Modelling inhomogeneous magnetization transfer in myelin and intra-/extra-cellular water in normal and injured rat spinal cords ex vivo

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Myelin is an insulating layer, or sheath that forms around nerves, including those in the brain and spinal cord. It is made up of protein and fatty substances. The myelin sheaths allow electrical impulses to transmit quickly and efficiently along the nerve cells. A number of neurodegenerative diseases are caused by demyelination or traumatic damage to myelin sheaths. Thus, quantifying myelin content through in vivo imaging methods is extremely important for diagnosing demyelinating diseases and injuries to the central nervous system. Inhomogeneous magnetization transfer (ihMT) imaging and myelin water imaging (MWI) have both established themselves as myelin-specific MRI techniques. In this study ihMT and MWI were combined to provide new insight into myelin state following traumatic spinal cord injury in a preclinical model ex vivo.

The combined ihMT/MWI data were acquired from 9 formalin-fixed rat spinal cords: uninjured (3), and 3 weeks (3) and 8 weeks (3) post dorsal column transection injury. A bi-exponential function was used to fit the T_2 decays of each saturation type, to quantify the ihMT effect in the myelin water (MW) and intra-extracellular water (IEW) pools separately. Different levels of the T_{1D} filtering was applied by using 11 τ_{switch} times in the ihMT part of the pulse sequence. Data was modelled with modified four pool model with addition of dipolar reservoirs.

Values of the dipolar order relaxation time in myelin (T_{1D}^m) measured in this study were close to previously reported. There was a significant drop in T_{1D}^m in the 3 weeks post-injury spinal cords in the fasciculus gracilis region, which suggests that T_{1D}^m may be a potential marker for distinguishing functional myelin from myelin debris. More studies on a larger cohort are required to confirm this result. Additionally, modifications need to be made to the model to improve the fit of the ihMTR-IEW data points.