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Rotating frame relaxation techniques as MRI contrast in brain

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A classical example of rotating frame relaxation is T1rho-relaxation, which refers to relaxation during a continuous wave (cw) on-resonance RF-pulse under spin-lock conditions. This type of RF-pulses have been used as a preparatory pulses in pulse sequences to increase MRI contrast for decades starting from pioneering work by Sepponen et al (1). The overarching motivation to use rotating frame relaxation as MRI contrast is sensitivity to slow molecular motions and the versatility to tune the sensitivity of the contrast to specific motional regime by changing the RF-pulse parameters. However, the range of molecular motion assessed by conventional cw-type T1rho is rather limited in experimental and in clinical MRI, as high spin-lock fields cannot be used due to technical obstacles such as high specific absorption rate (SAR). Furthermore, off-resonance effects may significantly contribute the classical T1rho contrast.

During a last decade we have develop several advanced rotating frame relaxation MRI approaches that go beyond conventional cw-T1rho. These novel approaches have reduced sensitivity to off-resonance effects, enlarge the range of molecular motion probed by RF-preparation and/or significantly reduce SAR. These techniques include T1rho and T2rho relaxation during adiabatic RF-pulses (2) and Relaxation Along Fictitious Field (RAFF) (3,4). We have tested both conventional and advanced rotating frame relaxation techniques in several different brain pathologies. Our results demonstrate that variants of T1rho contrasts can be sensitized for example to cell death in acute stroke (5), glioma gene therapy (6,7) and Parkinson's disease (8). Furthermore, higher rank RAFF approaches (4) give excellent correlation with myelin density (9) in both normal and demyelinated brain.

The recent development in rotating frame relaxation MRI contrast opens up a myriad of opportunities to modulate relaxation based MRI contrast to make it more specific to certain pathological process. Due to low SAR, novel approaches are also translatable to clinical MRI.

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