Purpose: Knowledge of tissue alterations at an early stage following traumatic brain injury (TBI) is critical for injury management and prevention of secondary damage to the brain. In this study we investigate whether diffusion kurtosis imaging is sensitive to the microstructural changes in water diffusion in various grey and white matter regions in a controlled cortical impact (CCI) injury rat model at both the acute (2 hours) and the sub-acute (7 days) stages following injury.

Methods:12 adult male Sprague-Dawley rats were subjected to left parietal CCI injury. Imaging was performed on a 7 Tesla Bruker system using a four channel receive coil. Diffusion tensor images of the entire brain was obtained at an in-plane isotropic resolution of 200 microns and a slice thckness of 1mm with diffusion encoding in 30 directions. Images were precessed for fractional anisotropy (FA), mean diffusivity (MD) and mean kurtosis (MK). Immunohistochemistry staining for astrocytes using anti-GFAP was obtained for correlation with imaging findings.

Results: Changes in standard diffusion tensor parameters, including FA and MD that normalized by the sub-acute stage. However, MK was significantly elevated and remained elevated at 7 days in the ipsilateral regions of the hippocampus, cortex and the external capsule. Further, at 7 days abnormal MK was observed in the contralateral regions while no changes were observed with MD and FA. An increase in mean kurtosis was directly associated with increased reactive astrogliosis from immunohistochemistry analysis in the cortex, hippocampus, corpus callosum and the external capsule.

Conclusions:This study for the first time provides direct evidence for the ability to detect in vivo via MK, the increased astrocytic activity that leads to microstructural changes. Monitoring changes in MK allows the investigation of molecular and morphological changes in vivo due to reactive astrogliosis and may complement information available from standard DTI parameters.