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Dissertations-Kurzfassung

Development of Quantitative Methods for Myocardial Tissue Characterization using Magnetic Resonance Imaging at 1.5 Tesla

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Quantitative myocardial T1 mapping is an emerging technique with the potential to assess diffuse cardiomyopathies. However, insufficient certainty of current measurements limits the clinical applications. The aim of this work was to develop novel methods for myocardial T1 mapping with improved accuracy and precision for two applications: post-contrast and native T1 mapping.

In the first part, a novel magnetization preparation for cardiac magnetic resonance imaging using a hybrid saturation/inversion recovery scheme (SAPPHIRE) is used to erase the dependence on the magnetization history, while maintaining a large dynamic signal range. SAPPHIRE was shown to remove imaging artifacts caused by heart-rate variability in Late Gadolinium Enhancement (LGE) imaging. Multiple SAPPHIRE 2D single-shot images enabled quantitative post-contrast T1 mapping without the commonly observed heart-rate dependence. In-vivo SAPPHIRE T1 times showed 44% - 86% reduced variability in half the scan time compared to the base-line method. Furthermore, 3D T1 mapping during free-breathing was enabled using a compressed-sensing based respiratory gating and Bloch equation fitting. Whole heart coverage with increased in-vivo precision was achieved in 4 minutes compared to 10 minutes with 2D breath-hold methods. Moreover, the integrated acquisition of T1 maps and LGE images in a single-scan could be achieved using compressed-sensing with adaptive under-sampling rates and joint-navigator gating. Thereby, high resolution images and spatially registered T1 maps were acquired in reduced scan-time.

In the second part, a head-to-head comparison was performed to study four common techniques for native myocardial T1 mapping. Inversion recovery based sequences showed decreased accuracy but increased precision and robustness compared to saturation based techniques. To mitigate these shortcomings, firstly, the use of non-Cartesian imaging for more robust saturation based T1 mapping was enabled, by mathematically deriving a fit model. Fat-suppressed radial T1 mapping showed comparable T1 map quality to Cartesian sequences. Secondly, in a novel inversion recovery based sequence for native T1 mapping the slice-interleaved acquisition allowed time efficient and accurate measurements. The accuracy in phantom scans was increased by 71% compared to established inversion-recovery sequences, while the precision and the in-vivo T1 map quality were similar.

The novel methods provided more accurate and precise T1 measurements in shorter scan times, enabling advanced clinical applications.