Ruprecht-Karls-Universität Heidelberg

Medizinische Fakultät Mannheim

Dissertations-Kurzfassung

Body Human Applications at 3.0 Tesla Development of RF Resonator Systems for Quantitative Sodium MRI of the Kidney in Preclinical Studies at 9.4 Tesla and Whole

Author: Raffi Kalayciyan
Institute: Computer Assisted Clinical Medicine
Supervisor: Prof. Dr. L. R. Schad

In sodium magnetic resonance imaging (^{23}Na-MRI), the signal-to-noise ratio (SNR)-optimized RF resonators play a key role for the quantification of the renal sodium concentration (RSC). The main objective of this work is to develop an SNR/time-optimized quantification method for the RSC measurement in the rodent kidney at 9.4T, and to transfer this method to a 3T clinical MRI system.

The RSC quantification in preclinical ^{23}Na-MRI at 9.4T is realized by using a dual RF resonator (TORO) system composed with a novel two-element ^{23}Na receive-only phased array including low-noise preamplifiers. Another saddle shaped transceiver (TXRX) RF surface resonator is developed for bilateral ^{23}Na-MRI of rodent kidneys with high spatiotemporal resolution. The SNR comparison of the TXRX and TORO setups shows that the TORO resonator is the most beneficial concept for imaging of the superficial rodent kidneys with an SNR benefit of about 30% compared to the TXRX coil, and an SNR increase by a factor of 4 compared to a standard TXRX volume resonator.

The anisotropic 3D-UTE sequence with the spatial resolution of (1 x 1 x 4) mm^3 allows for increased SNR/time due to very short TE down to 60 µs (TXRX) and 185 µs (TORO). High quantification accuracy of ± 10% is achieved in a 10-min acquisition time, which could be reduced down to 2 min for investigating the qualitative ^{23}Na signal with increased temporal resolution.

Further preclinical RF resonators developed for 3T clinical MRI are a single channel saddle shaped receive-only coil based on the TORO concept at 3T, and a multi-resonant (^{23}Na and ^{1}H) TXRX surface resonator. Initial rodent kidney experiments are successfully realized at 3T despite the field strength penalty, and the results matched the measured values at 9.4T very well. In *in vivo* experiments of diuresis model (n = 6) using the TORO resonator at 9.4T, the RSC was decreased from 213 ± 24 mM to 132 ± 25 mM with high significance ($P < 1 \cdot 10^{-4}$) in the inner medulla (-38%) and the RSC was slightly increased (+22%) from 86 ± 16 mM to 105 ± 18 mM in the cortex ($P < 2 \cdot 10^{-2}$). In *in vivo* experiments of diuresis model (n = 8) using the TXRX resonator, the ^{23}Na signal slope was investigated. A negative slope in the inner (-4.6 ± 1.3 %/min) and in the outer (-1.4 ± 0.9 %/min) medulla, but a positive slope of +1.7 ± 0.9 in the cortex were observed.

Finally, initial human ^{23}Na-MR measurements at 3T are realized by using the dual RF resonator concept in combination with the whole body ^{23}Na resonator. For instance, the receive chain of the TORO setup is improved by a single-tuned figure-eight resonator for bilateral breast ^{23}Na-MRI, or the newly developed five-channel phased array for ^{23}Na-MRI of the human spine. A future perspective of functional ^{23}Na-MRI is to establish it as an early diagnostic monitoring technique for common lifestyle diseases such as cancer, hypertension, or herniated vertebral disks.