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Diffuse T1-MRI White Matter Volume Decrease in Patients with Sickle Cell Disease

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Introduction
Sickle cell disease (SCD) is a genetic blood disorder associated with anemia, chronic vascular damage, recurrent stroke, silent cerebral infarction and early mortality.1,2 Patients with SCD have increased cerebral blood flow to compensate for their anemia but nevertheless exhibit regional cerebral hypo-perfusion and neurocognitive decline.1,3,4 Previous volumetric studies in SCD have shown delayed growth, gray matter (GM) loss, while white matter (WM) loss, and decreased cortical thickness compared with control subjects.3,5 Diffusion-tensor imaging has demonstrated compromised WM integrity in major fiber pathways diffusely throughout the brain.1,6 Further regional investigations of structural outcome could potentially help expand our understanding of the neurobiology of SCD.

Subjects
T1-weighted MRI was obtained on 23 subjects on a 3T Philips Achieva as part of a study on sickle cell disease and neurological outcome. All patients were recruited with informed consent or assent; the study was approved by the Institutional Review Board at Children’s Hospital Los Angeles (IRB #11-0083). 14 clinically asymptomatic SCD patients (age:21.6 ± 4.8; F:8, M=6) were compared against 9 ethnically matched control subjects (age:23.0 ± 3.7; F:6, M=3). Exclusion criteria included pregnancy, previous overt stroke, acute chest or pain crisis hospitalization within one month.

Methods
T1-weighted images were processed using BrainSuite (brainsuite.org) in a semi-automated fashion with limited manual correction of the cortical boundaries—minimizing extraneous inclusion of meninges or exclusion of cortex—to extract, classify tissue types, and render 3D-surfaces of the inner and pial cortices. Surface-Volume Registration (SVReg) was used to automatically segment the brain into two separate segmentation schemes. The first segmentation divided the cerebrum into 4 lobes and the second segmentation divided the brain into 90 regions of interest (ROI). (Figure 1) Average cortical thickness, GM volume, and WM volume were calculated for all ROIs. Group comparisons were made using t-tests (p<0.05) using JMP statistical software (Version 10.0, SAS, Cary, North Carolina).

Results
6 SCD patients had one or more silent infarcts identified on T2 images. Volumetric comparisons showed no differences between SCD patients with silent infarcts and those without.

Brain lobe comparisons: SCD patients showed WM volume loss in comparison to control subjects bilaterally in the frontal, parietal, and temporal lobes, and cerebrum while sparing the occipital lobe. Total volume loss was seen in the right frontal and occipital lobes, and bilaterally in the parietal lobes. SCD patients had greater cortical thickness in the right temporal lobe in comparison to controls but GM volume was not significantly different. (Table 1)

Subparcellated region comparisons: SCD patients exhibited diffuse gyral WM loss in 28 out of 68 cortical regions, located primarily in the frontal, parietal, and temporal lobes. Left insula was the only cortical region where WM volume was greater in SCD patients against control subjects. Of the 20 non-cortical and extra-cerebral regions, WM volume was significantly lower in the left hippocampus, bilateral caudate, and right putamen in SCD patients. GM volume in these regions showed no differences. (Figure 2)

Conclusions
In SCD, silent cerebral infarcts primarily involve the frontal lobe, followed by the parietal lobe, subcortical nuclei, and temporal lobe, with very few lesions reported in the occipital lobe or cerebellum.3,4 We observed a nearly identical pattern for WM volume loss, even though WM volumes were no different in patients with or without silent cerebral infarction. Although we did not identify GM volume loss, our patient population was significantly older than cohorts for whom GM volume loss has been previously described. Further investigation of brain morphological abnormalities in SCD patients may provide insight into disease mechanisms and progression.

References