NEW IMAGING MODALITIES IN GLAUCOMA

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“Life is trying things to see if they work”
Ray Bradbury
Structure

Function

SAP

FDT

SWAP
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.

Fluorescent-labeled Annexin V

cSLO 488 nm

DARC (Detection of Apoptosing Retinal Cells)
Non-invasive, \textit{in vivo}, real-time Visualization of Single Retinal Cells Undergoing Apoptosis

- Early Diagnosis, Monitor Progression and Treatment Efficacy.
- Effect of therapy \textit{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)

- Elevated IOP
- Apoptosis

Axonal Transport (BDNF)

- Dynamic Imaging of Axonal Transport in Living Retinal Ganglion Cells In Vitro
- BDNF + GFP

- Control
- Glaucoma
Lamina Cribrosa

Principal site of RGC axon damage in glaucoma

Pre-laminar thinning

TLPG

PP sclera stretching

CT deformation & Re-modeling.

DD Glaucomatous vs. non-glaucomatous cupping
Localized Glaucomatous Damage & Focal Progression

- Peripheral LC.
- Inf. & Sup. Poles:
  - Larger pores.
  - Thinner CT.
  - Less glial tissue.
- Early: Precedes clinical findings.
- Damaged LC: More susceptible to further damage.

Adaptive Optics

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

Pore Geometry
LC Micro-Architecture

- 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. *JOVS May 2014; 55 : 3067-3073.*
• 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*.

Ocular pulsatility: significantly greater amplitude in glaucoma.

Retina & LC move in opposite directions —— deformation and stretching of GC axons.
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.
**Anterior Chamber Angle**

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

Less distinct at S & I quadrants.

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

**Omega Zone**
Absence of Glaucoma.

**Axonal Transport**

**LC micro-architecture**

**OCT Angiography**

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

**Gamma Zone**
Absence of Glaucoma.
“By seeing more, we should be able to diagnose and then intervene at a much earlier stage”

Thank You