- Glaucoma Progression Detection with OCT

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- B. Francis: grant support for AIGS from NEI / NIH
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- Glaucoma Progression with OCT
- Scan Quality
- Floor Effect
- Age related Loss
- Intervisit Reproducibility
- Event Based Progression
- Trend Based Progression
- Guided Progression Analysis
- Glaucoma Progression on OCT

SCAN QUALITY

- signal strength less than 6
- movement or blinking artifacts
- Scan alignment
- Glaucoma Progression on OCT

SCAN QUALITY

- Opacities (floaters) within the 1.73-mm radius around the optic nerve head
- Segmentation errors
- Scan centration
- The Right Test for the Right Patient
- Floor Effect
- Early to moderate glaucoma: best use of OCT for progression
- Advanced glaucoma: Floor Effect makes it less useful
    - RNFL rarely below 50 μm due to residual nonneural tissue
    - RNFL thickness therefore levels off
    - Visual fields more likely to detect progression
- Adjusting for Age Related Loss
- RNFL thinning as a result of aging
- Cross sectional: -0.33 microns per year
- Longitudinal: -0.52 microns per year
    - Leung CK, Yu M, Weinreb RN, *et al*. *Ophthalmology* 2012;**119**:731–7.

<u>AIGS Cross Sectional and Longitudinal Study:</u>

192 eyes (92 participants) over 5 years

- Cross Sectional: GCC -0.17 microns per year Overall RNFL -0.21 microns per year

- Longitudinal: GCC thickness: -0.25 microns per year
- Longitudinal: Overall NFL thickness: -0.14 microns per year
    - Zhang X, Francis BA, Dastiridou A, Chopra V, Tan O, Varma R, Greenfield DS, Schuman JS, Huang D. *Translational Vision Science and Technology*. April 2016.
    - Repeatability and Reproducibility of SD-OCT
- Intravisit Reproducibility
- Intervisit Reproducibility = 3.89 μm: suggesting a reproducible decrease of > 4 μm statistically significant change
- A more cautious cutoff would be a 10 μm change, twice the maximum standard deviation.
- Mwanza JC, Chang RT, Budenz DL, et al. Reproducibility of peripapillary retinal nerve fiber layer thickness and optic nerve head parameters measured with cirrus HD-OCT in glaucomatous eyes. Invest Ophthalmol Vis Sci 2010;51:5724-5730.
- Progressive RNFL Thinning
- Progressive RNFL thinning = progressive disease
- Global: Decreased Overall RNFL thickness
- Focal: Decrease in Quadrant or Section
- The top three RNFL progression patterns are:
    - Widening of an existing RNFL defect
    - Deepening without widening of an existing RNFL defect
    - Development of a new RNFL defect.
- Event Based Analysis
- Similar to VF progression methods
- Event-based analysis: progression when a follow up measurement exceeds a pre-established threshold for change from baseline.
- For example, a repeatable 10 micron decrease in superior RNFL thickness
- Susceptible to outliers, may identify false progression
- Trend Based Analysis
- Similar to VF progression methods
- Trend-based analysis: monitoring the change over time using regression analysis to provide a rate of progression and corresponding significance level.
- For example, slope of change of inferior RNFL thickness exceeds the expected normal range
- Requires large number of tests
- Guided Progression Analysis (GPA)
- Compares the RNFL thickness of individual clusters of A-scans between baseline and follow up RNFL thickness maps to an estimated test-retest variability.
- 2 baseline scans
- Local pixels exceeding such test-retest variability
    - YELLOW at the first event

    - RED if the same changes are seen on three consecutive images
- Overall trend plot, two baseline scans with three follow up scans
- Linear regression line in μm/yr, representing rate of change, is drawn with an estimated confidence interval carried forward.
- **Predicting Conversion & Progression in the Advanced Imaging for Glaucoma Study**
  AIGS
- Coauthors
- Xinbo Zhang, Ou Tan, David Huang
- Rohit Varma
- Brian A. Francis
- David S. Greenfield
- Joel S. Schuman, Nils Loewen
- Advanced Imaging for Glaucoma Study Group
- Goal
- **Predict glaucomatous visual field conversion among glaucoma suspects and pre-perimetric glaucoma eyes.**
- **Predict glaucoma progression among perimetric glaucoma eyes.**
- Participants for Conversion Prediction Analysis
- **Fourier-Domain Optical Coherence Tomography**
- Visual Field Conversion Defined
- Baseline Variables Predicting Conversion ($p<0.05$)
- Ganglion Cell Complex-Focal Loss Volume:
  Best Single Predictor of Conversion
- Glaucoma Composite Conversion Index (GCCI)
- GCCI Predicts Actual Conversion Rate
- Participants for Progression Prediction Analysis
- Event and Trend Based Glaucoma Progression
- Baseline Factors for Progression
- Ganglion Cell Complex-Focal Loss Volume is the Best Single Predictor of Progression
- Baseline GCC-FLV Classification Predicts Visual Field Progression Rate
- Glaucoma Composite Progression Index (GCPI)
- GCPI Predicts Actual Progression Rate
- Conclusions
- OCT can detect structural damage years before VF defects
- OCT structural damage is a strong predictor of VF conversion and progression
- Ganglion Cell Complex-Focal Loss Volume (GCC-FLV) is the most accurate predictor
- OCT predictive parameters are synergistic with VF, age, and central corneal thickness
- Glaucoma Progression with OCT
- Scan Quality
- Floor Effect

- Age related Loss
- Intervisit Reproducibility
- Event Based Progression
- Trend Based Progression
- Guided Progression Analysis

- Glaucoma Imaging
  in Clinical Practice
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- Optic nerve imaging
- How to read an OCT scan
- RNFL Thickness Map
- RNFL Thickness Deviation
- Overall, Quadrant and Clock Hour Analysis of RNFL Thickness
- TSNIT Plot and Overlay Graph of RNFL
- Best Predictor of Glaucoma
- Best Predictor of Glaucoma
- Ganglion Cell Complex
- Ganglion Cell Complex
- Optic Nerve Head Analysis
- Detecting Progression
- Detecting Progression
- Obstacles to Obtaining a Good Scan
- Signal Strength
- Poor Signal Strength OD
- Centration errors
- Decentered Scan OS
- Scan Signal Pattern
- Scan Signal Pattern
- Peripapillary Atrophy

- Poor Scan Alignment
- Segmentation Error
- Segmentation Error
- Segmentation Error
- Temporal Shift
- Temporal Shift
- Temporal Shift
- Conclusion
- Imaging provides complementary indicators of glaucomatous optic nerve damage
- Make sure scan is of sufficient quality
- Useful in earlier detection of GOND in glaucoma suspects
- Useful in following glaucoma suspects and mild to moderate glaucoma
- Information must always be taken in context with clinical exam and vision / VF testing
- References
- Anterior Segment Imaging with
  Spectral Domain
  Optical Coherence Tomography
- *choices for "viewing" the anterior segment*

Gonioscopy
UBM
AS-OCT

- *Anterior Segment OCT*
    - Excellent resolution of anterior segment
    - Technically easy to use and quick
    - Requires no contact or immersion
    - Provides light and dark measurements
- Anterior Segment OCT can distinguish between
  Open Angles vs Narrow/Closed Angles
- For teaching
    - Patients
    - Residents
    - Fellows
    - For guiding treatment
    - Peripheral iridotomy
    - Peripheral iridoplasty

        - Cataract surgery
    - For screening high-risk individuals
    - *Open Angle vs Closed Angle* on Time-domain AS-OCT
    - Angle Parameters are based on location of scleral spur using Time-domain OCT (TD-OCT)
    - Anterior chamber angle parameters such as
        - Angle-Opening-Distance (AOD-500)
        - Trabecular-Iris-Surface-Area (TISA)

are calculated based on proper identification/location of scleral spur (SS)

- Higher Resolution with SD-OCT leads to better visualization of outflow structures
- Zeiss Visante TD-OCT (1310 *nm*)
- TD-OCT has limitations in identifying angle structures
- Reports have shown that TD-OCT can only locate SS in approximately ¾ of cases
- Implementation of higher-speed, higher-definition spectral domain OCT (SD-OCT)
- Zeiss Cirrus SD-OCT (840 *nm*)

Advantages of SD-OCT

- Higher scanning speeds
    - 50-60 times faster than with TD-OCT
    - Greater axial resolution
    - 3-5µm (*vs* 8µm)
- 208 OAG eyes prospectively imaged using 2 devices
- Zeiss Cirrus SD-OCT (840 *nm*)
- Zeiss Visante TD-OCT (1310 *nm*)
- SD-OCT allows identification of angle structures in a larger percentage of eyes compared with TD-OCT
- Identification of Angle Structures
- SL was identified in 94% of images with calculation of a new angle metric, SL-Angle Opening Distance (SL-AOD)
- SD-OCT Metrics: Novel “TM-scoop”

Zeiss Cirrus SD-OCT (840 *nm*)

- Anatomy: Anterior Chamber Angle Structures
- Schwalbe’s Line Angle Opening Distance (SL-AOD)

SL was identified in 94% of images with calculation of a new angle metric, SL-Angle Opening Distance (SL-AOD)

- SL-TISA (vs SS-TISA)
  more representative of the true TM filtration zone
- AS-OCT Parameters
  Acute primary angle closure associated with narrower angles,
  smallest anterior chamber dimensions,
  increased Lens Vault (LV) (1200mm vs 850mm),
  decreased Trabecular-Iris-Surface-Area (TISA750),
  increased Iris Thickness (IT750)
- Case study ASOCT tube
- 79 yo F with POAG
- Prior BVI 350 tube shunt
- Corneal edema developing superiorly
- Tube position?
    - Slit lamp showed no tube touch centrally
    - Possible peripheral contact
- Case study ASOCT tube 2
- 29 yo M with Congenital Glaucoma
- BVI tube shunt ST 15 years ago
- Second BVI tube SN 3 months ago
- Second tube touching cornea, underwent surgical repositioning
- First tube position?
- Opacification over tube entry site peripherally?
- Congenital Glaucoma tube shunt
- AS-OCT Clinical Case: Canaloplasty POD#1
- AS-OCT for IOL power calculations post-LASIK/PRK
  Evaluation of anterior vs posterior corneal curvatures
  Best Method: OCT > Haigis-L > Shammas-PL
- AS-OCT for Posterior Polar Cataracts:
  Pre-surgical Planning + Evaluation of Posterior Capsule Integrity
- Anterior Segment OCT Research
- Wide scope of research
    - Screening at risk populations
    - Diagnostic ability
    - Management strategy planning
    - Treatment outcome monitoring
- Research potential
    - Need standardized definitions & protocols

    - Normative database?
- Clinical correlation
    - vs ? gold standard
- Structure-Function assessments