FORGE II
Focusing Ophthalmology on Reframing Glaucoma Evaluation

Perimetry in the Diagnosis and Management of Glaucoma
Content Consultants

George A. (Jack) Cioffi, MD
Chief of Ophthalmology
Chenoweth Chair in Ophthalmology
Devers Eye Institute
Portland, Oregon

Anne L. Coleman, MD, PhD
Professor of Ophthalmology
Frances & Ray Stark Chair in Ophthalmology
Jules Stein Eye Institute
David Geffen School of Medicine at UCLA
Los Angeles, California

Christopher A. Girkin, MD, MSPH
Associate Professor of Ophthalmology
Director, Glaucoma Service
Callahan Eye Foundation Hospital
University of Alabama School of Medicine
Birmingham, Alabama

Ronald L. Gross, MD
Professor of Ophthalmology
Clifton R. McMichael Chair in Ophthalmology
Cullen Eye Institute
Baylor College of Medicine
Houston, Texas

Jeffrey M. Liebmann, MD
Clinical Professor of Ophthalmology
Director, Glaucoma Services
Manhattan Eye, Ear & Throat Hospital
New York University School of Medicine
New York, New York

Robert N. Weinreb, MD
Distinguished Professor of Ophthalmology
Director, Hamilton Glaucoma Center
University of California San Diego
La Jolla, California
Glaucoma

- Characteristic optic neuropathy
- Multiple risk factors
- Progressive injury to retinal ganglion cells and their axons
- Specific pattern of optic atrophy ("cupping")
- Associated visual function defects
Glaucoma Assessment

Assessment and documentation of the optic nerve and visual field are an essential component to the diagnosis, staging and longitudinal assessment of glaucoma.
Impact of Glaucomatous VF Loss

• Glaucoma patients may be at increased risk of car accidents
  – Patients with moderate or severe visual field loss in the worse eye had approximately a 4 times greater risk of being in a car accident than patients with no VF defect\textsuperscript{1,2}
  – Patients with glaucoma may avoid difficult driving situations

• Glaucoma patients are at increased risk of falls\textsuperscript{3}

Five Rules (The 5 Rs) for Assessment of the Optic Disc

1. Observe the scleral Ring to identify the limits of the optic disc and its size

This section was developed by Robert Weinreb, MD, Felipe Medeiros, MD, and Remo Susanna Jr., MD
Optic Disc Size

Measurement of optic disc size with **biomicroscopy**

Volk lens

Measure length of slit beam

- Avg. vertical diameter: 1.8 mm
- Avg. horizontal diameter: 1.9 mm

Correction factors

- Volk 60D – x1.0
- Volk 78D – x1.1
- Volk 90D – x1.3
Optic Disc Size

Size of cup varies with size of disc
Large discs have large cups in healthy eyes

Small discs: avg vertical diameter <1.5 mm
Large discs: avg vertical diameter >2.2 mm
Five Rules for Assessment of the Optic Disc in Glaucoma

1. Observe the scleral Ring to identify the limits of the optic disc and its size

2. Identify the size of the Rim
ISNT RULE

Rim width
Distance between border of disc and position of blood vessel bending

ISNT rule
Inferior > Superior > Nasal > Temporal
Five Rules for Assessment of the Optic Disc in Glaucoma

1. Observe the scleral Ring to identify the limits of the optic disc and its size
2. Identify the size of the Rim
3. Examine the Retinal nerve fiber layer
RNFL Red-Free Photographs

- Bright striations
Localized RNFL Loss

Localized RNFL defect
Wedge-shaped dark area
Five Rules for Assessment of the Optic Disc in Glaucoma

1. Observe the scleral Ring to identify the limits of the optic disc and its size
2. Identify the size of the Rim
3. Examine the Retinal nerve fiber layer
4. Examine the Region of parapapillary atrophy
Five Rules for Assessment of the Optic Disc in Glaucoma

1. Observe the scleral Ring to identify the limits of the optic disc and its size
2. Identify the size of the Rim
3. Examine the Retinal nerve fiber layer
4. Examine the Region of parapapillary atrophy
5. Look for retinal and optic disc hemorrhages
Glaucoma Or Normal?

Use the 5 Rules

1. Observe the scleral Ring to identify the limits of the optic disc and its size
2. Identify the size of the Rim
3. Examine the Retinal nerve fiber layer
4. Examine the Region of parapapillary atrophy
5. Look for Retinal and optic disc hemorrhages
Glaucoma Or Normal?

1. Small disc size
2. Rim thinning (inferiorly)
   ISNT rule: 
3. Localized RNFL defect (inferiorly)
4. No significant PPA
5. Hemorrhage

GLAUCOMA
Visual Field Examination
SITA SAP

• SITA: Swedish Interactive Threshold Algorithm
• SAP: Standard Automated Perimetry
• SITA SAP is the standard method for assessing the visual field in glaucoma patients
• Algorithm analyzes the patient's responses and uses age-normalized statistical data to shorten the testing time

SITA SAP

- White stimulus on white background (achromatic)
- Detects visual field loss only after considerable damage to the optic nerve
  - May underestimate damage in early disease
NOT to be confused with SITA Fast

– SITA Fast is less sensitive\(^1\) and should NOT be used to diagnose and follow glaucoma patients

Visual Field Interpretation

Introducing “The 5 Rs” of visual field interpretation
5 Rules for Visual Field Interpretation

“The 5 Rs”

1. **Right** test
2. **Reliability**
3. **Review** probability plots
4. **RNFL** pattern of loss
5. **Re**-affirm the diagnosis
Rule #1: Be Sure the Right Test was Used
Right Test

- Strategy
- Test stimulus size
- Field size
- Eye
- Age (Date of Birth)
- Pupil size
- Refractive Error

SINGLE FIELD
NAME:
CENTRAL 24-

EYE: RIGHT
PUPIL DIAMETER: 3.0 MM
Right Test

- Right strategy?
  - Confirm SITA Standard

- Right test stimulus size?
  - Size III is standard
  - Size V used for advanced glaucoma and decreased visual acuity
Right Test

- Right field size?
  - 24-2 is the standard size
  - 10-2 can be used with visual field loss within the central 10° of fixation
Right Test

- Right age (date of birth)?
  - Correct normative database
  - Goldmann Table adapted from HFA instruction booklet

- Correct refractive error?

- Correct pupil size?
  \( \geq 3 \text{ mm} \)
Rule #2: Check Reliability of the Field
Reliability

- Reliability indices
  - False positives, false negatives
- Fixation losses

Appendix C
Reliability
False Positive Rate (FP)

• Percentage of time the patient responded in the absence of a stimulus
  • >25% – use caution
  • >33% FP rate – unreliable
  • Ideal rate is <10%

Elevated FPs artifactualy improve the appearance of the field
Reliability
False Negative Rate (FN)

- Percentage of time the patient failed to respond to a stimulus that should have been seen, based on past responses
  - >25% FN rate – use caution
  - >33% FN rate – unreliable

A high false negative rate may reflect fatigue or advanced visual field damage
**Reliability**

**Fixation Losses (FL)**

- Percentage of times the patient responded to a stimulus presented at the plotted blind spot

- FL increases if:
  - The patient does not maintain fixation
  - The blind spot was incorrectly located
  - The patient’s head moves

- FL rate >20% – use caution

- FL rate ≤ 33% – acceptable if the technician feels the patient maintained good fixation
• Clover leaf pattern that can accompany fatigue

• Patients who fatigue test well early, then lose concentration

• Four primary points around fixation are checked and confirmed
Rule #3: Review the Probability Plots
Review Probability Plots

Global Index: Mean Deviation (MD)

- Average loss of entire field in decibels
  - depression from age-normal hill of vision
    - A 4-dB depression at all points in the field or a depression of 8 dB over half of the field would both give an MD of -4 dB

- More negative MD = worse field

- A $P$-value is given for the probability the MD would occur in a normal individual
Review Probability Plots
Global Index: Pattern Standard Deviation (PSD)

• PSD is a measure of **focal visual loss**
• A higher PSD suggests greater localized field damage
• In OHTS, PSD was identified as 1 of 5 important contributors to the risk of developing glaucoma
• In advanced glaucoma, PSD can actually decrease because damage is no longer focal

<table>
<thead>
<tr>
<th>MD</th>
<th>-2.24 DB</th>
<th>P &lt; 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSD</td>
<td>2.26 DB</td>
<td></td>
</tr>
</tbody>
</table>
Review Probability Plots
Probability of VF Defect

- Probability plots
  - Total deviation
  - Pattern deviation

- Grayscale should only be used for patient education

Appendix C
Review Probability Plots
Grayscale

• Grayscale and probability plots may not agree
Review Probability Plots
Total Deviation and Pattern Deviation

• Most useful aspect of automated perimetry

• Comparison to normative age-matched database

• Examine depressed points
  – number of contiguous depressed points
  – location of depressed points
  – severity of depressed points
Review Probability Plots

Probability of VF Defect

• Global indices
  – Mean deviation (MD)
  – Pattern standard deviation (PSD)
  – Glaucoma Hemifield Test (GHT)
Review Probability Plots
Glaucoma Hemifield Test (GHT)

- Evaluates asymmetry between superior and inferior fields
  - Uses values from pattern deviation map grouped in clusters and compared between patient hemispheres and to normal values
  - Clusters chosen to imitate anatomy of the RNFL

Review Probability Plots
Glaucoma Hemifield Test (GHT)

- Printout
  - GHT Outside Normal Limits
    - Upper and lower fields differ in <1% of normals, or differ from normal
  - GHT Borderline
    - Upper and lower fields different to extent found in <3% of normals, or both different from normal
  - Within normal limits

Rule #4: RNFL Pattern of Field Loss
RNFL Pattern

Pattern deviation plot should be consistent with glaucomatous damage of NFL bundles

Appendix D
RNFL Pattern
Paracentral arcuate NFL defect may be very small

2/2003

24-2

10-2
RNFL Pattern

Cataract with generalized field loss can obscure localized defects
RNFL Pattern
Nasal loss

12-17-2004
GHT: Borderline
RNFL Pattern
Arcuate loss
RNFL Pattern

Hemifield loss is common in advanced glaucoma
Rule #5: Re-affirm the Diagnosis
**Re-affirm Diagnosis**

- Re-assess the retina and optic nerve seeking consistency with VF
- Repeat test if needed
- Re-frame disease severity, if appropriate
  - Where is the patient in the continuum?
Re-affirm Diagnosis
Confirm abnormal field even in experienced field takers

Consecutive follow-up visual fields for a patient in OHTS

85.9% of abnormal fields reverted to normal on subsequent testing in OHTS


April 2, 1997

April 9, 1997
Reframing Disease Severity

Substantial structure damage may exist by the time VF loss is detected by SAP.
Selective Functional Testing
Subtypes of Ganglion Cells

**Parvocellular RGCs**
- Most Common
- Color Sensitive
- Small Cells
- Fine Detail

**Magnocellular RGCs**
- Motion Sensitive
- Achromatic
- Large Cells

**Bistratified RGCs**
- Motion Insensitive
- Blue-on Yellow-off

(referencing the diagram for visual representation)
Conventional Perimetry Is Nonselective

- Conventional perimetry activates a variety of RGC processing pathways
- Any of these pathways can lead to perception of the stimulus
- This redundancy may be responsible for reduced sensitivity with SAP
SWAP Emphasizes Koniocellular Responses

- SWAP emphasizes responses of the bistratified RGCs
- Bleaching yellow background with a size 5 blue stimulus
- Emphasizing one pathway increases sensitivity
SWAP in Early Detection

- Longitudinal studies
- Correlates with optic disc
- Abnormal in suspects
- 8% - 30% abnormal in OHT
- Larger defects in GON
Limitations of SWAP

• Difficult and prolonged testing
  – SITA SWAP now available

• Vulnerable to lens effects

• Higher threshold variability
Frequency Doubling Illusion

**Actual Stimulus**

Time 1

1f: 1.0 c/deg

Time 2

Counterphased

**Perceived Stimulus**

Nonlinear Response

2f: 2.0 c/deg
FDT Emphasizes Magnocellular Responses

- FDT emphasizes responses of the magnocellular RGCs
- Flicker stimulus mimics motion across the retina
- Emphasizing one pathway increases sensitivity
FDT in Glaucoma Detection

- Correlates well with SAP
- 95% sensitive and specific
- Frequently abnormal in suspects
- Predicts SAP defects

Matrix 24-2 FDT

- Threshold variability unrelated to severity\(^1\)
- Sensitivity similar to SITA SAP\(^2\)

# Summary of Functional Tests

<table>
<thead>
<tr>
<th></th>
<th>SITA SAP</th>
<th>SITA SWAP</th>
<th>FDT Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td>“Gold Standard”</td>
<td>As fast as SITA SAP</td>
<td>More portable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Possibly more sensitive</td>
<td>Tolerates blur</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Possibly more sensitive</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Variability does not increase with severity</td>
</tr>
<tr>
<td><strong>Disadvantages</strong></td>
<td>Not sensitive enough to detect early glaucoma</td>
<td>Limited clinical evaluation</td>
<td>Limited clinical evaluation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variability</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Effect of cataract</td>
<td></td>
</tr>
<tr>
<td><strong>Best use</strong></td>
<td>Baseline VF and following progression in advanced disease</td>
<td>Early diagnosis</td>
<td>Early diagnosis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Younger patients</td>
<td></td>
</tr>
</tbody>
</table>
Practical Issues: Reimbursement

• Medicare documentation must include an order for the test and an interpretation of the results
  – Description of reliability, changes since last test, clinician’s assessment
  – Report must be signed and visual field printout dated and initialed by the clinician

• Extended examination (eg, HVF 30-2 or 24-2) and repeated test, if needed, billed as ICD Code 92083
Case Studies
Case Study 1

- 57 y.o. man; no complaints
- VA: 20/20 OU
- IOP: 22 mm Hg OU
- Optic disc: Small disc size, no cup

Appendix E
1. Right Test?

Case Study 1

Single Field Analysis

Central 24-2 Threshold Test

Eye: Left
DOB: 04-12-1948

Stimulus: III, White
Background: 31.5 ASB
Strategy: SITA-Standard

Pupil Diameter: 4.1 mm

Visual Acuity:
RX: +1.00 DS
DC X

Date: 03-27-2006
Time: 11:12 AM
Age: 57

Appendix E
Case Study 1

1. Right Test?
2. Reliability?

Appendix E
Case Study 1

1. Right Test?
2. Reliability?
3. Review Probability Plots

Appendix E
Case Study 1

✓ 1. Right Test?
✓ 2. Reliability?
✓ 3. Review Probability Plots
✓ 4. RNFL Pattern: Nasal Step
Case Study 1

✓ 1. Right Test?
✓ 2. Reliability?
✓ 3. Review Probability Plots
✓ 4. RNFL Pattern: Nasal Step
✓ 5. Reaffirm diagnosis

MODERATE GLAUCOMA
Case Study 2

- 40 y.o. man
- VA: 20/20 OU
- IOP: 25 mm Hg OU
- Optic disc: Average disc size, superior, inferior rim thinning
Case Study 2

1. Right Test?

**CENTRAL 24-2 THRESHOLD TEST**

- **STIMULUS:** III, WHITE
- **BACKGROUND:** 31.5 ASB
- **STRATEGY:** SITA-STANDARD

- **PUPIL DIAMETER:** 6.7 MM
- **VISUAL ACUITY:** 20/20

- **RX:** DS +1.00 DC X 112

- **DATE:** 06-19-2003
- **TIME:** 10:15 AM
- **AGE:** 40
Case Study 2

1. Right Test? ✓
2. Reliability? ✓
Case Study 2

✓ 1. Right Test?
✓ 2. Reliability?
✓ 3. Review Probability Plots
Case Study 2

✓ 1. Right Test?
✓ 2. Reliability?
✓ 3. Review Probability Plots
✓ 4. RNFL Pattern

GHT
WITHIN NORMAL LIMITS
1. Right Test?
2. Reliability?
3. Review Probability Plots
4. RNFL Pattern:
5. Reaffirm diagnosis

NORMAL STANDARD
AUTOMATED PERIMETRY
Case Study 2

1. Right Test?

24–2 FDT Threshold

PUPIL DIAMETER: 7.0
VISUAL ACUITY: 20/20
RX:
Case Study 2

1. Right Test?
2. Reliability?

- FIXATION ERRORS: 0/10 (0%)
- FALSE POS ERRORS: 0/10 (0%)
- FALSE NEG ERRORS: 0/6 (0%)
Case Study 2

1. Right Test?
2. Reliability?
3. Review Probability Plots
Case Study 2

✔ 1. Right Test?
✔ 2. Reliability?
✔ 3. Review Probability Plots
✔ 4. RNFL Pattern
Case Study 2

1. Right Test?
2. Reliability?
3. Review Probability Plots
4. RNFL Pattern
5. Reaffirm diagnosis
Case Study 3

Combining FORGE I and FORGE II

- 58 y.o. man seen 9 years ago
- IOP: 24-28 mm Hg OU
- Optic disc: Average size
- VF: Normal
- Presents for follow-up
- IOP: 22 mm Hg OU
Case Study 3

Glaucoma or Normal?

Use the 5 Rules

1. Observe the scleral Ring to identify the limits of the optic disc and its size
2. Identify the size of the Rim
3. Examine the Retinal nerve fiber layer
4. Examine the Region of parapapillary atrophy
5. Look for Retinal and optic disc hemorrhages
Case Study 3

1. Average disc size
1. Average disc size
2. Inferior rim thinning
   ISNT: −
Case Study 3

1. Average disc size
2. Inferior rim thinning
   ISNT: 
3. Diffuse RNFL loss
1. Average disc size
2. Inferior rim thinning
   ISNT: –
3. Diffuse RNFL loss
4. Beta zone
   parapapillary atrophy
Case Study 3

1. Average disc size
2. Inferior rim thinning
   ISNT: 
3. Diffuse RNFL loss
4. Beta zone
   parapapillary atrophy
5. No hemorrhage
Case Study 3

1. Average disc size
2. Inferior rim thinning
   ISNT: −
3. Diffuse RNFL loss
4. Beta zone
   parapapillary atrophy
5. No hemorrhage

GLAUCOMA
Case Study 3
Combining the 5 Rs of optic nerve examination and visual field interpretation

1. Right Test?
Case Study 3
Combining the 5 Rs of optic nerve examination and visual field interpretation

1. Right Test?
2. Reliability?

Fixation Losses: 3/14
False POS Errors: 4 %
False NEG Errors: 2 %
Case Study 3
Combining the 5 Rs of optic nerve examination and visual field interpretation

1. Right Test?
2. Reliability?
3. Review Probability Plots
Case Study 3
Combining the 5 Rs of optic nerve examination and visual field interpretation

1. Right Test?
2. Reliability?
3. Review Probability Plots
4. RNFL Pattern of Field Loss

Appendix F
Case Study 3
Combining the 5 Rs of optic nerve examination and visual field interpretation

1. Right Test?
2. Reliability?
3. Review Probability Plots
4. RNFL Pattern of Field Loss
5. Reaffirm diagnosis

MODERATE GLAUCOMA

Appendix F
Thank You