DEVELOPMENT AND PERFORMANCE EVALUTION OF A DUAL TUNED ^{23}NA/^{1}H KNEE COIL

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Introduction:

Although sodium imaging has shown promising results for years, sodium MR is still intrinsically challenging because of the low sensitivity of the ^{23}Na nucleus, low in vivo concentrations, fast transverse relaxation times and the requirement for dual tuned RF coils. Dual tuned coils allow exact co-registration of the different sodium and hydrogen imaging modalities since repositioning of the patient to change coils is avoided.
Several approaches to achieve dual tuning of a birdcage structure have been proposed over the years: Inserting LC-Traps [1] into the birdcage structure, either in the rings or rungs, to dual tune a coil is cumbersome and results in additional coil losses. Four ring birdcages have been shown to deliver double tuning with little impact on the efficiency at the low frequency [2]. Drawbacks of this approach are the inhomogeneity of the hydrogen B_1 field and the overall axial lengthening of the coil which might cause patient discomfort. In this study we use an alternate rung concept [3] to build a ^{1}H/^{23}Na quadrature birdcage and evaluate its performance in regards of SNR and B_1 homogeneity.

Materials and Methods:

The birdcage structure was constructed with an inner diameter of 18 cm, an inner end-ring separation of 14 cm and 16 rungs which are alternating resonant at the sodium respectively hydrogen frequency (16.8 and 63.6 MHz). A low pass configuration was used for both frequencies to avoid overlap of higher birdcage modes. Guard rings on the lower and upper end and a coaxial HF-shield were used to shield the coil and avoid aliasing from the other knee. To build the coil the starting values of the capacitors were calculated [3] and then manually adjusted. Cable traps and low/high-pass filters in the feed lines tuned to the appropriate frequencies were incorporated to ensure coil safety and stability.
A uniform cylindrical phantom with 5 g/L NaCl was used to evaluate the coil performance. Sodium B_1-mapping was performed with a phase-sensitive method [4] with a 3D gradient echo (GRE) readout. The hydrogen channel was checked with a GRE sequence. A GRE sequence was used to identify the reference voltage of the 180° pulse which serves as a measure of SNR.
Hydrogen (Siemens MEDIC 3D, resolution: 0.5 x 0.5 x 1.5 mm³, slices: 144, TE: 25 ms, TR: 48 ms, TA: 8:30 min) and sodium (GRE 3D, resolution 2.7 x 2.7 x 8 mm, TE: 4 ms, TR: 15 ms, Bandwidth: 85 Hz/p, TA: 9:36 min) in vivo images of a volunteer were acquired.

Results and Conclusion:

Both the sodium and hydrogen channel show good homogeneity over the volume of interest (Fig1). Compared to a mono resonant sodium quadrature birdcage (8 legs, 12 cm rung length, 18 cm diameter) the reference voltage increased from 45 to 50V which translates into a SNR loss of approximately 5 % for the dual tuned coil. In conclusion the presented approach allowed us to build a practical and well performing coil for both sodium and hydrogen imaging (Fig2).

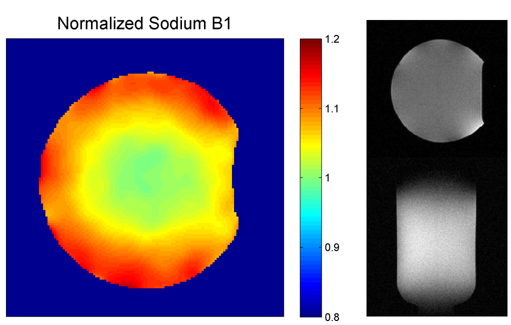

Fig 1: Sodium B_1 map (left) and hydrogen GRE images (right)

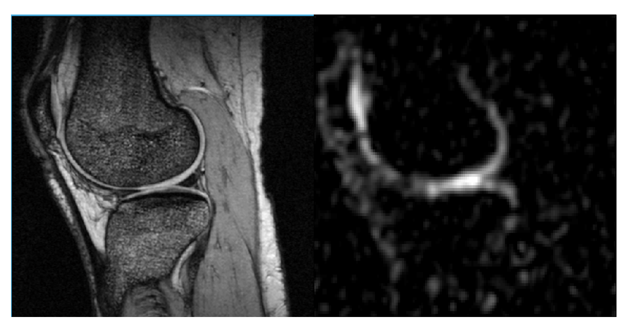

Fig 2: Hydrogen and corresponding sodium image of a volunteer's knee (sagittal slice)

Acknowledgement:

The research leading to these results has received funding by the European Union's Seventh Framework Program under grant agreement number 241719-ADIPOA.

References:

[1] Shen et al., MRM 38(5):717–25 (1997); [2] Peterson et al., ISMRM (2010); [3] Amari et al., MRM 37(2):243–51 (1997); [4] Morrell, MRM 60:889–894 (2008);