

# Sodium MR imaging of kidney and other abdominal organs using a dual-tuned body RF coil at 7T

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## [Introduction]

In vivo sodium MR imaging is promising because it is capable of providing physiologic and metabolic tissue information beyond conventional proton MR imaging. Unfortunately, the image quality of sodium MR imaging is poor when compared with proton imaging because of the low SNR due to the inherent low biological sodium content and low MR sensitivity. The low SNR problem may be alleviated with the use of a high-field MR scanner and high-sensitive surface coil. Physiologic imaging of abdominal organs, particularly the kidney, may provide additional insight into clinical applications. In this study, we demonstrated sodium MR imaging of abdominal organs using a 7T MR scanner and a multi-channel dual-tuned <sup>23</sup>Na and <sup>1</sup>H proton transmit (Tx)/receive (Rx) coil, and assessed the distribution of sodium signal within the kidney.

## [Materials and Methods]

All imaging was performed using a 7T human MR scanner (Siemens Medical System, Erlangen, Germany) with an in-house dual (<sup>1</sup>H/<sup>23</sup>Na)-tuned RF coil designed for covering the abdominal regions. Four channels proton Tx/Rx coil was matched at 297.2 Mhz (S11, -15 – -20 dB); 8 channels sodium Tx/Rx coil was matched at 78.61 Mhz (S11, -20 dB). One proton and two sodium loops were located on each plane (Fig. 1). To avoid the possible loss of signal due to mutual coupling between adjacent coil loops, the overlapping distance was manually adjusted.

MR imaging was performed on 3 healthy volunteers. Subjects were positioned with foot-first and the kidney region was centered to the coil and magnet. Eight markers (solution of 80 mM <sup>23</sup>Na saline) were positioned on the abdomen and back of subjects. Proton MR imaging was used for localizing, shimming, and high-resolution body anatomical imaging. Multi-slice 2D GRE sequence was used for proton anatomy imaging of the abdomen while subject's breath-holding for about 30 sec (TR/TE = 300/5 ms, resolution = 1.6 × 1.6 mm<sup>2</sup>, and slice thickness = 2 - 3 mm). A 3D spiral trajectory sequence was used for sodium imaging of the abdomen (TR/TE = 80 - 100/0.3 - 0.5 ms, isotropic resolution = 4 mm<sup>3</sup>, and total acquisition time = ~20 min). The sodium signal intensities were measured on different abdominal organs. In addition, the spatial variation of the sodium signal intensity of kidney was measured pixel-by-pixel along the corticomedullary axis [1].

## [Results and Discussions]

The anatomy of the abdominal organs was well demarcated in the proton images (Figs. 2A, D). Sodium signal intensity of the markers was 615. Among the abdominal organs, the kidneys showed the strongest sodium signal intensity (cortex = 265; medulla = 459) (Figs. 2B, E), as shown in previous studies [1, 2]. The sodium signal intensity from other abdominal organs was considerably weaker than the kidney: liver = 211; spleen = 182; pancreas = 165. Prominent sodium signal intensity was observed in the cerebral spinal fluid (369) and gallbladder (600).

On sodium images of the kidney, the signal intensity increased linearly from the cortex to each of the medullae (Fig. 3), as reported in a previous study of imaging human study at 3T [1].

In summary, we have performed dual-tuned <sup>1</sup>H/<sup>23</sup>Na MR imaging of human abdominal organs at 7T and demonstrated the spatial sodium distribution in the kidney. Future development of <sup>23</sup>Na MR imaging will be focused on clinical application of sodium MR imaging in the abdomen to assess a variety of physiological and pathological conditions accompanied with changes in sodium concentration.

## [Reference]

- [1] Maril et al. *MRM*, 56:1229–1234 (2006).
- [2] Ra et al., *MRM*, 7:11-22 (1988).

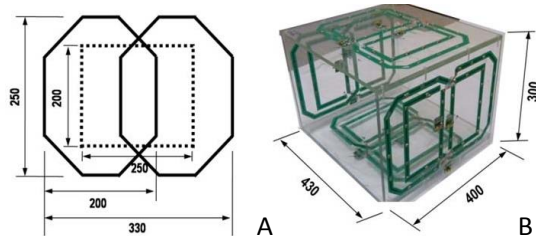


Fig. 1. Dual-tuned body RF coil at 7T. (A) Schematic drawing of coil loop: <sup>23</sup>Na (solid line); <sup>1</sup>H (dotted line). (B) Body coil assembled with four plates. Note: Measurements are mm.

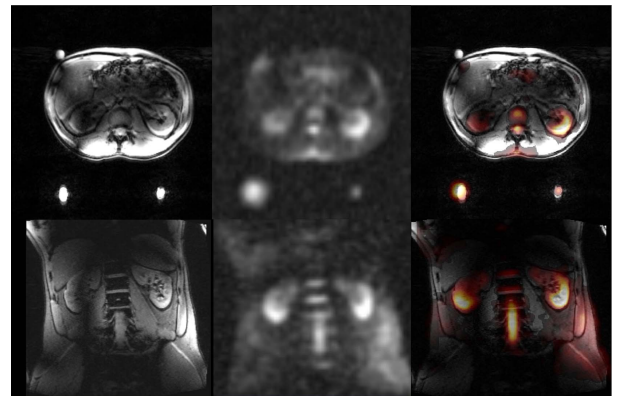


Fig. 2. <sup>1</sup>H/<sup>23</sup>Na abdominal MR imaging at 7T: <sup>1</sup>H (left), <sup>23</sup>Na (middle), and <sup>1</sup>H+<sup>23</sup>Na fusion (right) MR images of abdomen on axial (top panel) and coronal (bottom panel) plane. Two markers located on the back are visible as bright intensity circles on axial images. Note: Spatial resolution is 1.6 × 1.6 mm<sup>2</sup> on <sup>1</sup>H images and 4 mm<sup>3</sup> (isotropic) on <sup>23</sup>Na images.

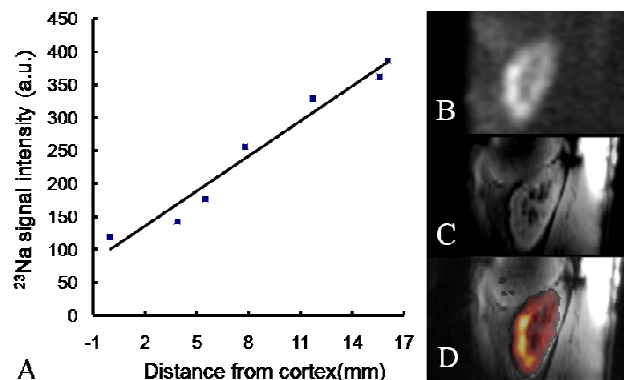


Fig. 3. Plot of <sup>23</sup>Na signal intensity (A) along one of the corticomedullary axes, obtained from an oblique sagittal <sup>23</sup>Na image (B), showing linear increase in sodium signal intensity towards the medulla. Corresponding oblique sagittal <sup>1</sup>H (C), and fusion (D) MR images.