OPTIMIZING DIAGNOSTIC ABILITY WITH SCANNING LASER POLARIMETRY

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Scanning Laser Polarimetry

- Laser light enters eye at specific orientation. As it goes through tubules, it returns at a different orientation/ axis.
- Near infra-red wavelength
- Laser double passes the retinal nerve fiber layer (NFL) and is split into 2 parallel rays by the birefringent fibers
  - The two rays travel at different speeds and this difference (called retardation) directly correlated to the layer thickness
- Completely objective
- Must have clear corneal surface with good tear layer
  - Do nothing to cornea prior to taking test
- Undilated pupils work best

Normative Values

- Normative data base from healthy volunteers
  - Sampling of races represented in US included
  - Parameters thought to best differentiate normals from glaucoma patients
- Developed a neural network to define proper weighting of the above significant parameters
- Comparison of patients to age- and race-matched normals

GDx Technology: Just the Facts

- Each quadrant is analyzed and actual deviation from normal, in microns, is displayed
- Deviations from normal are highlighted in various colors depending upon their statistical significance
  - All normal values are shown in green
  - Probability represents the likelihood that this value would been seen in a normal, healthy patient

Clinical Pearl: Be concerned when a value for a parameter in one eye is green and the same parameter in the other eye is red as this indicated a lack of symmetry between the two eyes.

Update: Corneal Compensation

- GDx measures the birefringence of the NFL
- To an extent, the cornea (as well as the lens) has birefringent properties as well
- This introduces artifact in that not everything measured by the GDx is NFL
- The early versions of GDx compensates for this aberrant birefringence in the majority of the population – fixed corneal compensator (FCC)
  - Some patients are not compensated for by the device
  - Present with significant artifact
- New Variable Corneal Compensator (VCC) adjusts for all patients
- This is incorporated into the original technology as GDx VCC

GDx VCC:

- GDx scanning laser polarimetry technology with variable corneal compensation (VCC)
- This is the state of the current technology
- Images 16,000 points
- At the macula, there should be no birefringence due to the anatomy of the NFL
- If there is an uncompensated bowtie appearing retardance image in the macular region, this indicates that the artifact showing through is from the anterior segment (cornea) because there is an absence of NFL at that region.
  - This is used by the device to adjust for the amount of cornea-induced artifact showing through.

GDx VCC: The Printout

Fundus Image

- Allows for evaluation of the quality of the image
- Adequate for analysis, i.e., reliable
  - Sharp focus, good contrast between vessels and retina, evenly illuminated w/o shadows, proper illumination, ONH centered
- Image quality check
  - Warning if image fails to meet criteria
  - Affected by cataracts, poor fixation, and poor media
- Focal NFL defects may be seen on image
  - Look for corresponding thin NFL on print out

Polarization/Thickness Map

- Color map to indicate NFL thickness
  - Bright/warm colors indicate thick NFL
  - Dark/cool colors indicate thin NFL
- Normal pattern
  - Symmetrical hourglass shape of bright colors superior and inferior and dark colors nasal and temporal
  - Deviations from normal include:

- Diffuse loss of NFL, causing areas that should be yellow to fade to red
- Focal defects as concentrated dark areas (should be visible on fundus image as well)
- Asymmetry between superior and inferior quadrants
- Asymmetry between OD and OS
- New color scheme allows to better visualize subtle changes

Deviation (from normal) Map:

- Shows how the patient's NFL: thickness compares with values derived from the normative database
- Small color coded squares indicate the amount of deviation from normal at each given location and are presented on a black and white image
- Color legend defines the degree of statistical significance for each point using p-values

TSNIT Graph:

- Displays the normal range and the patient's thickness from the points along the ellipse
- Quick, easy look at how the patient compares to normal
- In evaluating TSNIT graph, consider:
  - Symmetry between superior and inferior humps
  - Do the values for superior and inferior fall within normal range?
  - Do nasal and temporal values fall within normal range
  - Do the thickness values match the pattern or shape of the normal range
  - Are there differences between the peaks and valleys of the graph?
    - A flat TSNIT means loss of NFL. Flat is bad

TSNIT Parameters:

- TSNIT Average
  - The average thickness values within the calculation circle (measuring ellipse)
- Superior average
  - Average of all pixels in the superior 120 degrees of the calculation circle
- Inferior Average
  - Average of all pixels in the inferior 120 degrees of the calculation circle
- TSNIT Standard Deviation
  - Standard deviation of the values contained in the calculation circle. The higher the number, the greater the modulation of the double hump pattern
- Inter-Eye Symmetry
  - The correlation of corresponding points in the TSNIT data for the right and left eyes. The closer the ratio is to 1.0, the more symmetric the NFL.
- Nerve Fiber Indicator
  - Indicates the likelihood that a patient has glaucoma
  - Neural network analyzes parameters from GDx image and assigns a number between where '0' means normal and '100' means glaucoma

- As the number is still experimental, it does not have a color to indicate significance or deviation from normal. The following guideline should be used:
  - 0-30 normal (low likelihood of glaucoma)
  - 31-70 glaucoma suspect
  - 71-100 high likelihood of glaucoma
- Not an indication of severity or progression, but only if disease is present
- The remainder of the parameters from the original GDx can be determined and printed, if necessary

Clinical Pearl: I find that symmetry between the two eyes is perhaps the greatest indicator of glaucoma or normalcy.

Optimizing Diagnostic Ability

- Case: "Normal tension glaucoma" patients being treated with normal fields, normal pressures, and robust NFL due to "suspicious" disc appearance
  - Large disc area
  - Megalopapillae
    - Observable on fundus image
    - Treatment stopped
- Case: Patient with elevated IOP and normal fields who doesn't want treatment without definitive proof of glaucoma
  - Minimal field loss develops over years
  - Profound NFL damage
  - Needed treatment much earlier
- Case: Patient being treated for glaucoma and ophthalmologist recommends trabeculectomy due to patient appearing endstage
  - Asymmetric disc sizes makes disc appear more advanced
  - Plenty of NFL
- Case: Patient with treated POAG and stable fields for years
  - Moderate field loss with profound NFL damage
  - Treatment intensified