Power of OCT-A (Optical Coherence Tomography Angiography) in Glaucoma

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Introduction and Aim

Primary open-angle glaucoma (POAG) is a chronic ocular disease characterized by optic nerve damage. Without treatment, POAG leads to visual field (VF) loss and eventual blindness. In fact, POAG is the second leading cause of blindness worldwide.

One of the most widely used tests to diagnose POAG is a VF test to measure the patient's central and peripheral vision. However, glaucoma suspects, who are patients with an increased risk of developing glaucoma, have no visual field loss. Therefore, there is a need for an objective method to diagnose glaucoma suspects to prevent glaucoma progression.

OCT-A is a new, non-invasive, motion contrast micro-vascular imaging modality. OCT-A is able to calculate the vessel densities, ganglion cell complex (GCC) thickness, and retinal nerve fiber layer (RNFL) thickness in the eye.

The aim of this study is to determine if vessel density measurements and structural properties measured using OCT-A are able to differentiate between controls, glaucoma suspects and patients with mild, moderate and severe glaucoma.

Methods

In an IRB approved retrospective study, 69 controls, 36 glaucoma suspects, 54 mild glaucoma, 25 moderate glaucoma, and 12 severe glaucoma patients were studied. One eye was randomly selected per patient. Patients were excluded if they were < 18 years, had secondary glaucoma, signal strength index < 40, refractive errors > ± 5 D or ± 3 cylinder, corrected visual acuity worse than 20/40, or only one functional eye.

Collected data included: age, race, gender, family history of glaucoma, central corneal thickness (CCT), intraocular pressure (IOP), VF mean deviation (MD) and pattern standard deviation (PSD), cup/disc ratio (C/D), and OCT-A scanning parameters: global and sectoral optic nerve fiber thickness, ganglion cell complex thickness, disc vessel densities, retinal vessel densities, and the foveal avascular zone area.

For categorical data, the variables were listed in frequencies and were compared to each other with a chi-square test. For continuous data, the variables were reported with a mean and standard deviation and a Jonckheere-Terpstra, independent t-test, and correlation matrix were used to determine differences between controls and glaucoma groups.

Results

Characteristics of control, suspect and glaucoma eyes are shown in Table 1.

Optic disc and retinal vessel densities showed a significant decrease as the glaucoma progressed, from mild to severe form, 52.9% to 43.1% and 48.1% to 43.4%, respectively (p<0.01). Nerve fiber layer thickness decreased from 83.0µm to 60.1µm, respectively (p<0.01).

Both structural properties and vessel densities were effective at determining glaucoma stage, but neither variable was superior to the other (p=0.21).

Between controls and glaucoma suspects, we noticed structural property differences, but not vessel density differences (p≤0.05).

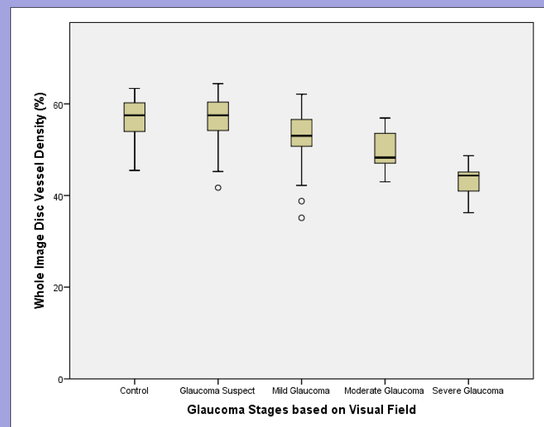

Figure 2: Whole Image Disc Vessel Densities by Glaucoma Stage

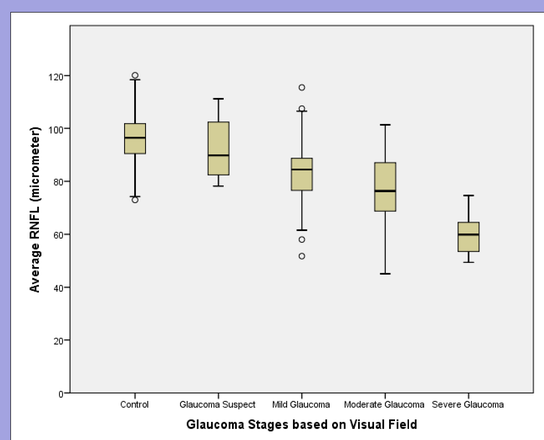

Figure 3: Average Retinal Nerve Fiber Layer Thickness by Glaucoma Stage

Variables		Control (n=69)	Glaucoma Suspect (n=36)	Mild Glaucoma (n=54)	Moderate Glaucoma (n=25)	Severe Glaucoma (n=12)	P value**
Age (years)		60.52±11.67	64.42±10.05	69.19±9.32	69.16±11.12	67.08±11.28	<0.01
Gender	Male (%)	34.8	30.6	40.7	68.0	8.3	<0.01
	Female (%)	65.2	69.4	59.3	32.0	91.7	
Race	White (%)	43.5	61.1	50.0	36.0	66.7	0.39
	Black (%)	26.1	25.0	31.5	28.0	8.3	
	Hispanic (%)	11.6	5.6	7.4	24.0	8.3	
	Others (%)	18.8	8.3	11.1	12.0	16.7	
Family History of Glaucoma	Yes (%)	47.8	61.1	51.9	24.0	33.3	0.01
	No (%)	46.4	27.8	38.9	56.0	50.0	
	Unknown (%)	5.8	11.1	9.3	20.0	16.7	
IOP (mm Hg)		14.94±2.75	15.94±4.64	15.04±3.87	14.76±4.31	13.88±4.4	0.17
CCT (µm)		536.13±36.44	563.97±35.90	546.94±32.26	525.29±33.23	548.1±67.89	0.52
Visual Field	Mean Deviation	-1.16±1.50	-0.80±1.51	-2.29±2.01	-8.26±1.51	-18.69±4.38	<0.01
	Pattern Standard Deviation	1.91±0.74	1.88±0.97	2.96±1.84	6.9±3.15	11.35±3.31	<0.01
C/D ratio	Total	0.49±0.14	0.43±0.17	0.54±0.15	0.57±0.17	0.73±0.12	<0.01
	Horizontal	0.77±0.14	0.68±0.20	0.78±0.14	0.81±0.13	0.9±0.1	<0.01
	Vertical	0.66±0.13	0.62±0.17	0.73±0.13	0.76±0.14	0.85±0.11	<0.01
Optic Cup Area (mm²)		1.21±0.46	0.91±0.49	1.25±0.47	1.24±0.47	1.4±0.48	0.27
Optic Rim Area (mm²)		1.18±0.28	1.11±0.29	1.01±0.34	0.93±0.39	0.53±0.35	<0.01
Average RNFL (µm)		96.11±9.80	92.00±10.02	82.95±11.75	76.91±14.45	60.13±7.51	<0.01
GCC Average (µm)		94.29±9.65	90.23±7.75	83.71±8.65	80.31±14.99	67.92±10.9	<0.01
Disc Vessel Density	Whole Image (%)	56.71±4.36	56.79±5.08	52.85±5.15	49.82±4.06	43.12±4.19	<0.01
	Inside Disc (%)	50.27±6.51	50.92±6.98	47.91±6.64	46.13±6.63	43.53±5.14	<0.01
	Peripapillary (%)	61.32±4.35	61.37±5.35	57.06±6.7	53.43±4.99	47.01±3.47	<0.01
Retina Vessel Density	Whole Image (%)	50.27±4.23	49.04±4.70	48.12±3.8	46.13±3.91	43.43±4.71	<0.01
	Fovea (%)	27.1±5.42	26.76±5.96	27.69±5.67	24.52±6.05	27.84±8.4	0.54
	ParaFovea (%)	52.72±4.66	51.40±5.28	50.74±4.04	48.45±3.98	45.77±4.98	<0.01

Table 1: Characteristics of control, suspect, and glaucoma eyes
*Baseline clinical data of subject eye per group reported as mean ± standard deviation.
**P-values from Jonckheere-Terpstra test for continuous data and chi-square for discrete data.

Discussion

The vessel densities and structural properties from OCT-A have a significant decreasing trend as glaucoma progresses and they support the clinical diagnosis of glaucoma based on VF damage (Figure 2). However, in glaucoma suspects, the structural properties were reduced compared to controls (Figure 3), while vessel densities remained unchanged. This could suggest that structural damage may occur before vessel damage in glaucoma suspects when there is no VF defect.

Conclusion

Optic disc and retinal vessel densities and structural properties assessed by OCT-A can provide an objective measure of glaucoma damage in the eye. Our study has shown that structural damage may occur before vessel density damage in glaucoma suspects.

References

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Financial Disclosures: None

Acknowledgements

Supported in part by an unrestricted grant from the Research to Prevent Blindness, New York, NY. Supported in part by the Research to Prevent Blindness, NY, NY; Visual Sciences Core Grant EY020799 and NIH CTSA Grant UL1TR001105.

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