Fast high-resolution brain imaging with balanced SSFP: Interpretation of quantitative magnetization transfer towards simple MTR

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Magnetization transfer (MT) reflects the exchange of magnetization between protons bound to macromolecules, such as lipids and proteins, and protons in free liquid, and thus might be an early marker for subtle and undetermined pathologic changes in tissue. Detailed analysis of the entire MT phenomenon, however, commonly requires extensive data acquisition and scanning time, and hence is only of limited clinical interest. Therefore, in practice, magnetization transfer effects are commonly confined into a simple ratio measure, the so-called magnetization transfer ratio (MTR), calculated from a MT-weighted and a non-MT-weighted image. However, subtle physiologic and pathologic changes in tissue, invaluable for specific diagnostic imaging, may be lost since MTR-values depend not only on quantitative magnetization transfer (qMT) parameters but also on sequence parameters and relaxation properties. In order to evaluate and assess the diagnostic specificity of MTR versus qMT, high-resolution whole brain MT data was collected from twelve healthy volunteers using balanced steady-state free precession (bSSFP). In contrast to common MT imaging based on spoiled gradient echo (SPGR) sequences, whole brain qMT imaging can be performed with MT-sensitized bSSFP within a clinically feasible acquisition time. Hence, MT-sensitized bSSFP provides access to both MTR and qMT parameters within a clinical setting. The reliability and possible diagnostic value of MTR are analyzed for twelve white matter (WM) and eleven gray matter (GM) structures of the normal appearing brain. Strong correlations were found within and between longitudinal and transverse relaxation times (T1, T2) and MT parameters (ratio between macromolecular and water protons, F, and magnetization exchange rate, kf), whereas weaker correlations were observed between MTR-values and relaxation times or MT parameters. Structures with highly similar MTR-values, such as the crus cerebri and the anterior commissure in the WM, or the pallidum and the amygdala in the GM, however, were also found that showed significant differences in most quantitative parameters. This observation was confirmed from simulations revealing that the overall effect on MTR from an increase (decrease) in relaxation times may be counterbalanced with a decrease (increase) in MT parameters. These findings corroborate the expectation that qMT is superior to MTR imaging, especially for the evaluation and assessment of pathologic or physiological changes in healthy and pathologic brain tissue.
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