Optic Nerve Imaging in the Diagnosis and Management of Glaucoma

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Glaucoma Diagnosis

• Involves numerous diagnostic modalities
  - IOP measurement
  - Optic disk examination
  - Visual field testing

• Inter-individual variability in optic disk makes early diagnosis difficult
Glaucoma Progression

• Detection of glaucoma progression has numerous obstacles
  - Lack of standardized definition of progression
  - Test-retest variability (visual fields)
  - Subjective assessment of serial disk photos

Imaging and Glaucoma

• Technological advances in ophthalmic imaging offer potential improvement in identification of structural abnormalities caused by glaucoma
  - Optic nerve head
  - Retinal nerve fiber layer
Imaging and Glaucoma

• Multiple instruments each based on different imaging principles
  - Confocal scanning laser ophthalmoscopy
    • Heidelberg Retinal Tomograph
  - Scanning laser polarimetry
    • GDx
  - Optical coherence tomography

Reproducibility

• To be useful, any new imaging instrument must be reproducible
  - Improved in some cases by averaging of multiple scans
  - Each has been shown to have good reproducibility
HRT

• Diode laser (670 nm)
  - 15 x 15 degree scan (384 x 384 point grid)
  - Resolution:
    • 300 µm axial
    • 10 µm transverse
• 3-D image of ONH
  - Series of 16 to 64 2-dimansional scans

HRT

• Operator defined optic disk margin
  - “Contour line”
HRT

• Contour line defines the “reference plane”

HRT

• HRT measurements are strongly related to the reference plane location
  - Greatest source of measurement variability
HRT III

- Improved software
- Single image analysis does not depend upon user-identified optic disk margin
- Improved progression analysis
HRT

• Indirect measure of RNFL thickness
  - Confounding by non-glaucomatous variation in optic nerve head anatomy
  - Poor performance in distinguishing glaucoma from normal in population-based studies
    • Sensitivity 65%
    • Specificity 83%

GDx

- GDx measures thickness of retinal NFL
- Scanning laser polarimetry
  - Measures birefringence of RNFL
  - Birefringence varies with RNFL thickness
GDx

- Uses diode laser light source (780 nm)
- 20 x 20 degree measurement area
- Data displayed as 256 x 256 pixel grid

GDx

- Artifact in NFL thickness measurement introduced by birefringence of other ocular structures
  - Cornea
- Older generation of instrument adjusted for expected corneal birefringence
GDx VCC

- Variable Corneal Compensation (VCC)
  - Allows measurement of individual corneal birefringence
  - Compensates for individual differences
  - Improves reliability and detection of early glaucoma
Optical Coherence Tomography

- OCT
  - Optical equivalent of B-scan ultrasonography
  - Short wavelength yields high resolution
Recent Developments in OCT

- OCT is an evolving technology

Spectral Domain OCT

- Uses spectroscopy rather than time delay to detect depth information
- Dramatically reduces scan time
- Allows significant increase in resolution

Cirrus OCT (Zeiss)
Spectralis OCT (Heidelberg)

SD-OCT vs. Stratus OCT

• Fewer artifacts
• Better reproducibility
SD-OCT vs. Stratus OCT

- Better sensitivity/specificity in detecting perimetric glaucoma
- Similar sensitivity/specificity in detecting perimetric glaucoma

SD-OCT vs. Stratus OCT

- Principal advantages are improved reproducibility
  - Easier to detect progression
- Ability to measure RNFL thickness in entire peripapillary retina
  - High scan speed
- Better progression software still needed on all SD-OCT devices
How can new imaging technologies influence clinical practice?

Problems in Early Detection

• IOP
  - Diurnal variation
  - Corneal thickness
  - Variable sensitivity to IOP-related damage
• Inter-individual variability of optic disks
  - Physiologic vs. pathological cupping
  - Disk size
Problems in Early Detection

• Visual Fields
  - High degree of variability, even in reliable patients
  - Many patients are not so reliable

• Suspicious vs. definitive findings
Imaging and Glaucoma

- Provides another parameter to increase or decrease suspicion of glaucoma (or glaucoma progression)

Don’t overreact

- Imaging abnormality in isolation is not enough to diagnose glaucoma

- Look for image quality and artifact before jumping to conclusions
Imaging and Glaucoma

- Useful in clinical practice in conjunction with clinical exam and visual fields
- Cannot interpret results of imaging in isolation

- Each instrument has its advantages and disadvantages
- No instrument proven to be clinically superior to others
- Initial studies suggest superior reproducibility and diagnostic performance of SD-OCT over Stratus-OCT
Evolving Technology

• HRT and GDx are nearing maturity
• OCT has potential for significant improvement
  - Scan speed
  - Resolution

Evolving Technology

• Improved software for detection of optic nerve abnormality and glaucoma progression needed to take advantage of higher resolution of SD-OCT
  - Numerous manufacturers in the market should help speed introduction of these improvements into clinical practice