

Structural Changes in Glaucoma: A Volumetric MRI Study

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Purpose:

To investigate brain structural changes in patients with glaucoma.

Methods:

High resolution 3D T1-weighted MP-RAGE MRI images were collected in 15 glaucoma patients (5 female, 10 male, 67+/-11 yrs), and 15 age- and gender-matched controls (66+/-11 yrs). The images were first analyzed using an automatic voxel-based morphometry technique which combines a fully automated spatial normalization approach, dubbed HAMMER [1], in conjunction with a tissue mass preserving framework called RAVENS [2]. Four consecutive steps were carried out: removal of non-brain voxels, tissue segmentation, spatial normalization to a standardized template, and generation of a mass-preserving tissue density map (i.e. RAVENS map) for each tissue type (GM, WM, ventricles). Measurements of volumes of individual brain structures: From the RAVENS maps of each individual subject's brain, the HAMMER technique generated measurement of the sizes of 110 brain structures. These 93 structures were labeled in the template brain. Group comparison to identify structures that are different between groups in comparison: Analysis of Covariance with age as a co-variant was carried out to identify structures that are significantly different between the two groups in comparison.

Results:

Table 1 listed structures that showed significant difference in volume. Interestingly, these structures are bigger in the glaucoma group than in the control group. In a companion study, a correlation analysis was carried out between the imaging results and clinical assessments for the interpretation and understanding of the findings (Program #5624).

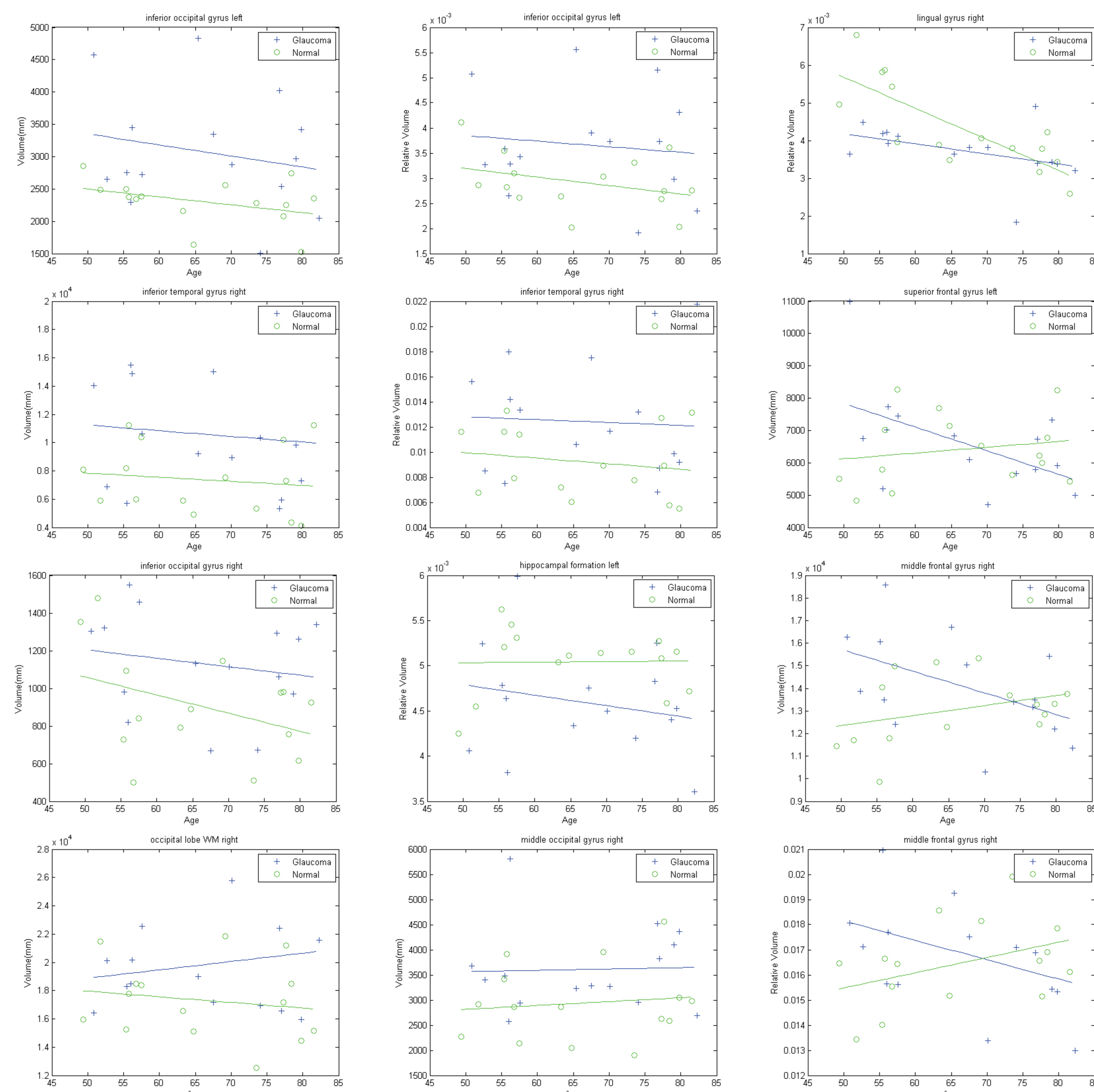


Figure 1: Plots of brain-area volumes (absolute and relative) detected to have significant group differences ($p < 0.05$) as listed in Table 1. Note that lingual gyrus right and hippocampal formation left are smaller in the glaucoma patients, while other structures are larger in glaucoma group.

Brain Area	group	Absolute (volume)		Relative (volume)		p values					
		mean	sd	mean	sd	Group		Age(Glaucoma+Normal)		Age(Glaucoma vs Normal)	
						Absolute	Relative	Absolute	Relative	Absolute	Relative
inferior occipital gyrus left	Glaucoma	3,066.53	903.34	0.00366	0.00103	0.00510	0.02204	0.22213	0.33363	0.83185	0.84021
	Normal	2,302.33	356.83	0.00292	0.00056						
inferior temporal gyrus right	Glaucoma	10,573.60	4,208.95	0.01242	0.00434	0.01991	0.02789	0.57156	0.60058	0.92655	0.86479
	Normal	7,375.13	2,452.98	0.00923	0.00281						
hippocampal formation left	Glaucoma	3,828.27	427.34	0.00460	0.00060	0.26801	0.02427	0.26953	0.53645	0.28336	0.48195
	Normal	4,010.87	439.95	0.00504	0.00037						
lingual gyrus right	Glaucoma	3,131.87	653.35	0.00373	0.00070	0.21671	0.02937	0.00014	0.00007	0.08392	0.02505
	Normal	3,452.73	991.83	0.00435	0.00117						
inferior occipital gyrus right	Glaucoma	1,129.53	268.17	0.00135	0.00032	0.02958	0.07338	0.13315	0.18736	0.58373	0.33993
	Normal	905.47	281.26	0.00114	0.00034						
occipital lobe WM right	Glaucoma	19,863.20	3,324.79	0.02382	0.00416	0.03373	0.12541	0.86765	0.68661	0.35338	0.22047
	Normal	17,317.00	2,731.72	0.02176	0.00275						
middle occipital gyrus right	Glaucoma	3,608.93	831.23	0.00431	0.00090	0.03545	0.08442	0.71132	0.44942	0.85578	0.80532
	Normal	2,939.13	758.01	0.00370	0.00091						
middle frontal gyrus right	Glaucoma	14,115.13	2,218.19	0.01685	0.00221	0.11217	0.56738	0.41726	0.82744	0.02675	0.03989
	Normal	13,063.93	1,522.62	0.01646	0.00171						
superior frontal gyrus left	Glaucoma	6,612.13	1,523.53	0.00789	0.00161	0.63580	0.71928	0.20839	0.41932	0.03790	0.06395
	Normal	6,411.93	1,097.33	0.00809	0.00134						

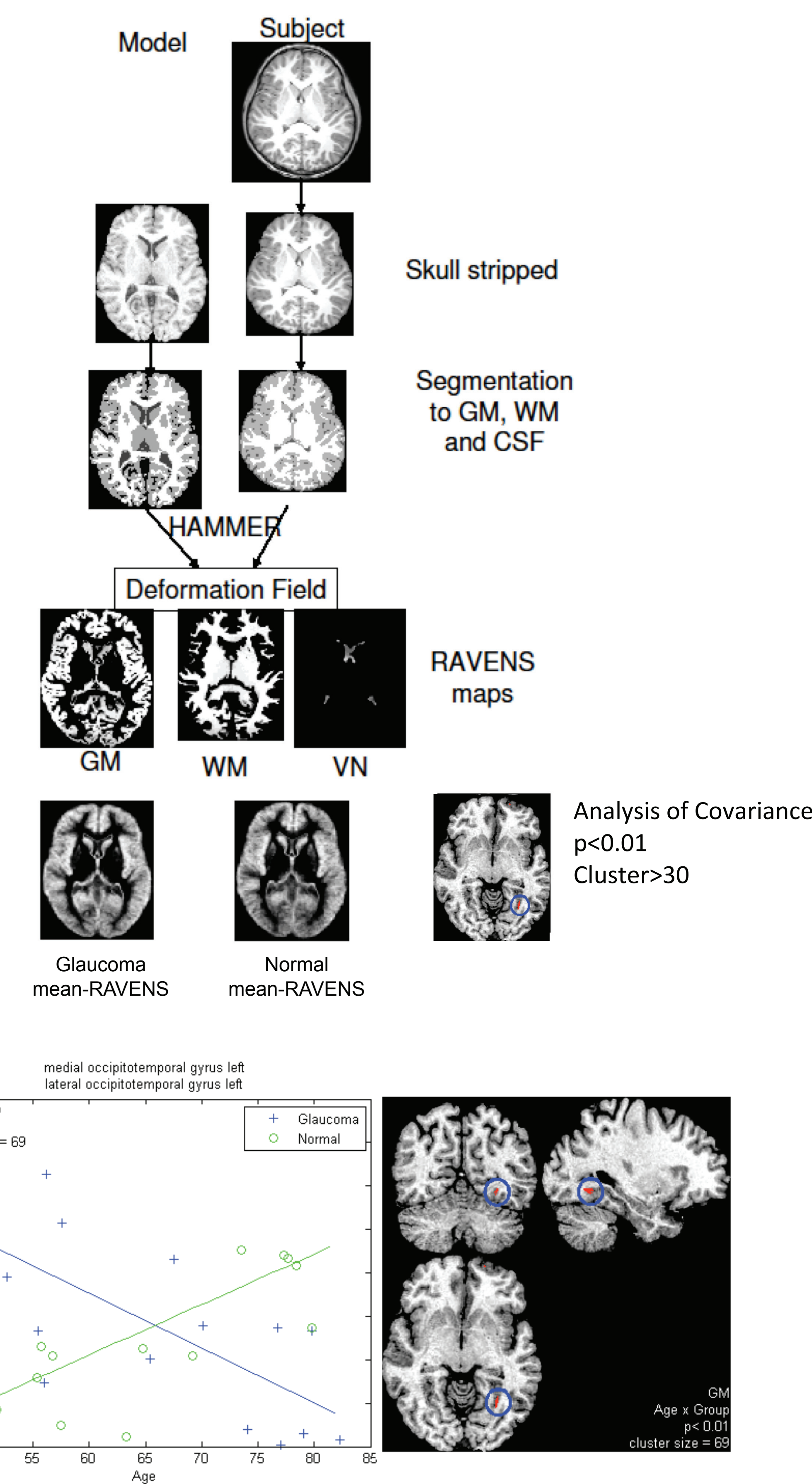


Figure 2: Analysis of Covariance with age as a co-variant was carried out on RAVENS maps. An interaction of age-by-group is observed on a voxel-by-voxel basis ($p < 0.01$, cluster size = 69.) This cluster located in the medial and lateral occipitotemporal gyrus left is observed to be larger in Normals in older age, but larger in Glaucoma patients in younger age, with a cross point at age ~65.

Conclusions:

This study has reinforced the value of MRI as a robust tool to identify structural changes in the brain of glaucoma patients.

References:

- [1] D. Shen, et al., IEEE Trans Med Imaging, 2002. 21(11):1421-39
- [2] Davatzikos, et al., Neuroimage, 2001, 14(6):1361-9