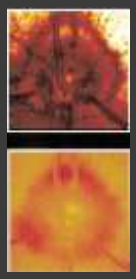
Optic Neuropathy Induced by Experimentally Reduced Cerebrospinal Fluid Pressure in Monkeys. *IOVS May 2014 ; 55 : 3067-3073.*

Optic Disc Movement with Variations in Intraocular and Cerebrospinal Fluid Pressure

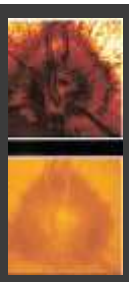
William H. Morgan,[1] Balwantray C. Chauhan,[2] Dao-Yi Yu,[1] Stephen J. Cringle,[1] Valerie A. Alder,[1] and Phillip H. House[3]

The Influence of Cerebrospinal Fluid Pressure on the Lamina Cribrosa Tissue Pressure Gradient

William H. Morgan, Dao-Yi Yu, Richard L. Cooper, Valerie A. Alder, Stephen J. Cringle, and Ian J. Constable



IOP 17
CSFp 8



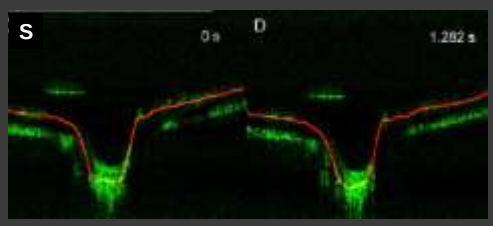
IOP 33
CSFp 10

- **No significant laminar changes when IOP and CSFp increase *equally.***
- **CSFp changes *cause much greater effect* than equivalent changes in IOP.**
- **Cup volume changes due to IOP/CSFp changes *rather than neural tissue loss.***

Glaucoma

Pulsatile Movement of the Optic Nerve Head and the Peripapillary Retina in Normal Subjects and in Glaucoma

(*Invest Ophthalmol Vis Sci.* 2012;53:7819–7824)



Ocular pulsatility : significantly greater amplitude in glaucoma.

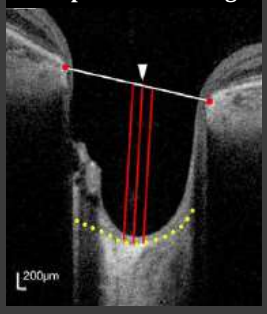
Retina & LC move in opposite directions
⟶ deformation and stretching of GC axons.

Glaucoma

Alterations in the Neural and Connective Tissue Components of Glaucomatous Cupping After Glaucoma Surgery Using Swept-Source Optical Coherence Tomography

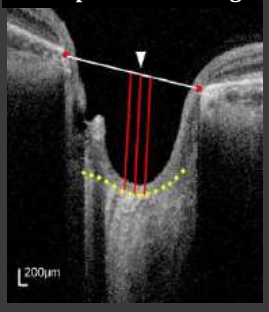
Invest Ophthalmol Vis Sci 2014 ; 55: 477 . 484.

Pre-op IOP 40 mmHg



LC Depth 927 µ

Post-op IOP 16 mmHg



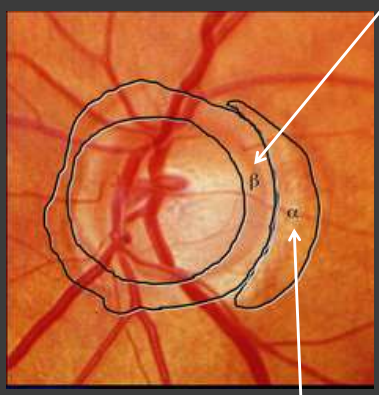
LC Depth 711 µ

Advanced Glaucoma : LC more susceptible to IOP changes . Cause or Result ?!

Early : LC compression …. Late : LC atrophy

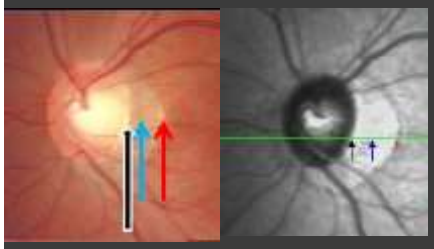
Para Papillary Atrophy

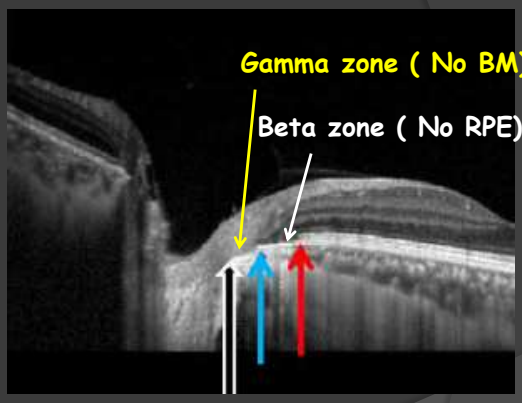
Visible sclera and large ch v.

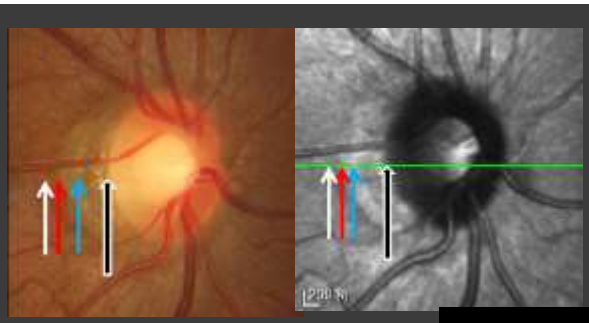


Irregular hypo- / hyper pigmentation

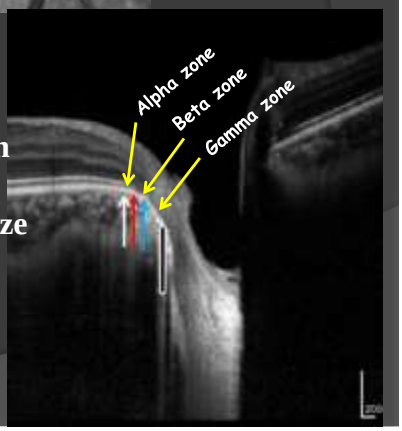
SD-OCT Correlate of Para papillary region.





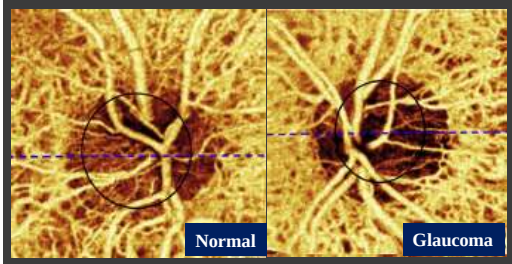


- Beta zone : glaucoma association.
- Gamma zone : *NO* glaucoma association more in moderate myopia (-8.0 D).
- Both increase with age , myopia , disc size



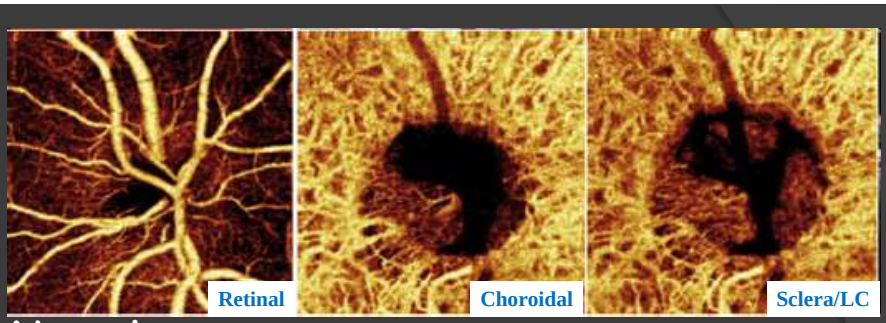
OCT Angiography

Doppler Frequency Shift of Back scattered Light

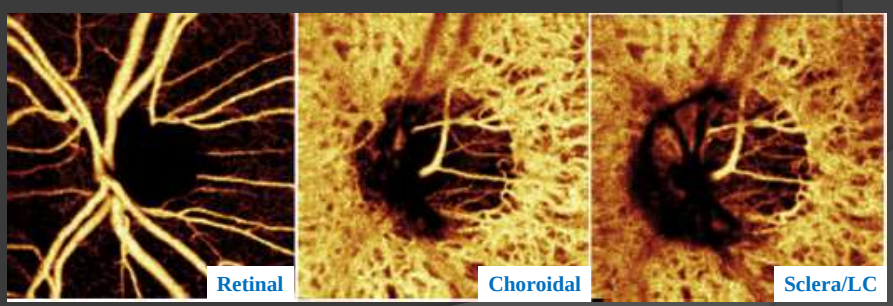


- Disc flow index , correlated with the severity of glaucoma & Functional tests (VF PSD) .
- Used to determine OH and Glaucoma suspects that require Treatment.

Disc perfusion is reduced in glaucomatous eyes.

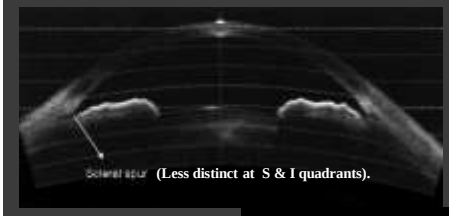


Normal



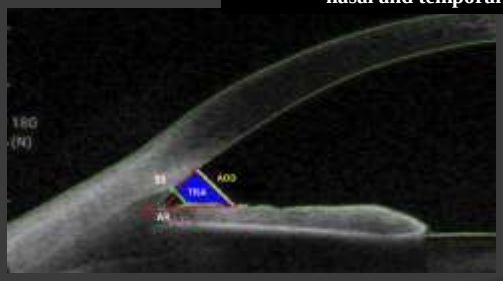
Glaucoma

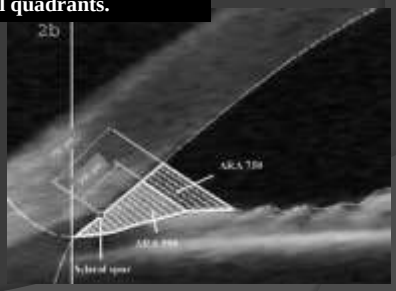
Anterior Chamber Angle



(Less distinct at S & I quadrants).

Good reproducibility & gonioscopy – correlated in nasal and temporal quadrants.

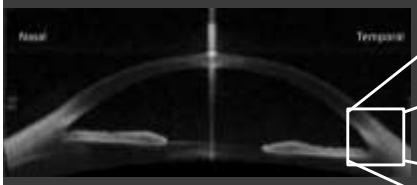


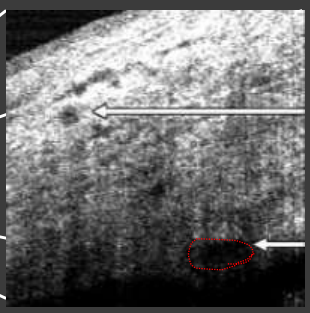


Length **µ (AOD) ,** ***Area*** **sq µ (TISA) ,** ***Angle*** **º (TIA) .**

Aqueous Outflow Structures

SD - OCT

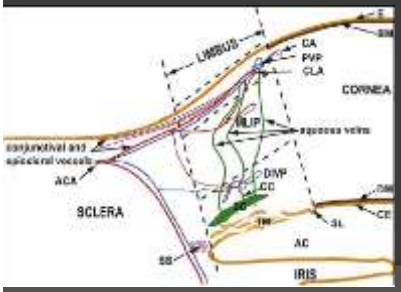




Scleral Vein

Collector Channel

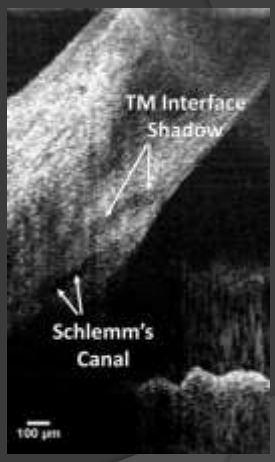
SC

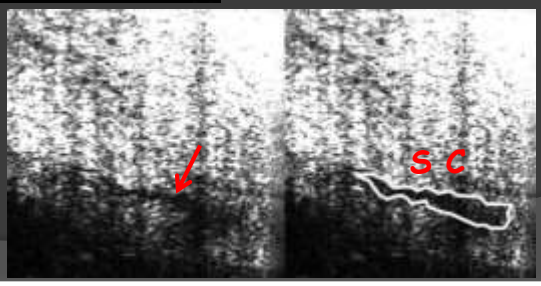


Aqueous Outflow Structures

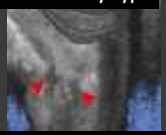
SC cross-sectional area:

- Significantly ***Smaller*** in Glaucoma Patients.
- Significantly ***Larger*** on the Nasal side.
- ***Collapse*** after Glaucoma Drainage Device.

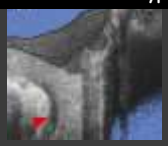




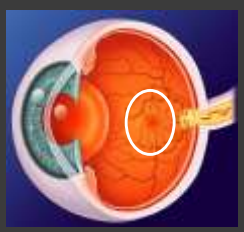
Lamina Cavity type



Lamina Disinsertion type

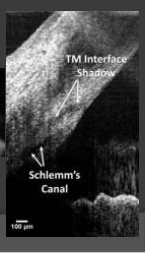


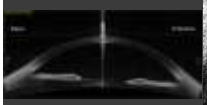
Axonal Transport



DARC
In-vivo , Real-time , Non-invasive Imaging of Single Cells undergoing Apoptosis.

OCT Angiography





LC micro-architecture

Gamma Zone
Absence of Glaucoma.

“ By seeing more ,

we should be able to diagnose

and then

intervene at a much earlier stage”

Thank You