A 7-Tesla Transmit with 15-Channel Receive-Only Array Knee Coil for Sodium Imaging

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Introduction: A major emerging clinical advantage of 7T MRI is the signal-to-noise (SNR) ratio available to nuclei other than hydrogen is large enough to be useful in multiple applications. In particular, the buildup or absence of sodium (^{23}Na) has already been applied to the head for detection of stroke and multiple sclerosis [1]-[2]. Another area that has benefits to using sodium MR is orthopedic applications, primarily in the knee, where cartilage degeneration can be more easily characterized [3]-[5]. As the application and practice of x-nuclei imaging continues to grow, RF coil hardware should be developed and optimized for this specific purpose. With this in mind, a coil was developed for sodium imaging at 7T modeled on previous work at 3T, where a local transmit and high-channel receive coil was developed using phased array concepts to maximum SNR [6].

Methods: The 15-channel receive-only knee array for sodium imaging consists of 3 rows with 5 loops in each row, identical to the previous work [6]. Overlaps were adjusted to minimize the coupling between neighboring elements at the 7T sodium frequency of 78.6 MHz. As before, an unshielded, 12-rung, high-pass, circularly polarized birdcage transmitter was used.

The same mechanical package was used (Fig 1), as its size enables it to fit a large percentage of the population and its split-top design allows for easy patient setup and positing. With limited space for the electronics, an ultra-compact, low noise, pre-amplifer [7] was developed for 78.6 MHz and properly positioned relative to the B0 field as to maximize its performance [8].

Siemens MAGNETOM 7T systems at New York University Langone Medical Center, Max-Delbrueck-Center for Moleculare Medicine in Berlin, and Medical University of Vienna were used for testing.

Results: Images were obtained from a healthy volunteer scanned with the 7T 15-channel sodium array (Fig 2). Additional images were obtained from another healthy volunteer (male, 47 year old marathon runner). Using the same 47 year old male, SNR was compared with a CP volume coil (Fig 4).

Figure 1: Mechanical package

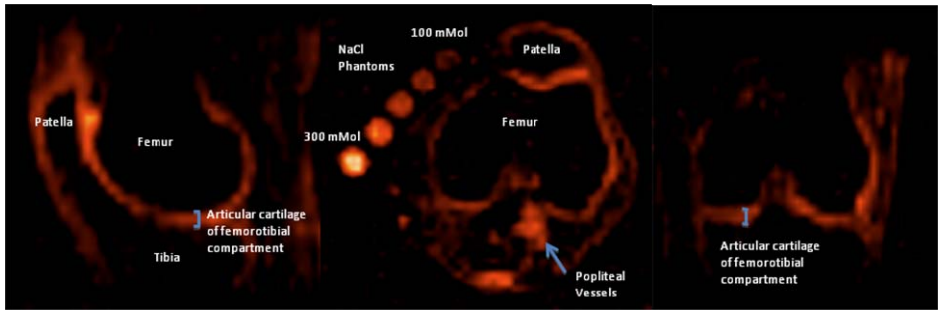

Figure 3: Image in all 3 planes of healthy volunteer. Sequence Parameters: 3D GRE (TR/TE=100/4.6, 250V, Cartesian k-space, TA=10 mins, 3 mm isotropic). Courtesy of New York University's Langone Medical Center.

Figure 2: Image of healthy volunteer. Courtesy of Medical University of Vienna.

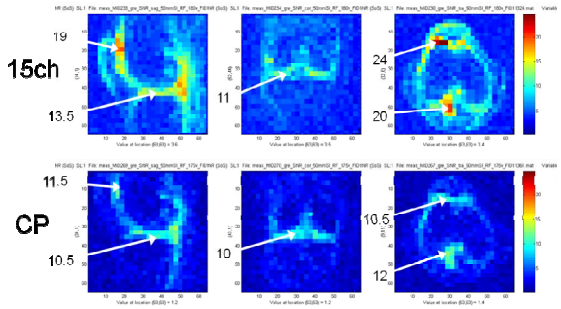

Figure 4: SNR comparison of 15ch vs. CP sodium knee coils. Courtesy of New York University's Langone Medical Center.

Conclusion: A 7T transmit with 15-channel receive-only array was successfully constructed. Images from healthy volunteers were obtained and an SNR comparison shows a significantly improved SNR at the surface while maintaining equal to better SNR at the center as compared to a CP volume coil. Future work will involve further refinements to the receive array to increase SNR.

References:

[1] G. Madelin, et al., "7 Tesla Sodium MRI of patients with Multiple Sclerosis: A preliminary study", in Proc. Intl. Soc. Mag. Reson. Med. 16, 511 (2008).
[2] F. E. Boada, et al., "Ultra-High Field MRI of Primary Brain Tumors: Contrast and Resolution", in Proc. Intl. Soc. Mag. Reson. Med. 18, 2178 (2010).
[3] E. Staroswiecki, et al., "In Vivo Measurement of 23Na T2* in Human Articular Cartilage at 3T and 7T", in Proc. Intl. Soc. Mag. Reson. Med. 16, 324 (2008).
[4] V. B. Kassey, et al., "Age dependent modulation of Aggrecan in human knee cartilage measured via sodium MRI at 7T", in Proc. Intl. Soc. Mag. Reson. Med. 18, 3189 (2010).
[5] J-S. Lee, et al., "Fluid-suppressed 23Na MRI of Knee Joint at 7T", in Proc. Intl. Soc. Mag. Reson. Med. 18, 3388 (2010).
[6] M. Finnerty, et al., "A 3D Parallel Imaging Capable Transmit and 15-Channel Receive Array Knee Coil at 3T", in Proc. Intl. Soc. Mag. Reson. Med. 16, 1077 (2008).
[7] H. Fujita, et al., "A 3T Head Transmitter Integrated with 3D Parallel Imaging Capable 16-Channel Receive Array Coil", in Proc. Intl. Soc. Mag. Reson. Med. 15, 3254 (2007).
[8] C. Possanzini and M. Boutelje, "Influence of magnetic field on preamplifiers using GaAs FET technology", in Proc. Intl. Soc. Mag. Reson. Med. 16, 1123 (2008).

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