Evaluation of Brain Atrophy Measurements from Multiple Scanners

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Introduction

Whole brain atrophy has been proposed as a marker of disease progression in a number of neurological diseases including multiple sclerosis [1]. A fully automated brain segmentation method has been developed to estimate the brain parenchymal fraction (BPF) from MRIs [2-3]. Application of the method in MS studies have shown the measurement to be reproducible for images acquired on the same scanner. The usefulness of BPF measurement in treatment trials and routine clinical practice is partially dependent upon its stability across sites. The purpose of this study was to determine the "worst case" variability of BPF across different field strengths, scanner manufacturers, and slice thicknesses.

Methods

Ten normal healthy volunteers (6 males, 4 females, 19-38 years old) participated in the study. Each volunteer was imaged at 4 different sites under the following 6 conditions: (1) Siemens 1.5T, 3mm slice thickness; (2) Siemens 1.5T, 5mm slice thickness; (3) Siemens 1.0T, 5mm slice thickness; (4) Siemens 0.2 Open MR, 5mm slice thickness; (5) Picker/Marconi 1.5T, 5mm slice thickness; and (6) GE 1.5T, 5mm slice thickness. The image acquisition consisted of a standard localizer and a fluid-attenuated inversion recover (FLAIR) sequence. All images were acquired over an 8 week period. There were no special requirements with respect to patient positioning or specific pulse sequence parameters. Each image was analyzed automatically to calculate the BPF as the volume of brain parenchyma divided by the total volume contained within the outer contour of the brain. The resultant segmented images were qualitatively evaluated by 3 observers. To account for systematic differences, each BPF was normalized to the BPF from the Siemens 1.5T 5mm image. The coefficient of variation over the six measurements was calculated.

Results

The qualitative evaluation showed that segmentation quality was correlated with image quality, as expected. Segmentation was rated acceptable in 93% of the images, including those acquired on the open MR scanner. Figure 1 shows the BPF values for each subject imaged under the 6 sets of conditions (a) before and (b) after normalization. The normalized BPF results for each individual are given in Table 1. The mean coefficient of variation before normalization was 1.26% (std. dev. 0.34), whereas after normalization it was 0.49% (std. dev. 0.16).

Discussion

Systematic differences in BPF between imaging conditions were evident. This is not surprising since we intentionally did not try to acquire comparable image data across sites and the images had substantial differences in tissue contrast levels and signal to noise ratio. A simple normalization was effective for correcting the systematic error, which accounted for approximately 60% of the overall variability across imaging conditions. There was less variability between measurements with different slice thicknesses than between different field strengths and different scanners. These findings indicate that systematic differences should be accounted for in multi-center trials that use BPF as an outcome measure. The low after-normalization COV of 0.5% indicates that the overall accuracy of the BPF measurement is high, regardless of the scanner used.

References

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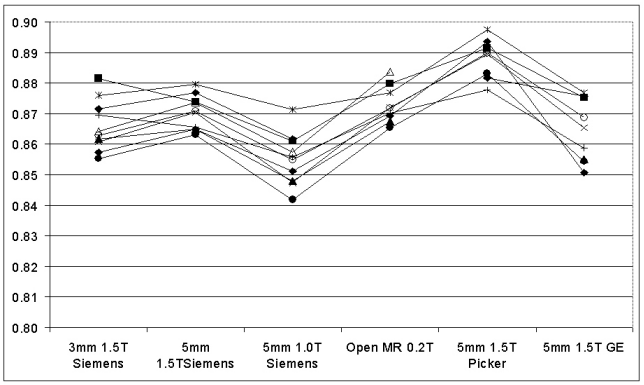

Figure 1 (a)

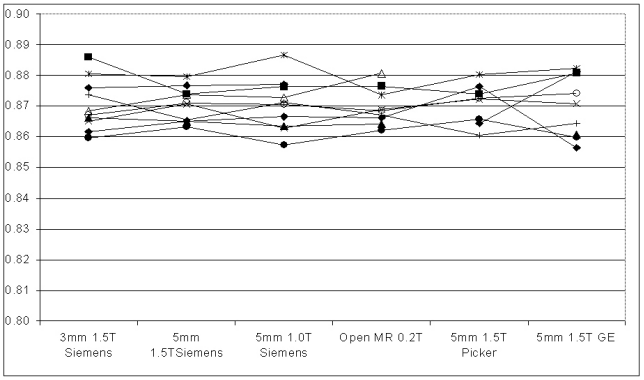

Figure 1 (b)

Table 1

	Mean Across Scanners	Standard Deviation	COV (%)
Subject 1	0.87509	0.0063	0.72
2	0.87796	0.0046	0.53
3	0.86390	0.0021	0.24
4	0.86844	0.0036	0.42
5	0.88051	0.0042	0.48
6	0.86130	0.0030	0.35
7	0.86706	0.0048	0.56
8	0.87393	0.0050	0.57
9	0.87065	0.0026	0.29
10	0.86531	0.0066	0.76