New Concepts in Glaucoma

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New Concepts in Glaucoma

• Optical Coherence Tomography: Is it necessary and needed to diagnose and monitor glaucoma?
  • Ben Gaddie

• Converting visual fields to linear equations: Why and How
  • Louis Pasquale

• Central Fields: Do they add to the diagnostic picture of glaucoma?
  • Murray Fingeret

Optical Coherence Tomography:
Is it necessary and needed to diagnose and monitor glaucoma?

Ben Gaddie, OD
OCT in Glaucoma: Clinical Utility

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OCT Utility in Glaucoma

- RNFL Analysis
  - RNFL Asymmetry
- Ganglion Cell Layer Analysis
- Optic Nerve Size
  - Optic Nerve Asymmetry
- Normative Databases
- Neuroretinal Rim Tomography
- RNFL Progression (not discussed here)
Looking at Disc Asymmetry By Disc Size
Common OCT Imaging Problems

Floaters/Vitreous Syneresis and Condensation
Pathological Myopia
Very Large Optic Nerves
Macular Vulnerability Zone


White matter damage of the macula

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Converting Visual Fields to Linear Equations: The Why and The How

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HVF interpretation

Superior paracentral defect

Objective

• Partition VF defects into multiple components
• Quantify each component
VF interpretation: Qualitative

- Manual inspection for:
  - Nasal Step
  - Nasal depression
  - Paracentral loss
  - Temporal wedge

VF Interpretation: Quantitative and Semi-Quantitative Measures

- Quantitative:
  - MD
  - PSD
- Semi-quantitative:
  - GHT

VF Interpretation: Machine learning approaches

- Self organizing maps¹
- Variational Bayesian – independent component analysis²
- Archetype analysis³

1. Hensen et al. BJ O 1996
2. Goldbaum et al. IOVS 2005
3. Culter Techtronics 1994
Advantages of partitioning VFs in a quantitative manner

• Decomposition algorithm provides an objective snapshot of visual function
• Partition coefficients may be useful to stage disease and monitor progression
• Objectively derived patterns may have correlations that provide insight into disease pathophysiology

METHODS

R codes for decomposing VFs is supplemental material

Archetypes sorted by decreasing relative weight
What is the archetype for this VF?

\[ \text{VF} \approx 0.86 \text{ (AT}_{10}) + 0.07 \text{ (AT}_{9}) + 0.06 \text{ (AT}_{11}) \]

CONSTRUCT VALIDITY: ARCHETYPE ANALYSIS

- DEFINITION: Degree to which a construct truly measures what it is theoretically intended to measure

Archetype (AT) Construct Validity

- Data source: 30,955 reliable HVF 24-2 SITA Standard tests
- Study Sample Inclusion: 243 patients
  - AT coefficient ≥ 0.7 for most ATs
  - V, 20/50+
  - At least 10 VFs in each AT category

Archetype – Glaucoma Feature Correlations: AT2

- 20 patients
- Minimal coefficient = 0.77
- MD = -5.5 ± 1.3 dB*
- PSD = 6.8 ± 1.6 dB*
- GHT % ONL = 100%
- % with ptosis: 60% vs. 9% for the other participants; (p<0.001).
* Means ± STD

Conclusions

- Archetype analysis can convert VFs to a simple linear equations
- Archetype analysis has the potential to provide insights into glaucoma pathogenesis.
- In future, we assess whether this approach can simplify our ability to detect disease progression.
The Role of the Central Visual Field in the Diagnosis of Glaucoma
Murray Fingeret, OD

The Glaucoma Evaluation
- History/risk factor analysis
- Intraocular pressure
- Anterior segment/Gonioscopy
- Pachymetry
- Structure
  - Optic Nerve, RNFL, Macula
  - Direct assessment, photography, imaging
- Function
  - Visual field
    - 24-2, 30-2, 10-2
  - Forms of perimetry - White on white (SAP), SWAP, FDT, HEP
  - Electrodiagnostic testing

The Central Field in Glaucoma
- Glaucoma is characterized as a condition that affects the central field last as the condition progresses
  - Is this conventional wisdom true?
  - SD OCT allows us to better evaluate the layers of the retina and where damage is occurring
Greater resolution and better segmentation algorithms

Is This Presentation Rare?

Central Field Loss is Important

- Central visual field loss (within 10° of fixation)
  - Meaningful for the patient
  - Decreased reading vision
  - Altered driving ability – reading signs
  - Increased risk of falls/fractures
- Peripheral visual field loss
  - Asymptomatic (unless bilateral and severe)
The Central Field in Glaucoma

- Does the central visual field using the 24-2 detect functional vision loss in all cases
  - Points in test grid are 60 apart in a grid pattern
- Is there a role for a complementary test such as the 10-2 in which 55 points are placed in a 100 area that are 20 apart
  - Will this detect small scotomas that fall between the cracks?
- Is glaucoma a disease that involves the macula region early in the condition?

NFL Orientation and Visual Field

- Diagram of NFL orientation and visual field

- Image of a retinal scan
The Central Field in Glaucoma

- The presence of paracentral loss has been well described as a feature of glaucoma.
- Common in advanced cases
- Limited assessment because most textbooks, researchers and clinicians use testing paradigms with test point 6° apart
- SD-OCT revolutionizing our ability to identify structural alteration and has led us to renewed interest

The Central Field in Glaucoma

- Heijl and Lundquist noted "a large preponderance" of damage at 5° in eyes converting from normal to abnormality
- Langerhorst followed 121 eyes: 36.4% had damage on 10-2 vs. 48.5% on 24-2.
- Schiefer: 50% of eyes had damage within 3°
- Traynis et al
  - VF better than -6dB
  - 53% abnormal 10-2 vs 55% abnormal on 24-2

1. Heijl and Lundquist et al. (1987)
2. Langerhorst 1997
3. Schiefer 2010
4. Traynis 2012

- Histologically defined as a region at where the RGC layer is at least two cells thick
- Central 8°
- 2% of retinal surface, 30% of all RGCs
- Projects to roughly 50% of visual cortex
- Fovea-disc border distance: 14.8±0.9°
- Optic disc generally lies above horizontal meridian (6.3±3.0°)

2. Hood DC et al. PRER 2013;1-25

- RGC+ (RGC and inner plexiform layer) thickness for healthy eyes resembles histology
- In GS and glaucomatous eyes, inferior RGC+ has greater thinning than the superior region
- The central 4 points of the 6° degree grid of the 24-2 visual field are the only points that test this region
- Local RGC+ loss is arcuate in nature and associated with localized VF loss and RNFL thinning at the ONH
Choroidal Thickness

The Central Field in Glaucoma

- Learn more about the S-F relationship
- Local damage to circumpapillary RNFL has a variety of axons and does not point to a location in space
- FDOCT makes evaluation of the macula and RGC+ layers possible!

The Optic Disc is Higher than the Fovea

Macular RGC and RNFL Anatomy

- Thickest portion of the RGC+ layer falls within ±8° of the fovea
- The relationship between our FDOCT measurement of macular thickness is similar to histology*
- High degree of correlation between postmortem and FDOCT data
- Minimal aging effects on anatomy

*Curcio 2011
Macular Vulnerability Zone

- 27 degrees of the inferior optic disc
- Inferior disc is the location of most frequent RNFL damage
- Most common location for disc hemorrhage1-3
- Disc hemorrhage more common in eyes with paracentral loss4
- A small region of the disc is responsible for a significant portion of central vision loss

2. De Moraes CG. RF paper
3. De Moraes CG et al. IOVS spatial consistent

*eyes with MD worse than -5.5 dB
Summary

- Glaucoma affects RGCs throughout the retina
- Macular RGCs are often damaged early in the course of the disease
  - FDOCT can detect macular structural changes
  - Damage is typically in a small inferior disc region
- VF grid patterns set 6° apart are insufficient to detect functional damage in the macula; but can be detected with 2° spacing
- There is a precise macular structure-function relationship when the anatomy is understood

Recommendations

- Testing of the central visual field using a 10-2 strategy should be incorporated into the diagnosis and management of all patients with glaucoma
  - Loss of vision in the central field is an extremely important quality of life issue
- Macular FDOCT imaging in the diagnosis and management of glaucoma