Clinical Insights in Diagnosing Glaucoma

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Goldmann Applanation Tonometry

- Goldmann applanation tonometry assumes central corneal thickness (CCT) of 500 um
- GAT over- or under-estimates IOP by as much as 5 mmHg for every 70 um of CCT difference from ~520um

Pachymetry is Part of the Ocular Examination Whenever Glaucoma is Suspected

Pachymetry is Part of the Workup for the Glaucoma Suspect/Glaucoma

Central Corneal Thickness and the Diagnosis of Glaucoma

- Re-classification on basis of correction factors
  - 44% of Normal Tension Glaucoma become POAG
  - 35% of Ocular Hypertension become normal
CCT and risk of glaucoma

- Is the increased risk of glaucoma with a thin cornea a result of
  - IOP measurement error?
  - Greater susceptibility?
  - Do corneal biomechanical properties reflect scleral/lamina biomechanical properties?

Should You Use the Pachymeter To Screen for Glaucoma?
Should you do the test on everyone presenting to your office, not just suspects or those with glaucoma?

Should IOP be adjusted for Central Corneal Thickness?

Is there a purpose for the conversion charts that come with pachymeters?

What Should One Do When a Person Has Glaucoma and the IOP Never Appears to Be Elevated?

Distribution (%) of 24-hour peak IOP (habitual body positions)
Key Factors for Gonioscopy

- Good anesthesia
- Dark room
- Start with 1mm, narrow beam of light
  - Keep beam away from pupil
- Patient’s maintains primary gaze
- Minimize lens tilt
  - Only minor movements permitted to see over convexity of iris
  - Otherwise narrow open will appear open

Key Factors for Gonioscopy

- Use high magnification
- Assess whether iris is in contact with TM
- If not, estimate geometric angle b/w TM and adjacent peripheral area of iris
- Describe level of most anterior point of contact b/w iris and cornea-scleral coat
- Once gonio is completed 360°, repeat with increased illumination and indentation

Key Factors for Gonioscopy

- To understand if angle is narrow but open,
  - For Goldmann style lenses, instruct patient to look toward mirror while pressing on rim of lens overlying mirror
  - Indents central cornea
- Describe the level of insertion of iris as well as height and circumference of peripheral anterior synechia

Key Questions with Gonioscopy

- In evaluating angle questions to address include
  - Does the iris touch the TM?
    - If no, is there evidence of prior contact?
    - If yes, is the contact reversible?
    - If not, what is extent of synechial closure?
      - Height and circumference

What is the First Optic Nerve Instrument I Should Buy?

A Digital Fundus Camera

Standard of Care is For Some Form of Documentation When Glaucoma is Presented or Suspected

May be done with Photography or Imaging
Why Document?

- Evidence suggests disc documentation is poor
- Glaucoma staging
- Disc size determination
- Assessment of quantitative and non-quantitative features
- Global risk assessment
- Detection of progression

Do We Need Imaging?

- Will Imaging Allow Earlier Diagnosis?
  - More cases detected based upon structural evaluation of the optic nerve or NFL using imaging instrumentation?
- Is IMAGING the STANDARD of CARE?
  - No, documentation is
  - Imaging is very useful but not required AT THIS TIME

The Glaucoma Continuum

![The Glaucoma Continuum diagram]

Structural Damage May Precede Functional Vision Loss

![Structural Damage May Precede Functional Vision Loss diagram]

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

Optic Disc Size

![Optic Disc Size diagram]
Identify small and large optic discs

Small discs: avg vertical diameter <1.5 mm

Large discs: avg vertical diameter >2.2 mm

Size of cup varies with size of disc

Large discs have large cups in healthy eyes

Small discs with glaucoma may have small cups

Rim thinning

Measurement of optic disc size with direct ophthalmoscope

Small aperture (5 degree) of Welch-Allen direct ophthalmoscope

Size of light spot ~ size of average optic disc

Measurement of optic disc size with biomicroscopy

Volk lens

Measure length of slit beam

Correction factors

Volk 60D – x 1.0
Volk 78D – x 1.1
Volk 90D – x 1.3

Avg vertical diameter: 1.8 mm
Avg horizontal diameter: 1.7 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
Superior > Inferior
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

Diffuse RNFL Loss

Normal RNFL
Diffuse RNFL loss (advanced glaucoma)

Localized RNFL Loss

Localized RNFL defect
Wedge-shaped dark area

Parapapillary Atrophy

Alpha zone
- Hypo- and hyper-pigmented areas
- Present in normal as well as in glaucomatous eyes

Beta zone
- Atrophy of the retinal pigment epithelium (RPE) and choriocapillaris
- Large choroidal vessels become visible
- More common in glaucomatous eyes

Beta zone
- Width of beta zone inversely correlates with rim width at same area
- Larger beta zone → thinner rim
- Progression of beta zone associated with progressive glaucoma

Parapapillary Atrophy

Thin rim
Larger β zone
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

Optic Disc Hemorrhage

Normally disappears after 2-6 months

Structural Assessment in Glaucoma

- The Optic Nerve Head
- The Nerve Fibre Layer
- Retinal Thickness

What's New

- Primer
- Acquisition Quality Control
- Alignment Algorithm
- Larger Database
  - Ethnic Selectable
- Printout
- Glaucoma Probability Score
- Glaucoma Change Analysis
- Enhanced Progression Analysis

Disc Size

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Analysis of ONH Topography

Classification:
- Parameters differ between diagnostic groups
- **But** physiological variability high
- **High** sensitivity and specificity
  - Discriminative Ability
    - Zangwill et al., Invest Ophthalmol Vis Sci, 2004
    - Mean Height of Contour in sectors, ROC 0.98
    - Bowd et al., Invest Ophthalmol Vis Sci, 2004
    - HRT classifications techniques and stereophotograph assessment can detect optic disc topography abnormalities in glaucoma-suspect eyes before the development of SAP abnormalities.

The CSLO Ancillary Study to OHTS: Study Design and Baseline Factors.

- The first multicenter clinical trial to use CSLO imaging to monitor changes in the optic disk
- 7 of the 22 OHTS clinical centers
- 439 subjects with good quality images
- Associations analyzed using linear mixed effects models
- No associations between HRT and
  - Diabetes
  - Systemic hypertension
  - Cardiovascular disease
  - IOP
  - Visual function

Summary:
- Baseline HRT stereometric optic disc parameters and HRT indices are significantly associated with the development of POAG in OHTS participants (up to 8 years prior).
- The vast majority of eyes (92% to 95%) with an MRA result within normal limits at baseline did not develop POAG during the follow-up period.

The CSLO Ancillary Study to OHTS: Baseline Measurements Associated with Development of POAG

- Baseline HRT stereometric optic disc parameters and HRT indices are significantly associated with the development of POAG in OHTS participants (up to 8 years prior).

Structural Assessment in Glaucoma

- The Optic Nerve Head
- The Nerve Fibre Layer
- Retinal Thickness

Glaucoma Imaging Devices

- GDx, OCT & HRT
- OCT, RTA & HRT
- OCT, RTA & HRT (Retinal Thickness)
- RNFL
**OCT Stratus**

**Stratus OCT in Glaucoma**

**RNFL Analysis**
- Three 1.73mm radius circle scans

**Optic Nerve Head Analysis**
- Six 4mm radial line scans

**Macular Analysis**
- Six 6mm radial line scans

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**Normative Data Display**

**Optic Nerve Head Analysis**

- Radial scanning across ONH
- Six 4mm scans

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**Scanning laser polarimetry**

**Birefringence and Retardation**

- Nerve fiber layer is form-birefringent
- Light passing through a birefringent medium:
  - Light traveling perpendicular to fibers undergoes a phase shift
  - "Slows down" (retardation)
Screening Visual Fields

- Screening fields are an excellent test to use as part of the pre-test evaluation
- Loss, if the test is repeated and confirmed, indicates some damage to the visual system
- Comprehensive exam can then be used to search for cause of field loss

Screening Visual Fields

- Automated screening tests often have sensitivity/specificity that preclude their use as single test
- Tests that have been part of eye examination have similar problems
  - IOP, optic nerve
- Positive finding on screening test done at initial stage of examination would be explored during eye examination

Screening Visual Fields

- Sensitivity needs to be high enough to find most moderate-severe cases of glaucoma
  - Need to find right combination
- Specificity should be high to not overcall normal individuals as having glaucoma
- FDT in the screening mode has set the model

Six Steps in Analyzing the Single Field Printout

- Reliability Indices
- Gray Scale
- Raw Data
- Total/Pattern Deviation Printouts
  - Compare between the two
    - Explain any differences
- Global Indices
- Glaucoma Hemifield Test
False Positives may be the Most Important Reliability Indicator
Second Best is Whether the Blind Spot was Plotted
Is there a 0?

Unreliable Visual Field
• Excessive Fixation Losses
• High False Positives
• Borderline False Negatives
• White Scotomas
• GHT-Abnormally High Sensitivity

False Negatives are Not a Good Indicator of Unreliability

The Learning Curve is Real
Glaucomatous Visual Fields are Extremely Variable
Need to confirm change and confirm again

New Tools for Diagnosing Glaucoma
• Structure vs. Function
• Goal is to Detect Damage Very Early
• What is Their Role?
• What do you do when imaging test is positive is everything else is negative – Does the imaging test drive the diagnosis?
Glaucoma Imaging Devices

GDx, OCT & HRT

OCT & HRT ONH

RNFL

OCT, RTA & HRT (Retinal Thickness)

Fovea

ONH

Ganglion Cell Bodies

New Perimetric Tests
FDT Matrix and SITA SWAP

Frequency Doubling Perimetry

- Low spatial frequency (<1 cycle per degree) and high temporal frequency (25Hz) grating
  - undergoes counter phase flicker
- 10^3 target size
  - large target
  - reduced fluctuation
  - reduced variability across field
  - scotomas once identified tend to be consistent
- Contrast varied in step wise fashion until detected

Short Wavelength Automated Perimetry (SWAP)

- Also called Blue-Yellow perimetry
- Detects early damage several years before present on conventional perimetry
- Now available in SITA Mode
  - SITA SWAP

Photoreceptors

L cones
“Red”

M cones
“Green”

S cones
“Blue”

Rods

Inner Retina

Ganglion Cells

Visual Function

P-cells

K-cells

M-cells

VISUAL PROCESSING

Visual Acuity

HRP

SWAP

B Y

Frequency Doubling

Short Wavelength Automated Perimetry (SWAP)