Quantitative correlation-time diffusion MRI of the brain: in vivo measurements and comparison to conventional echoplanar diffusion MRI

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PURPOSE

To measure diffusion coefficients in human brain parenchyma and CSF using a mixed turbo spin echo (mixed-TSE) sequence with correlation-time diffusion technique, which is theoretically less vulnerable to effects of non-diffusional motion and artifacts [(1)], and to compare these measurements to pulse-field-gradient (PFG)-encoded single shot spin echo echoplanar imaging (SS-SE-EPI), our conventional clinical diffusion-weighted MRI technique.

METHODS

Images were acquired with a 1.5T MRI system (NT-Intera, Philips Medical Systems, N.A.) with a maximum gradient of 23 mT m^{-1} and a maximum slew rate of 105 mT m^{-1} ms^{-1}. Using the Bloembergen-Purcell-Pound relaxation theory [(1)], a diffusion coefficient formula as function of the proton density (PD) and the longitudinal relaxation time (T1) was derived. A model conforming algorithm employing this formula was implemented to compute the correlation-time diffusion coefficient maps from self-coregistered PD and T1 maps generated with the mixed-TSE pulse sequence [(2,3)] (80 contiguous slices, 0.9x0.9x2.5 mm^3 voxel) in 12 human subjects. 14 regions of interest (ROI) in bilateral cortical and deep gray matter, white matter, and CSF were measured for a total of 336 mixed-TSE correlation-time and SS-SE-EPI ROI diffusion measurements. *Ex vivo* diffusion coefficient measurements of water and olive oil phantoms were also obtained. Descriptive statistics and linear regression was performed using Microsoft Excel.

RESULTS

Linear regression analysis between the two sets of diffusion coefficients revealed a strong linear correlation (slope=0.96, R^2=0.93) over the full range studied, from 0.03 to 4 mm^2/s. When restricted to brain parenchymal tissues, a significantly weaker correlation (slope = 0.26, R^2=0.5) was observed due to the lower gray-white matter contrast in the SS-SE-EPI diffusion maps. Correlation-time diffusion mapping technique demonstrated superior image quality and higher gray-white matter contrast compared to conventional PFG-encoded SS-SE-EPI.

CONCLUSIONS

Correlation-time diffusion mapping was compared to conventional PFG-encoded SS-SE-EPI diffusion MRI for *in vivo* brain imaging and in phantoms, showing a strong global correlation between both techniques of regional diffusion coefficients measurement. However, correlation-time diffusion mapping showed better image quality and a higher gray-white matter contrast. To our knowledge, this is the first *in vivo* comparison of correlation-time diffusion MRI to standard PFG-encoded SS-SE-EPI diffusion MRI. Correlation-time diffusion MRI may have future applications in conditions such as stroke, neoplasm, infections, or inflammation.

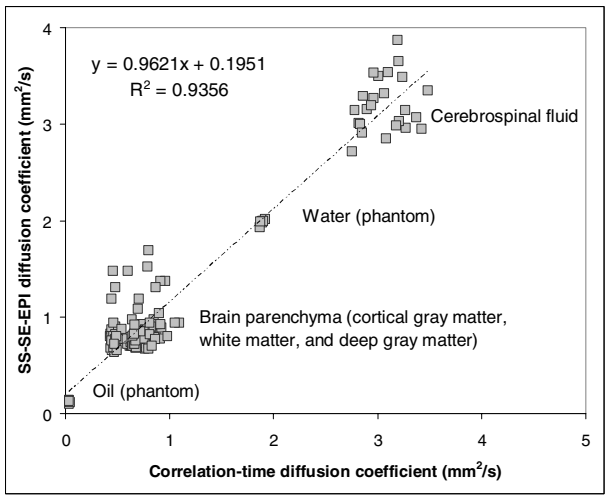

Fig 1: Comparison of correlation-time and conventional single shot spin echo echoplanar imaging diffusion coefficients demonstrated strong global correlation.

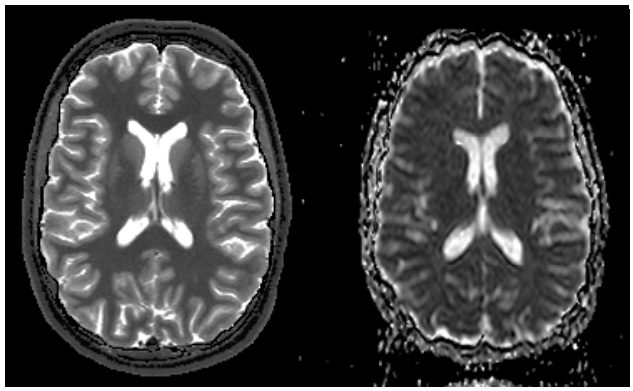

Fig 2: Correlation-time diffusion map (right) and SS-SE-EPI diffusion map (left) of the same human subject at the level of the caudate nuclei in the brain. Note the image quality and gray-white matter contrast of the correlation-time diffusion map.

REFERENCES

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