Ruprecht-Karls-Universität Heidelberg
Medizinische Fakultät Mannheim
Dissertations-Kurzfassung

Efficient Quantification of In-vivo ^{23}Na Magnetic Resonance Imaging

Autor:	Anne Adlung
Institut / Klinik:	Computerunterstützte Klinische Medizin
Doktorvater:	Prof. Dr. L. R. Schad

The tissue sodium concentration (TSC) can be obtained from quantitative sodium (^{23}Na) magnetic resonance imaging (MRI). It provides valuable information about tissue physiology, and cell vitality and viability that cannot be derived from conventional hydrogen (^{1}H) MRI. However, even after decades of research, quantitative ^{23}Na MRI is still facing crucial challenges such as its long measurement times and elaborate measurement setups. Thus, its clinical establishment is still pending. This thesis aimed to explore data acquisition and post-processing techniques, which could make quantitative ^{23}Na MRI more efficient for its clinical applications. It intended to obtain further knowledge about TSC in exemplary pathologies.

For the absolute TSC quantification, usage of external reference phantoms is state of the art. However, it requires additional efforts and carries the risk of introducing errors, e.g., because of the phantoms' spatial distance to the region of interest. In this thesis, the absolute TSC quantification was performed by considering internal instead of external quantification references in the ^{23}Na MR image of the brain from patients with ischemic stroke. The results indicated a reliable TSC quantification based on an internal reference within the vitreous humor. Prospectively, this could allow for an easier measurement setup whilst maintaining robust absolute TSC quantification.

Measurement time is a crucial parameter for MRI sequences, and ^{23}Na MRI takes substantially longer than ^{1}H MRI. A convolutional neural network was optimized, trained, and tested with the purpose of reducing the required measurement time for quantifiable ^{23}Na MR images. The results showed that a multiple-fold under-sampling might be possible for ^{23}Na MR images when applying a properly adjusted network to the post-processing algorithm, prospectively allowing for substantially shorter data acquisition times.

Two prospective in-vivo studies were conducted to obtain further knowledge about TSC alterations: One study investigated TSC in the brain of patients with brain metastases undergoing stereotactic radiosurgery. The study included ^{23}Na MR images pre- and post-irradiation. The results indicated that TSC might be able to quantify radiation-induced tissue changes. The other study investigated TSC in the human prostate. The results showed differences between TSC in the prostate of patients diagnosed with cancerous lesions and those with clinically inconspicuous findings. The findings indicate the additional diagnostic information that quantitative ^{23}Na MRI could be able to provide if being established for clinical applications.

The thesis aimed to contribute to quantitative ^{23}Na MRI overcoming its obstacles. It proposes how to enable faster, easier, and thus more efficient data acquisition. Furthermore, it gives insights into the significance of TSC, which was exemplary explored within patients with ischemic stroke, brain metastases and prostate cancer.