Maximizing Glaucoma Diagnostic Technologies: Something Old, New, Borrowed and Blue

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Assessing the optic disc: Is it still necessary in the OCT era? Joseph Sowka, OD

Predictive Value of Nerve Head Evaluation for Glaucoma:

If done properly, evaluation of the optic nerve head and nerve fiber layer should allow an experienced clinician to predict correctly:

1) Which patients do not have glaucoma 95% of the time and
2) Which patients have glaucoma 85% of the time
    - The reason for this is that 85% of the time, glaucoma presents with ONH changes prior to visual field changes.

- Average disc size ranges from 1.7 and 2.0 mm vertically and 1.6 to 1.8 horizontally (1.9 mm x 1.7 mm is a good average)
    - Physiologically large nerves have large cups
        - Occur more commonly in patients with normally large chorioscleral canals and large discs
        - 1 million axons need only so much room
            - Megalopapillae
            - Causes over diagnosis of glaucoma
    - Physiologically small nerves have small cups
        - Moderate cupping can indicate significant loss of tissue
        - Causes under diagnosis of glaucoma

ONH: Rim Tissue

- Pink coloration due to axons and capillaries
- Glaucoma: rim is always pink (except in very endstage disease)
- Pale cupping (pallor exceeding cupping): compressional lesion, ischemic vascular accident, neurological event. No rim pallor in glaucoma - if this occurs, it is <u>not</u> glaucoma (alone)
    - Rim pallor can only rarely be accepted as glaucomatous once other potential causes have been ruled out
    - Other diseases can cause "cupping", though there will be other features inconsistent with glaucoma such as central acuity loss and disc pallor. Non-glaucomatous cupping include arteritic anterior ischemic optic neuropathy and possibly some others:
        - Compression
        - Inflammation
        - Trauma
        - Hereditary diseases

ONH: Notching

- Focal loss of tissue- very specific for glaucoma
- Highly indicative of glaucoma
- While other conditions can cause optic atrophy and increased in cup, they don't notch the nerve like glaucoma.
- Inferior, Superior, Nasal, Temporal (ISNT) rule. Any disc that breaks this rule of rim thickness is suspect.
- Vertical elongation
  - Axons loose in inferior and superior lamina- this is the reason for vertical elongation
  - Look for narrowing of neuroretinal rim superiorly and inferiorly
    - Inferior temporal or superior temporal (usually)
      - Inferior or superior in 2/3rds of cases

ONH: Hemorrhages

- Names: NFL hemorrhages, splinter hemorrhages, Drance hemorrhages, disc hemorrhages
- Inferior, inferior temporal, superior, superior temporal regions of the disc most susceptible and account for virtually all true disc hemorrhages
  - Hemorrhages at other areas of the disc (nasal and temporal) tend to not be associated with glaucoma
  - Typically occurs where notches occur
  - Resides in the retinal nerve fiber layer, not in the cup
- Small and contiguous with the neuroretinal rim

Nerve Fiber Layer Evaluation

- Normal NFL- striate appearance- underlying vessel obscured as if transparent tape was over them
- Alteration in appearance of normal striated pattern of NFL around ONH
  - Diffuse or focal
- Selective damage
- Precedes field loss (in one study, 50% showed NFL loss 5 years prior to field loss)
- NFL loss is 85% specific for glaucoma (in certain patterns)
- Precedes disc changes
- Often appears as a dull area to the fundus which allows a better observation of the underlying choroidal details

NFL Defects

- Slit
- Wedge (bigger than slit)
- Diffuse
- NFL defects must meet two criteria:
  - They are at least the same caliber as an arteriole
  - They must extend to the disc
    - Anything that doesn't meet these criteria are pseudodefects- just anomalous

anatomy

OCT Evaluation of the Optic Disc and RNFL/GCC

- Finite amount of information in normative data base
- "Red Disease" - a normal patient fall outside the normative data base
  - Leads to over diagnosis of glaucoma if no other factors are considered
- "Green Disease" – an abnormal patient has measured data that falls within the normative data base
  - Leads to under diagnosis of glaucoma if no other factors are considered.
- OCT printout does not indicate when patient has myopic disc, tilted disc, Colobomatous disc, etc. that will affect application of normative data base
- OCT will not show disc hemorrhage, pallor, or other features of glaucoma or non-glaucomatous optic nerve disease

Optical Coherence Tomography

I. Anterior segment OCT
   a. Angle configuration
   b. Anterior chamber-OCT correlation with gonioscopic findings
      i. Landmarks on OCT
   c. Features of gonioscopy
      i. Peripheral anterior synechiae
      ii. Pigmentation of angle structures
      iii. Angle neovascularization
   d. Role of AC-OCT in primary angle closure
   e. Role of OCT in assessment of patency of laser peripheral iridotomy

II. Time domain vs. spectral domain OCT
   a. Significantly improved resolution

III. Anatomy of an OCT scan
   a. Retinal nerve fiber layer analysis
   b. Ganglion cell analysis

IV. Normative Database in SD-OCT
   a. Depend on the inclusion criteria of the study protocol. No patients with comorbidities included
   b. Carl Zeiss (Cirrus)
      i. 284 patients aged 19-84, USA, China
   c. Optovue (RT-Vue)
      i. 480 patient aged 18-84, 11 countries worldwide
   d. Heidelberg (Spectralis)
      i. 201 patients aged 18-78, all Caucasian, Germany

V. What makes a "good" optic disc scan?
   a. Signal strength
      i. i.e. >7 on Cirrus
   b. No blinks, no missing areas
   c. Limited saccades

VI. Image acquisition errors which result in in inaccurate scan quality
    a. Depth of scan must be correct-entire image must be visible
        i. Missing data results as 0 μm thickness measurement
        ii. Can be difficult in myopic eyes
    b. Optic nerve must be centered in scan circle
        i. Ensure that the patient is focused on the correct target
        ii. When the optic disc is too close to the scan circle it overestimates the RNFL
    c. Floaters over the imaged area result in missing data
        i. Lens opacity, dry eye
VII. Segmentation error
    a. Automated delineation of the RNFL from other retinal layers (segmentation)
    b. Delineation of optic disc margins
        i. Peripapillary atrophy in high myopia
        ii. May ignore the metrics including thickness—as normative databases do not include patients with high myopia
VIII. Optic disc size
    a. Optic disc area using Cirrus OCT
        i. Small optic disc $<1.58mm^2$
        ii. Medium optic disc $1.58\text{-}1.88mm^2$
        iii. Large optic disc $>1.88mm^2$
    b. Patients of African Descent have larger optic disc areas (mean $1.93mm^2$) than patients of European Descent (mean $1.68mm^2$)
IX. Floor effect
    a. When RNFL reaches approximately 50μm, even with further disease progression, thickness measurement will not change
        i. May provide false sense of stability of disease
X. Ganglion cell analysis
    a. Ganglion cell complex
    b. Retinal layers which are included in "ganglion cell analysis" between OCT manufacturer varies-thickness measurements cannot be directly compared between instruments
    c. Ganglion cell complex utility is limited with coexisting macular pathology
    d. Role of GCC in early disease detection
        i. "Macular vulnerability zone"
XI. Which happens first-structural or functional damage?
    a. Baseline values matter
    b. Test selection matters
    c. Typically structure and function agree
XII. OCT Angiography in Glaucoma
    a. Clinical utility is not yet clear
    b. May allow for objective assessment of progression below typical "floor" of GCC and pRNFL on SD-OCT
XIII. Summary

a. Anterior segment OCT is not a replacement for gonioscopy, but is a useful adjunct when assessing primary angle closure and assessing patency of laser peripheral iridotomy
b. RNFL and GCC analysis has excellent sensitivity and specificity which aids in the detection of glaucoma
c. Must understand the parameters—not just rely on the normative database
d. Must make clinical anatomical correlation with all imaging results

Bringing the Love Back to the Visual Field

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I. Normal Visual Field Parameters
   a. More than 90 degrees temporal
   b. 60 degrees nasal and superior
   c. 70 degrees inferior
   d. Horizontal 150 degrees and vertical 130 degrees
   e. Most visual fields test 0-51 decibels
      i. 41-51 decibels is outside human vision

II. Pearls on setting up the visual field
   a. One diopter of refractive blur in undilated patient
      i. A little more than one decibel of depression of the hill of vision
         1. With Goldmann III stimulus
   b. Leave cylindrical errors of less than 2 diopters uncorrected
      i. Adjusted with spherical equivalent
      ii. Above 2 diopters correct the astigmatism with trial lens
   c. The background of a visual field illuminated (31.5 apostilbs)
      i. The minimum brightness for photopic or daylight
      ii. Cones are isolated, test photopic system
         1. More object contrast, less on absolute brightness
      iii. Changes in pupil size, crystalline lens color and transparency have less effect on result

III. Interpreting the Visual Field Results
   a. Reliability Indices
      i. Fixation Losses
      ii. False Positives
      iii. False Negatives
   b. Threshold Values
   c. Numerical Total Deviation Map
   d. Numerical Pattern Deviation Map
   e. Total Deviation Map
   f. Pattern Deviation Probability Map
   g. Visual Field Indices
      i. Mean Deviation (MD)
         1. How deep is the defect
      ii. Pattern Standard Deviation
         1. How localized is the defect
      iii. Visual Field Index (VFI)
         1. 100-0 %
   h. Glaucoma Hemifield Test (GHT)
      i. Likely be the best place to look for glaucoma defect

ii. Not designed to be sensitive to neurological or retinal field loss

i. What parameters are best for staging the patient of time?

i. Mean deviation and visual field index

IV. Let's look at a visual field of a blind eye and discuss:
   a. Mean deviation
   b. Pattern standard deviation
   c. Visual field index

V. Let's look at a visual field of a patient trigger happy; increased false positives
   a. Discuss Pattern Deviation Plot

VI. Let's look at a visual field of a patient dazed or not paying attention; increase false negatives
   a. Discuss why cloverleaf visual field

VII. Perimetry in Eye Care
   a. Neurological disease
   b. Retinal disease
   c. Glaucoma
      i. Perimetry is essential in diagnosis and management
      ii. Why test the central 24-30 degrees?
         1. Only a small percentage of glaucomatous defects occur in the peripheral visual field alone
         2. Testing the central 25-30-degree field is preferred in glaucoma management
         3. Most of the retinal ganglion cells are within the 30 degrees of fixation
      iii. 24-2 versus 30-2 Visual Field
         1. 30-2 tests 76 locations
         2. 24-2 tests 54 locations, and tests 30 degrees nasal
            a. Little diagnostic information lost in 24-2
            b. Time is saved
            c. Fewer trial lens and lid artifacts
         3. 24-2 have become the VF for glaucoma
            a. Only down side; 30-2 can sometime find progression earlier due to more test points
      iv. Sita Standard versus Sita Fast
         1. Sita (patented) strategies are twice as fast as order strategies
         2. Sita fast takes 2/3rd the time of Sita standard
            a. Sita fast has larger retest variability
         3. Primary difference is between the two strategies is the amount of certainty that is required before testing is stopped
         4. Sita standard
            a. More precise
            b. More tolerate of mistakes
            c. Easier test as stimuli are brighter
      v. Fovea On versus Off
      vi. Short Wavelength Automated Perimetry (SWAP)
         1. Blue-yellow perimetry, Goldmann V stimuli on yellow background
            a. Thought to detect glaucomatous defect earlier than white on white
         2. Due to Sita standard strategy, can find defect as early

VIII. Interpreting visual fields
   a. No longer reliable or unreliable

i. A continuum from highly reliable to marginally informative
ii. False positives- are more destructive to interpretation than formerly believed
iii. Gaze tracker is typically a better indicator than blind spot
iv. False negatives are expected to be abnormal, even in attentive tester
v. Progression is not present or absent
    1. Is the rate of change acceptable

IX. How to use visual field to set target IOP
    a. Mild VF defect
    b. Moderate VF defect
    c. Severe VF defect