

# Strategies for Better Diagnosis of Glaucoma

Danica J. Marrelli, OD, FAAO  
University of Houston College of Optometry

dmarrelli@uh.edu

1

## Disclosures

- Allergan
- Bausch & Lomb
- Carl Zeiss Meditec
- Glaukos
- M&S Technologies
- Santen
- Thea

2

## What is glaucoma? What makes someone a suspect?

- Chronic, *progressive* disease of retinal ganglion cells
  - Characteristic optic nerve changes
  - Characteristic visual field changes
  - Potential for blindness
  - Elevated IOP is often present, but does not define the disease
- Suspect:
  - Suspicious optic disc
  - Abnormal visual field
  - Elevated IOP
  - Other risk factors

3

## The Glaucoma Evaluation

- History
- VA
- Pupils
- SLE
- Tonometry
- Pachymetry
- Corneal hysteresis
- Gonioscopy
- Dilated exam with careful ONH/RNFL evaluation
- Perimetry
- Optical Coherence Tomography (OCT) of RNFL/macular ganglion cell

4

## Pertinent History

- Related to Diagnosis:
  - Family history of glaucoma
  - Corticosteroid use
  - Ocular injury
  - Uveitis
  - Vascular disease (DM, HTN, vasospastic disease)
- Related to management:
  - Family history
  - Medications
  - Allergies


5

## Let's talk IOP

- No clear boundary at which glaucoma will develop
- Higher IOP = increased risk of developing glaucoma
  - Asymmetry >2mm is not common in healthy eyes
  - Extremely asymmetric IOP = think secondary cause/unilateral disease
- Not everyone with elevated IOP will develop glaucoma
  - Ocular Hypertension Treatment Study (OHTS)
- Glaucoma can occur in patients with IOP always in the "normal" range
  - Normal Tension Glaucoma
    - LOTS of differentials!
    - Get many IOP readings

6

### Is there more than IOP and CCT?

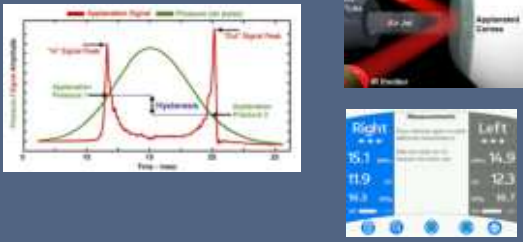


Ocular Response Analyzer (Reichert)

**Corneal Hysteresis**

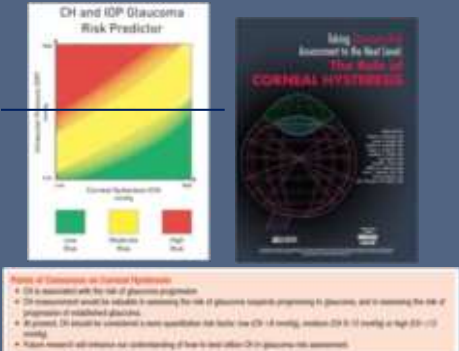
- Refers to specific number from this instrument
- Reflects the ability of the corneal tissue to dissipate energy
- Hysteresis (biomechanical property) is different than corneal thickness (geometric attribute)
- May provide additional diagnostic/risk information

7



The graph displays two curves: a red curve for 'Applanation Right' and a green curve for 'Applanation Left'. The y-axis is 'Force (mN)' and the x-axis is 'Time (ms)'. The area between the curves is labeled 'Hysteresis'. To the right, a diagram shows a probe measuring the cornea, and below it, a screenshot of a device interface showing 'Right' and 'Left' eye measurements for CH, IOP, and CCT.

8



**CH and IOP Glaucoma Risk Predictor**

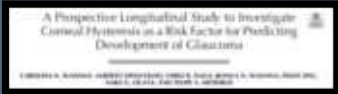
The heatmap shows risk levels from Low (green) to High (red) based on CH and IOP. A legend below indicates: Green (Low Risk), Yellow (Medium Risk), Red (High Risk).

**Notes of Correlation on Corneal Hysteresis**

- CH is associated with the risk of glaucoma progression.
- CH measurement would be useful in assessing the risk of glaucoma (visual field progression) in glaucoma, and in assessing the risk of progression of established glaucoma.
- At present, CH should be considered a semi-quantitative risk factor for CH < 10 mmHg, medium CH 10-15 mmHg, or high CH > 15 mmHg.
- Future research will enhance our understanding of how to best utilize CH in glaucoma risk assessment.

9

### Implications of Corneal Hysteresis



- Baseline lower CH measurements were significantly associated with increased risk of developing glaucomatous visual field defects over time.
- Each 1mm lower CH was associated with an increase of 21% risk of developing glaucoma during follow up.
- CH is an independent risk factor for developing glaucoma.

10

### Corneal Hysteresis as a Risk Factor for Glaucoma Progression: A Prospective Longitudinal Study

Felipe A. Medeiros, M.D., Ph.D.<sup>1,2</sup>, Daniel Feltzer, M.D.<sup>1,2</sup>, Renato Lisboa, M.D.<sup>1,2</sup>, Tung-Mai Kwang, MD, MPH<sup>1,3</sup>, Linda M. Zangwill, Ph.D.<sup>1</sup>, and Robert N. Weinreb, M.D.<sup>1</sup>

<sup>1</sup>Huntsman Glaucoma Center and Department of Ophthalmology, University of California, San Diego

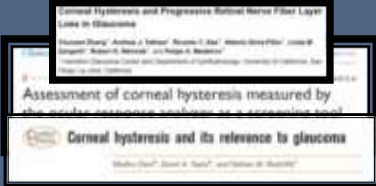
<sup>2</sup>Federal University of São Paulo, Department of Ophthalmology, Brazil

<sup>3</sup>Department of Ophthalmology, Taipei Veterans General Hospital

<sup>4</sup>Department of Ophthalmology, School of Medicine, National Yang-Ming University, Taipei, Taiwan

**Results**—CH had a significant effect on rates of visual field progression over time. In the multivariable model including only CH as a predictive factor along with time and their interaction, each 1mmHg lower CH was associated with 0.23% year faster rate of VFI decline over time (P<0.0001). The relationship would show that the effect of IOP on rates of progression depended on CH. Eyes with high IOP and low CH were at increased risk for having fast rates of disease progression. CH explained a larger proportion of the variation in slopes of VFI change than CCT (17.4% versus 5.2%, respectively).

11



**Corneal Hysteresis and Progressive Retinal Nerve Fiber Layer Loss in Glaucoma**

Abstract: Felipe A. Medeiros, Daniel Feltzer, Renato Lisboa, Tung-Mai Kwang, Linda M. Zangwill, Robert N. Weinreb

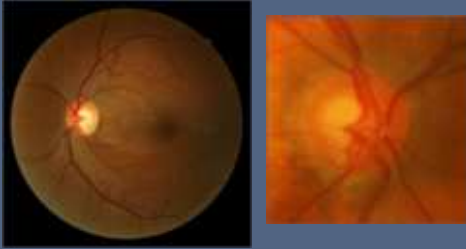
**Assessment of corneal hysteresis measured by the ocular response analyzer as a prognostic tool**

**Corneal hysteresis and its relevance to glaucoma**

12



### FOCAL LOSS (NOTCH)



19

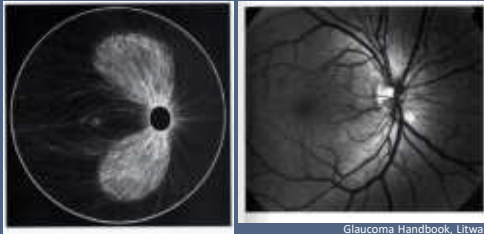
### EVALUATION OF RETINAL NERVE FIBER LAYER (RNFL)

- Defects in RNFL may precede glaucomatous visual field loss and structural changes in ONH
- Can help to differentiate physiologic cupping from glaucomatous cupping

20

### ANATOMY OF THE NERVE FIBER LAYER

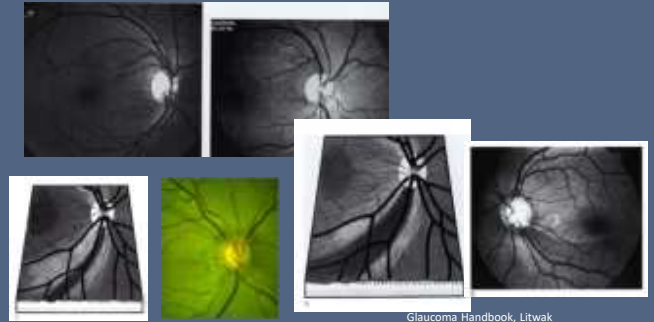
- RNFL is thickest (and brightest) in superior and inferior arcades
- RNFL is thinner (dimmer) in papillomacular bundle and nasal bundles
- "BRIGHT-DIMMER-BRIGHT" pattern



Glaucoma Handbook, Litwak

21

### RNFL Drop Out

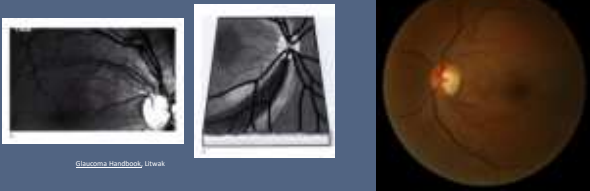


Glaucoma Handbook, Litwak

22

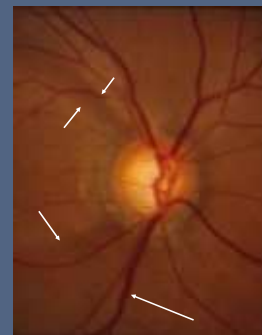
### RNFL Drop Out

- Focal Loss (less common): slits and wedges

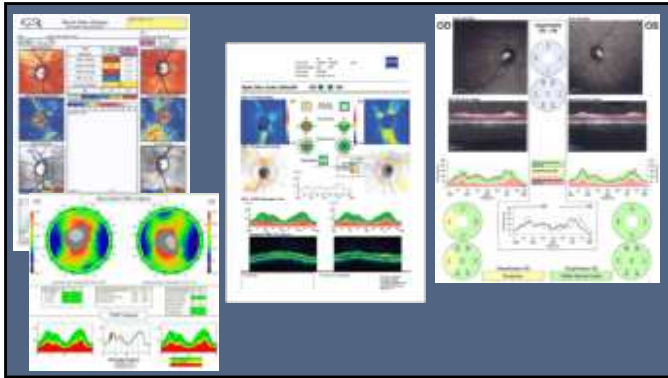


Glaucoma Handbook, Litwak

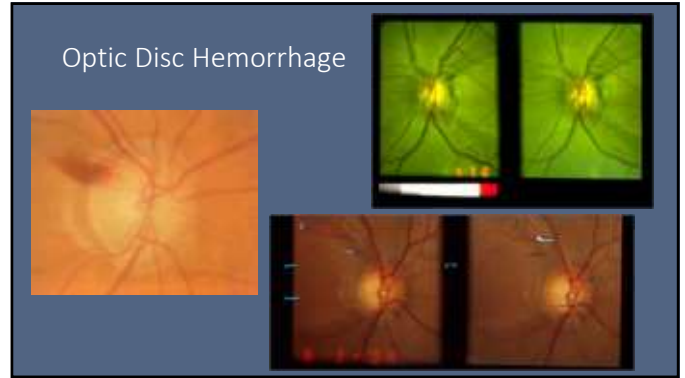
23



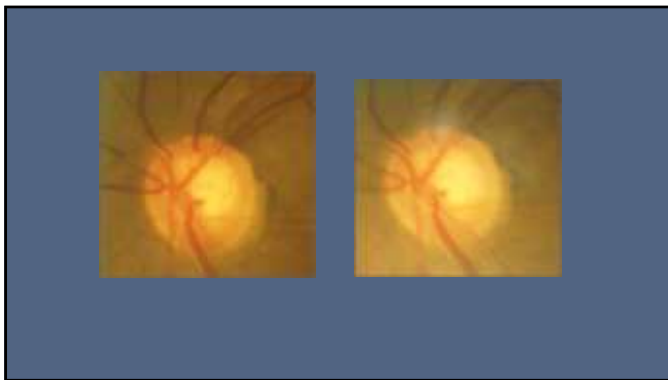
24



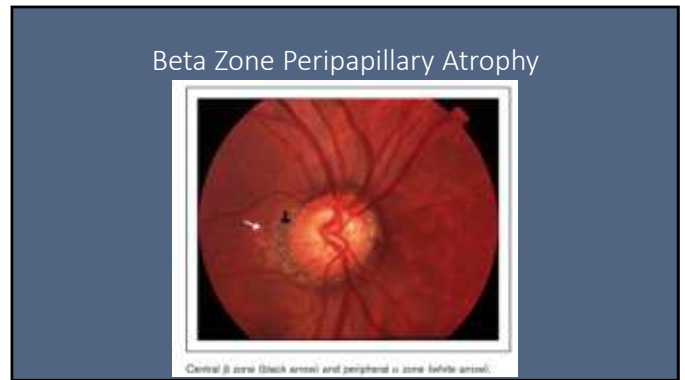
25



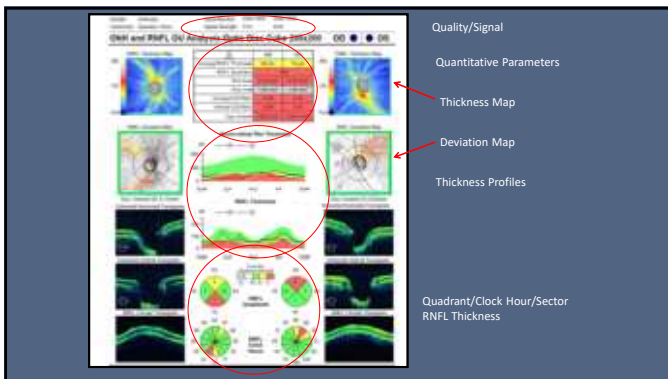
26



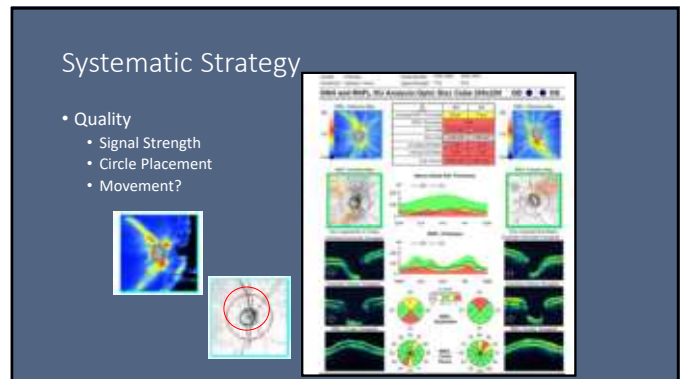
27



28



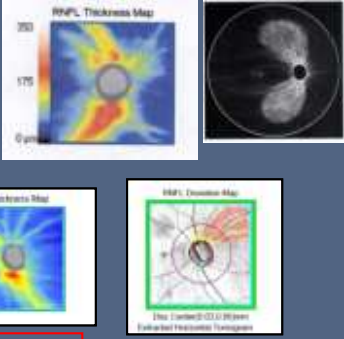
29



30

### Systematic Strategy

- Thickness Map
- Deviation Map

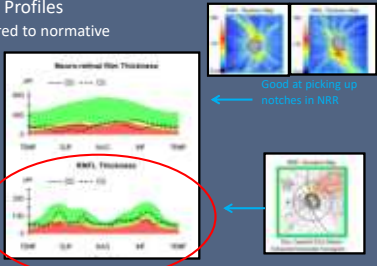


**IMPORTANCE OF BLOOD VESSELS!!!!**

31

### Systematic Strategy

- Thickness Profiles
- Compared to normative data

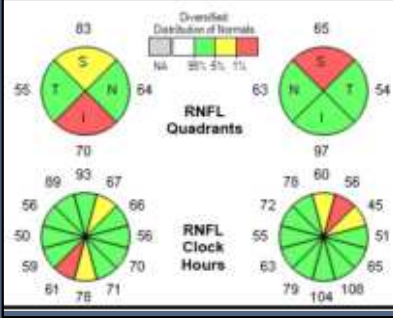


Good at picking up notches in NRR

32

### Systematic Strategy

- Quadrant and Clock Hour RNFL analysis




**Overseas Distribution of Normals**  
NA 25% 5% 1%

33

### Systematic Strategy


- Quantitative Parameters
- Average RNFL
  - Measures average thickness around calculation circle
  - Affected by blood vessels, astrocytes, glial cells
  - Global measure (will miss focal loss)
- RNFL Symmetry



34

### Systematic Strategy

- Quantitative Parameters
- Rim Area
  - Uses Bruch's membrane as edge of disc
  - Range 0.75-2.38mm (avg 1.31)
- Disc Area
  - Range 1.06-3.38 mm<sup>2</sup> (avg 1.83)
  - Small: <1.63
  - Med 1.63-1.97
  - Large >1.97
- C/D ratio
- Cup Volume



35

### Newest Addition to Glaucoma Diagnosis Arsenal: Macular Imaging

- 1998: Zeimer et al reported on macular thickness loss in patients with known glaucomatous damage
- 2003: Greenfield reported correlation between total macular thickness and MD on VF in glaucoma patients (time domain OCT)
- 2013: Hood et al – extensive investigation of segmented “RGC+” (RGC + IPL) layer and description of the “Macular Vulnerability Zone” (MVZ)

36



### Advantages of Macular Analysis

- Macula contains ~50% of retinal ganglion cells
  - Glaucoma is a disease of these cells
  - Macular thinning/irregularity cannot be detected during clinical exam
- More reproducible measure (if not using retinal nerve fiber layer) than peripapillary RNFL
  - Fewer blood vessels and other cell components
  - Less anatomic variation compared to optic disc/peripapillary region
- Better superior/inferior symmetry and symmetry between eyes than peripapillary RNFL

43

### Disadvantages of Macular Imaging

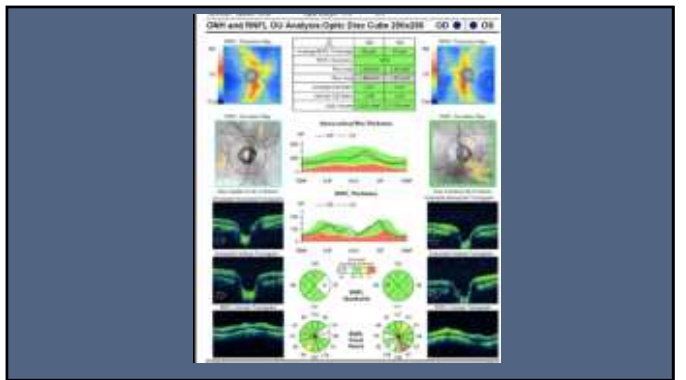
- Macular imaging is not helpful in glaucoma cases in which patients have concurrent macular disease
  - AMD
  - ERM
  - CME
  - DME
  - Macular hole

44

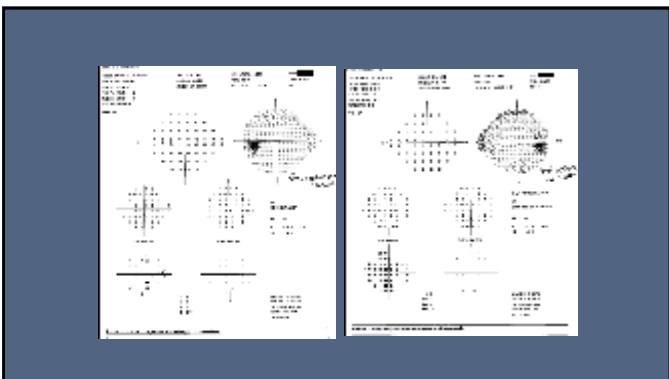
### Case: Leo

- 71yo AAM
- Referral for glaucoma suspicion, based on age/race/IOP
- POH: Unremarkable
- PMH: (+) DM2 and HTN
- FOH: Unremarkable
- VA: 20/20 OD, OS
- SLE: Normal OU, mild cataract OU
- IOP: 23mmHg OD, OS
- CCT: 587 microns OD 582microns OS

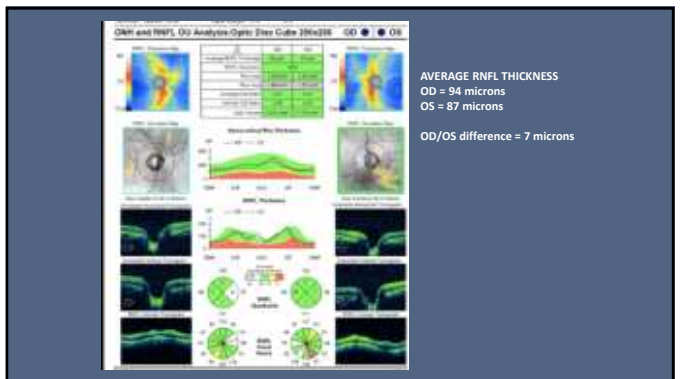
49



50

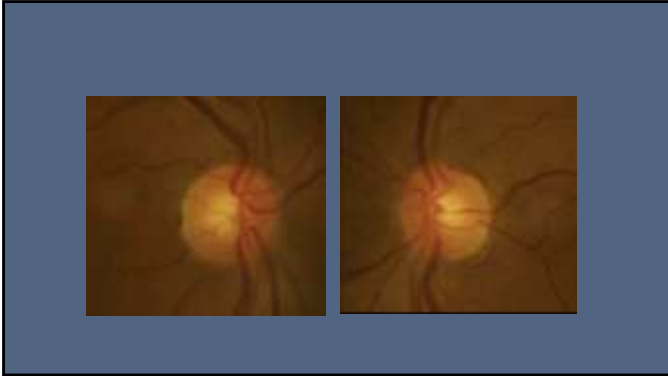


51

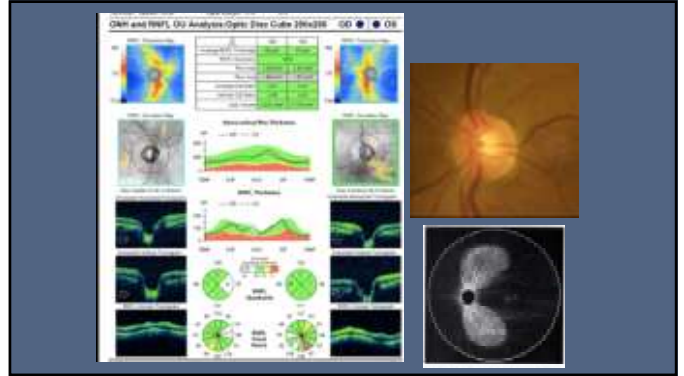


52

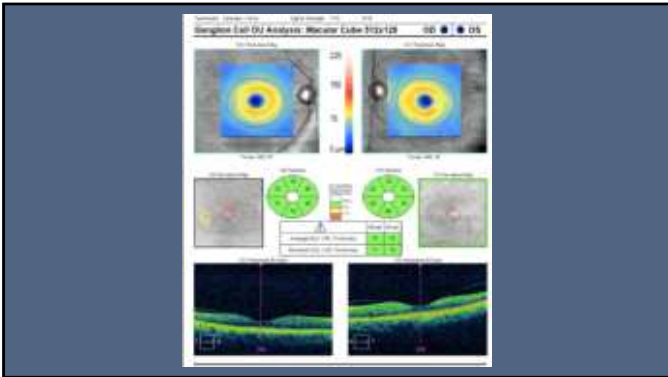




53



54

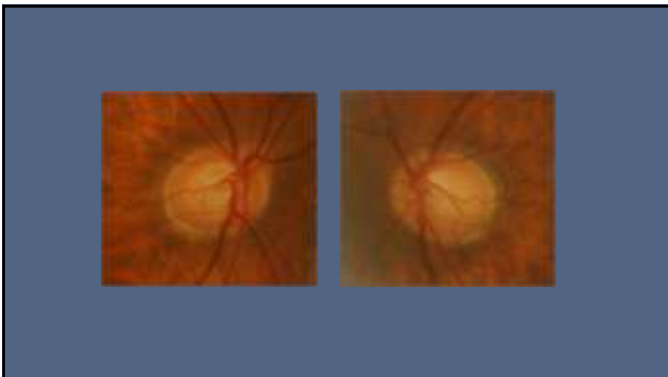


55

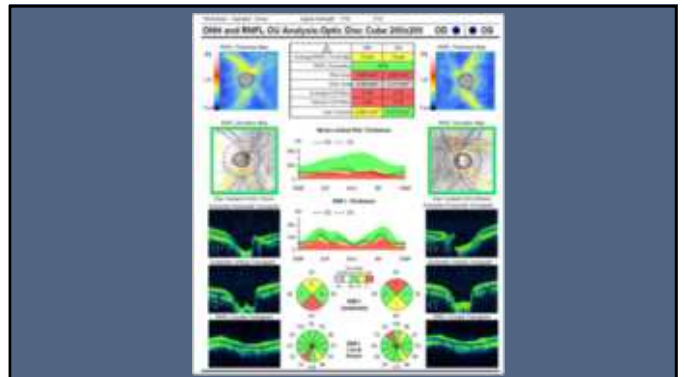
Case: Tony

- 51yo hypertensive HM
- POH: LASIK OU (2000) , PRK OS (2014)
- FH: (+) glaucoma – grandmother
- BCVA: 20/20 OD, OS
- Pupils, motility, CVF: Full OD, OS
- Slit Lamp Exam: LASIK flaps OU, otherwise nl
- Angles: open to CB 360 OU
- Tmax: 17mmHg OU
- CCT: 523 OD 489 OS

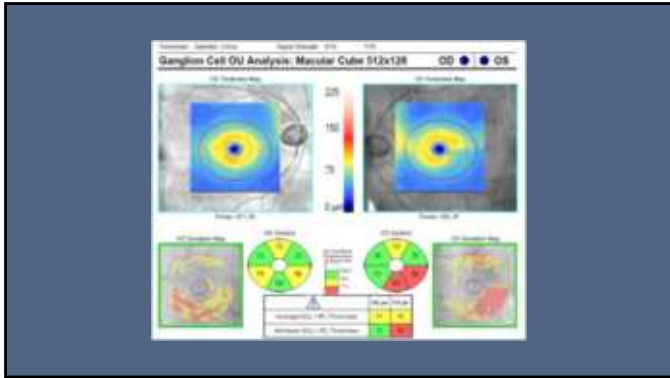
56



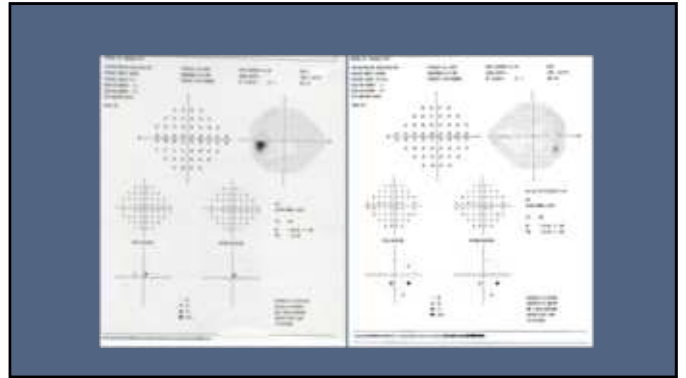
57



58



59

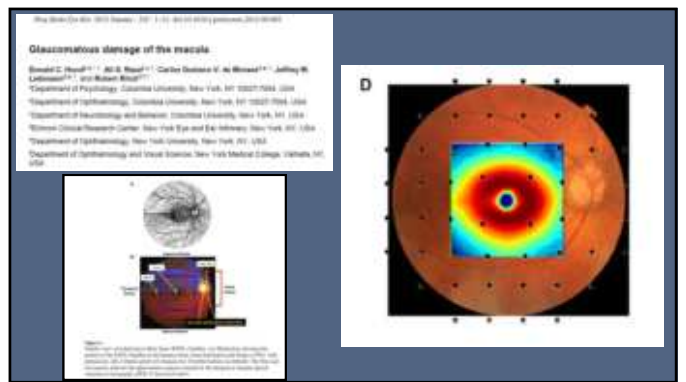


60

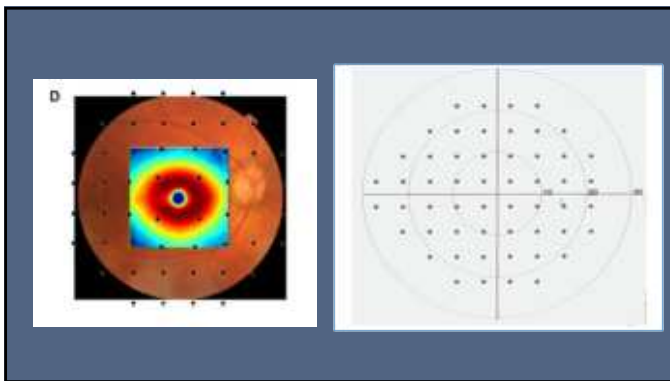
What about the 10-2 VF?

- Central 8 degrees from the center of the foveal contains more than 30% of retinal ganglion cells
- 24-2 and 30-2 test strategies use a 6 degree test grid pattern; these points fall outside of the densist region of ganglion cells
- 10-2 test strategy uses a 2 degree grid
- Recent research has shown that in some patients with small regions of macular ganglion cell loss, 10-2 testing may be better able to detect VF loss

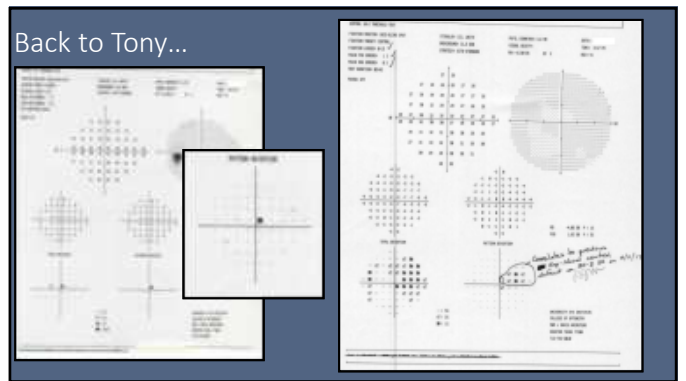
61



62

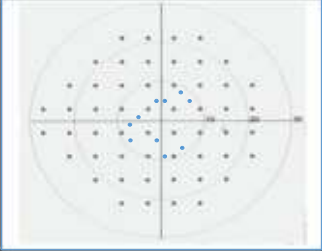


63



64

### Resulting SITA Faster 24-2C Pattern on HFA3

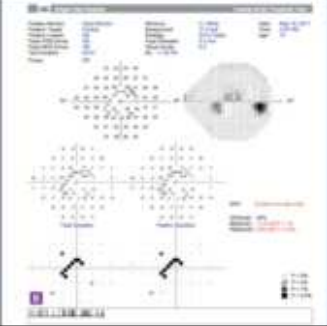


The 24-2C test pattern combines all 24-2 points  
 • ten selected 10-2 points (shown in OD orientation)

Large Gray	24-2 pattern
Large Orange	Ten additional 24-2C points
Small Gray	10-2 pattern

65

### 24-2C (SITA-FASTER ONLY)



66

### Macular Damage in Glaucoma (Take Home Message)

- Glaucoma damage to the macula is common
- Glaucoma damage to the macula can occur early in the disease
- Glaucoma damage to the macula is not visible on CLINICAL exam
- Glaucoma damage to the macula can be missed and/or underestimated by the standard 24-2 or 30-2 test grid
- \*\*\*New test patterns by perimetry manufacturers!!!

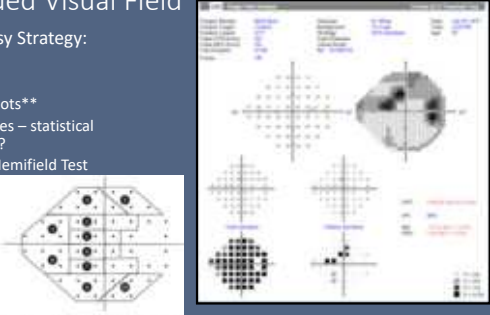
67

### Headset Perimetry

68

### The Dreaded Visual Field

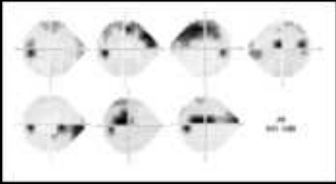
- Quick and Easy Strategy:
  - Reliability
  - Grayscale
  - Deviation Plots\*\*
  - Global Indices – statistical significance?
  - Glaucoma Hemifield Test (GHT)



69

### What are we looking for?

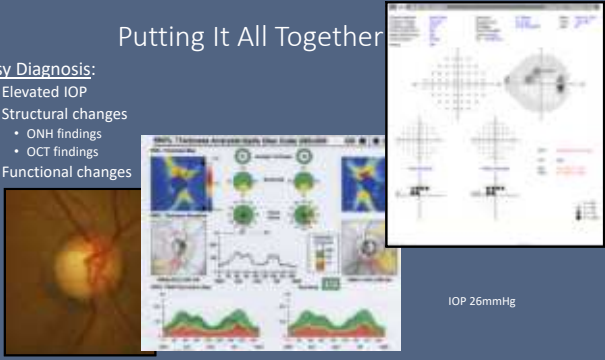
- Asymmetry superior-inferior
- Respect horizontal midline
- "point" back to blind spot
- Common nasal, arcuate bundle, paracentral



71

### Putting It All Together

- Easy Diagnosis:
  - Elevated IOP
  - Structural changes
    - ONH findings
    - OCT findings
  - Functional changes

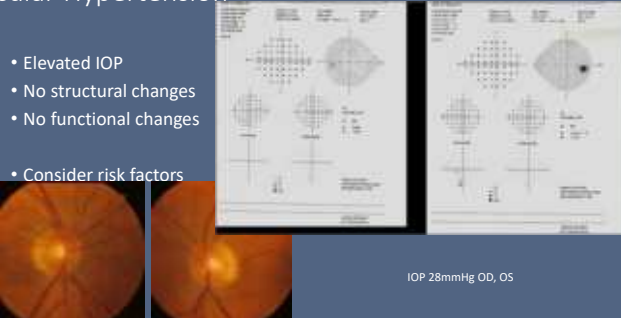


IOP 26mmHg

72

### Ocular Hypertension

- Elevated IOP
- No structural changes
- No functional changes
- Consider risk factors



IOP 28mmHg OD, OS

73

### Trickier...

- Normal IOP + structural and/or functional changes
  - Artifact/learning curve and/or anomalous (not pathologic) findings
    - REPEAT TESTING
  - Glaucoma (NTG or POAG with undiscovered/masked IOP)
    - REPEAT TESTING, MULTIPLE IOP READINGS
  - Non-glaucomatous, but real damage
    - BRAO, isolated ischemic event (hypovolemic crisis)
    - Repeat testing, watch for progression before treating

74

### Somewhere in the middle

- IOP borderline/slightly elevated
- Questionable changes structure/function
- KEY: Corroboration of evidence
- If not enough evidence, watch for progression/declaration
  - Establish good baseline
  - Follow with repeat testing at appropriate intervals

75

Thank You For Your Attention!

Questions?  
Email: dmarrelli@uh.edu

76