Multi-TE diffusion kurtosis imaging in vivo

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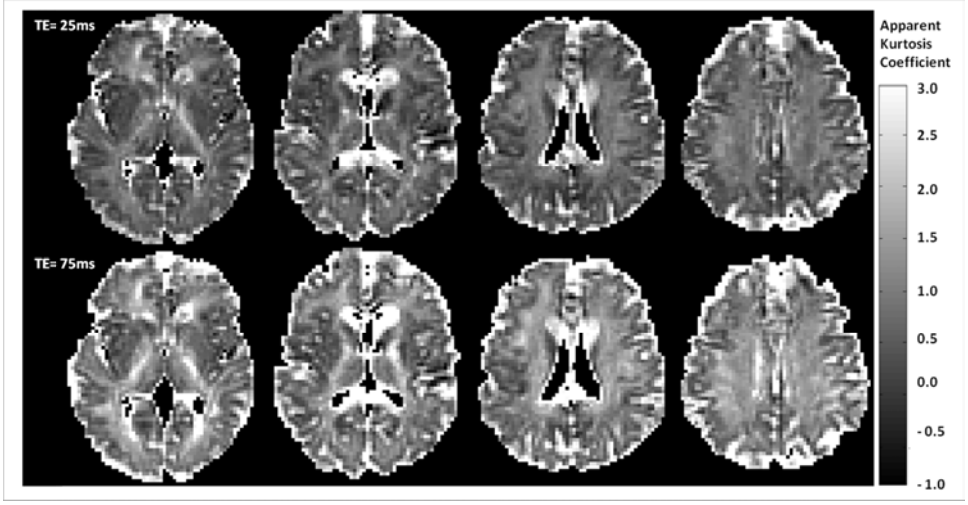
Introduction

Diffusion kurtosis imaging characterizes the non-Gaussianity of water diffusion in biological tissues providing complementary information to conventional diffusion tensor imaging methods [**1**] which can improve the assessment of white matter (WM) and gray matter (GM) microstructure. Diffusion kurtosis measurements generally requires a long echo time (>100ms) to accommodate large b-values (>2000 s/mm^2) preserving little signal from myelin water, which has a short T_2 relaxation time constant [**2**]. However, recent studies have shown that diffusion characteristics of myelin water differ significantly from those of axonal water [**3,4**]. In this report we compare in vivo diffusion kurtosis measurements acquired with short and long echo times (TE) and discuss their potential for deriving a diffusional kurtosis measures for myelin water in vivo.

Methods

A healthy volunteer was scanned on a clinical 3T scanner using a stimulated echo diffusion weighted sequence with single-shot spiral readout and inherent off-resonance correction capabilities [**5**]: TE1/TE2/TM/TR = 25/75/130/3000ms and 2.5x2.5x3.5 mm^3 resolution. High quality diffusion weighted images with b = 0, 500, 900, 1300, 1700 and 2100 s/mm^2. along 40 non-collinear orientations were acquired using short (25ms) and long TE (75ms) alternatively. To ensure a signal-to-noise ratio (SNR) matched comparison in white matter, two averages were acquired for each long TE measurement. Following correction for field inhomogeneities and direction dependent eddy currents [**5**], fourth order diffusion tensors were fit to both datasets and apparent kurtosis coefficients (AKC) were calculated and compared in WM and GM regions of interest (ROIs) [**1**].



	GM	WM
AKC short TE	0.32	0.83
AKC long TE	0.50	2.50

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Results and Discussion

In both GM and WM, our ROI analysis revealed significantly larger AKC values for the long TE dataset. In particular, the calculated diffusional kurtosis of white matter was approximately three times larger at TE=75ms than at TE=25ms. Compared to the long TE measurement (mainly axonal water), the signal at short TE averages significant contributions from both axonal and myelin water pools thus likely increasing the gaussianity of the total spin displacement distribution. In addition exchange between water compartments can also result in a decrease diffusional kurtosis, while partial volume effects with cerebrospinal fluid might also contributed to the observed behavior. Nevertheless, the differences between the measurements at short and long TE corroborate previous findings [**3,4**] suggesting that diffusion characteristics vary significantly across the T_2 spectrum.

Conclusions

In conclusion, we have characterized the diffusion kurtosis measurements acquired with a wide range of echo times. Our findings provide initial evidence that AKC vary significantly with TE indicating differences between diffusional characteristics of T_2 water pools in white matter. These results represent an initial step towards a more comprehensive characterization of myelin water diffusion properties in vivo. It is hoped that such an assessment could serve as a complementary biomarker in the early diagnosis of myelin related white matter pathologies.

References: **1**. Jensen et al, MRM 2005;53:1432, **2**. MacKay et al, MRM 1994:31:673, **3**. Andrews et al. MRM 2006;56:381, **4**. Avram et al., Neuroimage 2010;53:132, **5**. Avram et al., ISMRM 2011:173, **6**. Basser et al., Biophys J 1994;66:259,