In vivo Diffusion Kurtosis Imaging of Rat Brain

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Introduction

Biological systems are often made up of multiple compartments, or heterogeneous in nature [1]. As a result, the usually assumed water diffusion probability, Gaussian distribution, might not be appropriate to describe the true diffusion process *in vivo*. By means of characterizing non-Gaussian water diffusion using diffusion kurtosis imaging (DKI) [2], more information regarding the biological systems, particularly central nervous system, might become available. We therefore performed *in vivo* DKI experiments on rat brain to examine the detailed distribution of the parameters obtained from both diffusion tensor imaging (DTI) and DKI, and to compare the difference between the two.

Materials and Methods

Experiments were carried out on three normal adult rats (300-320g). All experiments were performed using a 7-T Bruker scanner (70/16 Bruker PharmaScan, Germany). Diffusion weighted (DW) images were acquired with a respiration-gated spin echo 4-shot EPI readout sequence. An encoding scheme of 30 gradient directions which are homogenously distributed on the unit sphere was used to acquire DW images [3]. The imaging parameters were: TR/TE = 3000/36ms, Δ=17ms, δ=5ms, slice thickness = 1mm, FOV = 35mm, data matrix = 128 x 128 (zero filled to 256 x 256), image resolution = 136 x 136 μm^2 and six b-values were used for each gradient direction (0, 500, 1000, 1500, 2000 and 2500 s/mm^2). The sequence was repeated three times for signal averaging, resulting in an acquisition time of approximately 120 minutes depending on the respiratory rate. The diffusion kurtosis tensor and diffusion tensor were computed using the method described in Ref. 2 (with image registration performed using AIR5.2.5, Dr. RP Woods), and mean kurtosis (MK), fractional anisotropy (FA) and mean diffusivity (MD) maps were generated. Histogram analyses were performed on all the slices acquired, covering the brain from the anterior commissure (ac) towards the corpus callosum (cc).

Results and Discussions

Fig.1(a-c) show the MD, FA and MK map of an adult rat brain respectively. It is worthwhile to note that the MK map showed a similar contrast to the FA map. However, there were certain white matter structures, e.g. the optic tract, which MK map did not show clearly. By performing histogram analysis of each slice of the rat brain (as shown in Fig. 2), it was observed that, despite of the less contrast of white matter provided by MK maps, the distribution patterns of FA and MK were appreciably different suggesting that MK could provide more or complimentary information regarding the brain microenvironment *in vivo*. It is also interesting to note that the distribution of FA at different slice locations seemed to be relatively similar, whereas distribution of MK showed more variations indicating its potential ability to better distinguish different microenvironment in the rat brain.

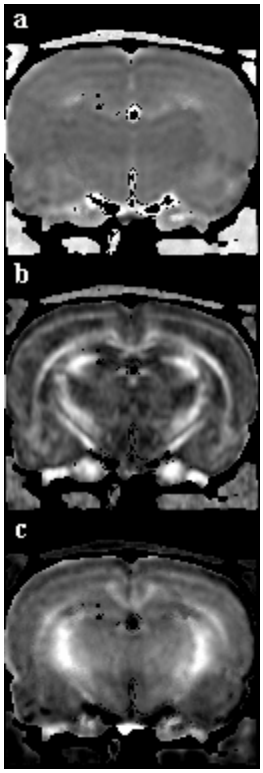

Figure 1. (a) Mean diffusivity (MD) **(b)** fractional anisotropy (FA) and **(c)** mean kurtosis (MK) map of an adult rat brain

Conclusions

Mean kurtosis map is useful for better differentiation of different brain tissues, especially gray and white matter tissues which DTI parameter maps, such as FA, cannot provide.

References

[1]. Le Bihan D., Magn. Reson. Q. 1991; 7: 1-30. [2]. Jensen JH et al., Magn. Reson. Med. 2005; 53: 1432-40. [3]. Jones D et al., Magn. Reson. Med. 1999; 42: 515-525.

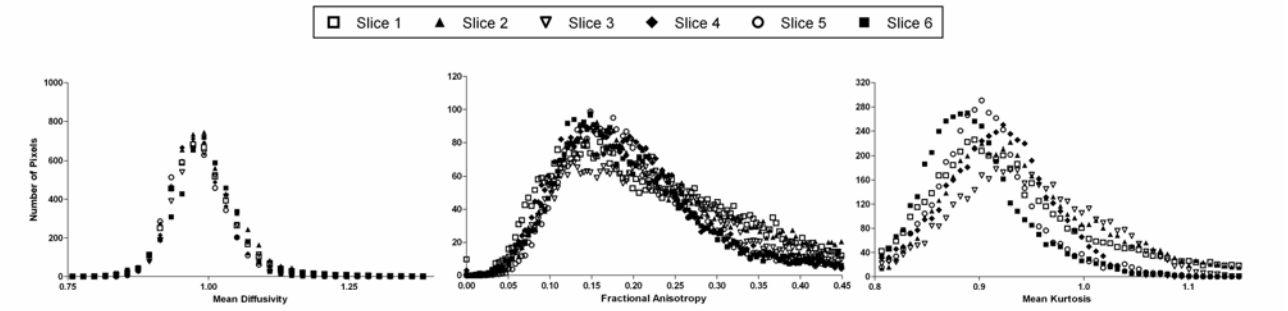

Figure 2. shows the histograms of mean diffusivity, fractional anisotropy and mean kurtosis in 3 adult brains studied in six slices. The error bars were removed for better clarity