OCT in Glaucoma and Retinal Disease
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Disclosure

- Speakers Bureau for Alcon, Allergan, Merck, Oculus, Optovue, Reichert, Synemed,

Widefield Scan Captures Macula and Optic Disc

~3 mm scan depth

Visualize more with deeper scanning

3D Vitreous Rendering
GLAUCOMA

- **OU / Symmetry**

Macular Ganglion cell density

- 50% of ganglion cells located in central 4.5mm
- Peak ganglion cell density is 15,000 cells/mm² in macula (white region)
- GCC map covers central 6mm area

Retinal Ganglion Cells extend through three retinal layers

Imaging the GCC

GCC is inner retinal layers

- Nerve Fiber Layer – Ganglion cell axons
- Ganglion cell layer – Cell bodies
- Inner-Plexiform Layer - Dendrites
**Ganglion Cell Complex (GCC) with Database comparisons**

- **Patient Information**
- **GCC Thickness Map**
- **Deviation Map**
- **Parameter Table**
- **Significance Map**

**GCC Deviation Map**

- Color coded map
  - Percent loss value at each pixel location relative to normal based on age-adjusted normative database of over 300 healthy eyes
  - Blue = thinning 20–30% relative to normal
  - Black = 50% loss or greater

**GCC Significance Map**

- Color coded map shows regions where the change from normal reaches statistical significance
  - Green = values within normal range (p-value 5% to 95%)
  - Yellow = borderline results (p-value < 5%)
  - Red = outside normal limits (p-value < 1%)

**Glaucoma Progression Analysis**

- Thickness Maps
- Deviation Maps
- Significance Maps
- GCC parameter change analysis

**Ability of Fourier-domain OCT to Detect GCC Atrophy in Glaucoma Patients**

- 113 patients with different stages of glaucoma; 30 normals
- Imaged NFL and GCC with Optovue RTVue–100
- Conclusions: GCC and NFL thickness measurements performed by FD–OCT showed high diagnostic ability in detecting glaucoma. Mean thickness values can be determined for each glaucoma stage.

**Diagnostic Accuracy: GCC vs FD OCT RNFL with RTVue**

- Rao et al. found GCC had similar accuracy levels as FD RNFL (AROC = 0.81 for GCC vs 0.88 for RNFL)
- Seong et al. found similar results (AROC = 0.95 for GCC and 0.97 for RNFL)
- Kim et al. found AROC values were higher for RNFL vs GCC in a group of advanced glaucoma patients (AROC = 0.92 for GC vs 0.96 for RNFL), but GCC values were higher than RNFL in a group of early glaucoma patients (AROC = 0.83 for GCC vs 0.78 for RNFL)


RTVue FD OCT: GCC vs Disc vs RNFL

- Huang et al. compared the diagnostic accuracy for GCC, optic disc, and RNFL from the RTVue
- AROC for RNFL was highest (AROC = 0.92), with GCC second (AROC = 0.86), and vertical C/D ratio a close third (AROC = 0.854)
- They found the accuracy improved when they combined all three structures in an LDF (AROC = 0.97)


CORNEA ANGLE or CENTRAL CORNEA

- This scan can be used to image and measure the Angle, or image and assess the central cornea

Angle Measurements

Normal

Narrow

OCT Angle

Pre-LPI

Post-LPI

Pigmentary Dispersion
68yo M referred as glaucoma suspect
MH: unremarkable
S/P RK OU; mild cataracts OU; PVD OU
VA 20/25 OU
IOP R 16 L 18
DCT R 26 L 27
Gonio: Grade IV 3+ pigment OU
Leaving state for 2 years

6/08/2011 7/08/2011

6/08/2011 7/08/2011
Still using Travatan-Z
S/P SLT OU
IOP R 14 L 12
IOP ORA R 17 L 15
Hysteresis R 10.4 L 9.4
56yo M C/O red eye OD
Conjunctival hem OD
Denies HTN, DM but on Toprol (metoprolol)
BP 132/91
IOP R 21 L 20
CCT R 568 L 555
Moderate cupping OU
Lost to FU x 10 years
62yo M C/O blurred VA and diplopia
Also C/O periodic "snowy vision" OU lasting 1 minute occurring 1–2x/wk over last 1 year
MH: HTN, DM x 2 wks, CVA x 6
- Last CVA caused diplopia with RE turned out
VA 20/20 OU
IOP R 32 L 28
Karen 9/1/05

- Taking Travatan OS
- IOP: R 14, L 13
- IMP: +response to Travatan
- Plan: Continue Travatan OS for now

Karen 2005  2013
62yo AF treated for NTG
Baseline IOP R 14 L 17
CCT R 512 L 510
S/P SLT OS
S/P phaco/IOL/iStent OU 2015
Still on Travatan-Z, dorzolamide-timolol OU
OCT Angiography: the Next Chapter in Posterior Imaging

- Images retinal microvasculature without dye injection
- Displays structure and function from a single imaging system

Principles of AngioVue OCTA

- OCTA uses motion contrast to detect flow from OCT data
- Rapidly acquires multiple cross-sectional images from a single location on the retina
- Flow is the difference in signal between two sequential B-scans

A New Approach to Visualizing Blood Flow

- Patient Benefits
  - Reduces patient burden to allow more frequent imaging
  - Avoid potential side-effects of fluorescein injection
- Clinical Benefits
  - Faster than a dye-based procedure
  - Ultra-high resolution imaging of retinal microvasculature
  - 3D visualization: segments retinal vasculature into individual layers

Enface OCTA Generated from OCTA Volume Data

- Multiple motion-contrast frames create 3D OCTA volume
- Enface visualization of layers obtained by slicing and projecting slabs from 3D OCTA data

Difference of Two OCT B-scans = Flow Signal (Red) Overlay on OCT B-scan

Deep Plexus (INL–OPL)
Superficial Plexus (ILM–IPL)
Outer Retinal Zone (ONL–BM)
Choroid Capillaris
Compared optic disc perfusion between normal subjects and subjects with glaucoma using OCTA.

Results: In normal discs, a dense microvascular network was visible on OCTA. This network was visibly attenuated in subjects with OAG. The intra-visit repeatability, inter-visit reproducibility, and normal population variability of the optic disc flow index were 1.2%, 4.2%, and 5.0% CV, respectively. The disc flow index was reduced by 25% in the glaucoma group ($P = 0.003$). Sensitivity and specificity were both 100% using an optimized cutoff. The flow index was highly correlated with VF pattern standard deviation ($R^2 = 0.752$, $P = 0.001$). These correlations were significant even after accounting for age, C/D area ratio, NFL, and rim area.

Conclusions: OCTA, generated by the new SSADA, repeatably measures optic disc perfusion and may be useful in the evaluation of glaucoma and glaucoma progression.

OCTA of the Peripapillary Retina in Glaucoma

- Peripapillary flow index and peripapillary vessel density in glaucomatous eyes were lower than those in normal eyes ($P < .001$ for both).
- Peripapillary flow index ($r = -0.808$) and peripapillary vessel density ($r = -0.835$) were highly correlated with visual field pattern standard deviation in glaucomatous eyes ($P = .001$ for both).
- The areas under the receiver operating characteristic curve for normal vs glaucomatous eyes were 0.892 for peripapillary flow index and 0.938 for peripapillary vessel density.

OCTA Vessel Density (VD) in Healthy, Glaucoma Suspect, and Glaucoma Eyes

- Used Optovue Avanti OCT
- Compared NFL thickness and VD in healthy, glaucoma suspect, and glaucoma patients in 261 eyes
- Vessel Density: % of area occupied by flowing blood vessels in the area
  - circumapillary region (cpVD) (750–mmwide annulus around the disc)
  - whole-image vessel density (wiVD) (entire 4.54.5-mm scan field)
- Areas under the receiver operating characteristic curves (AUROC) were used to evaluate diagnostic accuracy
- For differentiating between glaucoma and healthy eyes, the age-adjusted AUROC was highest for wiVD (0.94), followed by RNFL thickness (0.92) and cpVD (0.83). The AUROCs for differentiating between healthy and glaucoma suspect eyes were highest for wiVD (0.70), followed by cpVD (0.65) and RNFL thickness (0.65).

Relationship between OCTA Vessel Density and Severity of VF Loss in Glaucoma

- 153 eyes: 31 healthy eyes, 48 suspects, and 74 OAG pts.
- VD higher in NL eyes followed by OAG suspects, mild OAG, and moderate to severe OAG eyes for wiVD (55.5%, 51.3%, 48.3%, and 41.7%, respectively) and for cpVD (62.8%, 61.0%, 57.5%, 49.6%, respectively) ($P < .001$ for both)
- Conclusions: Decreased VD was significantly associated with the severity of VF damage independent of the structural loss. OCTA is a promising technology in glaucoma management, potentially enhancing the understanding of the role of vasculature in the pathophysiology of the disease.

Annette

- 69yoWF referred with large cups
- IOP
  - R 16, 11, 14 mmHg
  - L 18, 13, 16 mmHg
- (three separate exams)
- ORA IOP R 15.3 L 17.5 CH R 9.8 L 9.9
- CCT R 599 L 603
Mark

- 59yoWM treated for NTG
- Baseline IOP by report 19 OU
- Currently using Travatan-Z, dorzolamide-timolol OS only
- Allergic to brimonidine
- S/P trabeculectomy OD 2-16-17
- IOP R 07  L 15

OD Definitely worse on Matched Flicker 2015 v 2013
What does the visual field look like?
Mike 1/19/17

- 57 yo WM referred with H/O IOP R 42 L 16
- C/O HA’s with periodic blurring of VA OD
  - C/O pain in and around OD
  - Today 0/10 but occasionally 6/10
- IOP R 54 L 27
Retinal Scanning

Wide field OCT Displays Anatomy Outside the Standard 6x6mm Cube

Partial PVD from macula

HD Raster with Enhanced Depth Imaging

Larry
9 27 12
- 67yo WM
- VA R 20/80
- L 20/20
Phillip

- Review of past medical records:
- CVA 2004 affecting motor abilities left side of body
- MRI showed right parietal damage
- He later had a right carotid endarterectomy
- Possible old BRAO as cause of VF defect?

Reginald

- 6/18/16
- Poor VA OU
- Scheduled for PPV/gas

6/21/16 VMT with FTMH

9/06/16

Darlene Mc 2013 84yo WF VA??

Darlene McN 2013

Finger Counting
68yo WF C/O poor VA OU
S/P phaco/IOL OD Sep. 2009; poor VA since then; no reason given
VA R 20 25 – L 20/50
Pupils, color VA, CT NL OU
SLE: OD 2+ PCO OS Cataract
DFE: “Trace central sensory retinal change OU”
66yo WF
VA R 20/20 L 20/25
ERM with pucker

Myrna

66yo WF
VA R 20/20 L 20/25
ERM

Deann

66yo WF
VA R 20/20 L 20/25
ERM with pucker

Deann 2013
OD ERM superior nasal
OS ERM Central

Deann 2009–2011
No ERM
ERM
Deann

VF Defect on FDT
MH: unremarkable
IOP R 15 L 14
CCT: unknown
Pupils: normal, no APD

Catherine

68 yo F referred as glaucoma suspect
VF Defect on FDT
MH: unremarkable
IOP R 15 L 14
CCT: unknown
Pupils: normal, no APD
7/11/2017

75yo WM glaucoma

S/P Phaco/IOL

S/P Trabec

Recurrent CME OS

VA OS 20/40–20/100

Norman