APT and CEST Techniques for Clinical MRI
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Chemical exchange saturation transfer (CEST) based in vivo detection and quantification of endogenous macro-molecules (i.e., amide proton transfer, APT [1]) or exogenous contrast agents [2] is a highly sensitive molecular MRI technique bearing a substantial clinical potential for example in oncology [3] or for cerebro-vascular applications [1]. Techniques for APT/CEST MRI on clinical MRI scanners are reviewed. Typical limitations arise from hardware specifications of the radio-frequency (RF) source(s) regarding maximum pulse length or RF duty-cycle as well as limits imposed by regulations on specific absorption rates (SAR). Clinical APT/CEST techniques described in the literature [4,5] are compared to two novel approaches: (i) sequences based on operating the scanner in a mode provided for MRS proton-decoupling [6], and (ii), sequences based on the alternated use of the independent RF amplifiers within an MR system equipped with parallel RF transmission [7] (Figure 1). The standard APT/CEST signal detection is based on an asymmetry analysis for saturation offset frequencies around the water resonance and may be strongly biased by local magnetic field inhomogeneity δB0. Efficient CEST acquisition schemes in terms of z-spectral sampling and δB0 correction are presented. This includes CEST-Dixon techniques [6], where the δB0 information is directly obtained from a dual-echo CEST acquisition. At the same time, this allows to separate the fat fraction, which may interfere with the CEST signal evaluation and typically requires fat suppression techniques.

A sensitivity analysis of different APT/CEST techniques is performed on clinical 3.0T MRI scanners (Achieva TX, Philips Healthcare, NL) using phantoms prepared with different concentrations of egg-white proteins as a model for APT. Feasibility of precise APT measurements in the human head is demonstrated on healthy volunteers at 3.0T (Figure 2).

In emerging applications in the area of whole-body MRI, sensitivity of the APT/CEST techniques to physiological motion is of particular concern. A respiratory triggered sequence is presented using a continuous train of RF saturation pulses during the wait time for the trigger event [8]. A maximum number of saturation pulses is pre-defined and monitored during runtime to enable SAR-safe operation. The feasibility of respiratory triggered CEST is shown in the healthy human kidney [8] (in collaboration with Sherry AD et al., UTSW, USA) in the context of CEST-pH mapping using Iopamidol (Bracco Inc., Italy) as contrast agent (IRB approved protocol) and ratiometric CEST signal analysis [9].

References: