Automated Quantification of White Matter Hyperintensity Burden Using MPRAGE and FLAIR Images from a Large Population

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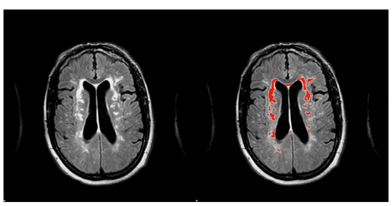
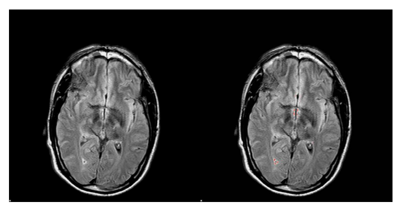
Introduction: White Matter Hyperintensity burden, as observed in T2 and proton weighted MR images, has been associated with several health factors such as decreased cognitive ability, hypertension, diabetes and cerebrovascular disease. (1) Available methods of using MR images from 3T scanners to assess WMH burden require some degree of operator involvement. (2) Assessing WMH burden in large population studies requires significant allocation of resources. We have developed an algorithm for automatically estimating WMH burden from pairs of MPRAGE and FLAIR images which is robust and requires essentially no operator involvement. WMH burden assessment was made for more than 1000 subjects.

Methods: Over 1000 pairs of FLAIR and MPRAGE images were acquired on a 3T Philips scanner without repositioning the subject between scans. The dimensions of the MPRAGE voxels were 1 mm x .90 mm x .90 mm and the dimensions of the FLAIR voxels were 5.0 mm x .45 mm x .45 mm. Segmentation of the brain was performed on MPRAGE images using SIENAX from the FSL library. (3) Segmentation information was applied to FLAIR images to delineate regions of the image to be used for threshold generation and threshold application. The WMH burden was estimated for each subject without employing any visual review of the images. The WMH burden estimate was examined for correlations with several known risk factors.

Results: Figure 1 shows FLAIR images of two subjects with different WMH burdens. The images are axial slices located at the level in which the most WMH was detected for that subject. The red pixels overlay the areas identified as WMH. Table 1 details the average percentage of WMH detected in groups of subjects with different risk factors. After removal of the effect of age on WMH burden, hypertension, gender and ethnicity were shown to be statistically significant factors. Diabetes and reduced cognitive ability were not shown to be statistically significant factors.

Discussion: The WMH burden estimation generated by this fully automated algorithm has been shown to correlate well with known risk factors for WMH burden. The algorithm does not require any visual review of images to produce a reliable and sensitive estimate of WMH burden. The results show expected correlations with age, gender, ethnicity, and hypertension. Conclusive results were not obtained for diabetes and reduced cognitive ability. In the case of diabetes the small number of diabetics among the subjects may have prevented gaining a conclusive result.





The images on the left in each frame are overlaid on the right with the automatically detected WMH in red.
Figure 1

Group Characteristic	# in Group	Average %WMH (95% confidence)	Average Age Adjusted %WMH (95% confidence)
Male	450	0.32(±0.06)	-0.04(±0.05)
Female	553	0.38(±0.06)	0.03(±0.05)
Hypertensive	259	0.57(±0.07)	0.11(±0.06)
Non Hypertensive	683	0.28(±0.07)	-0.04(±0.06)
Diabetic	76	0.54(±0.11)	0.06(±0.10)
Non Diabetic	897	0.34(±0.11)	0.00(±0.10)

Table 1. WMH Burden for Subjects of Various Groups

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