23Na/1H MR imaging of female pelvis at 7T using a dual-tuned multi-channel body coil

K. T. Bae[1], J-H. Kim[1], C. Moon[1], A. Furlan[1], B. Park[1], and J. Wang[1]
[1]University of Pittsburgh, Pittsburgh, PA, United States

[Introduction]

MR imaging of the female pelvis is a commonly performed clinical examination which allows for a superb delineation of various pathologies involving reproductive organs. In addition to anatomic imaging, physiologic imaging of female pelvis may provide new insights into pathological conditions. In this regard, in vivo sodium MR imaging is highly attractive because it is capable of providing tissue physiologic and metabolic information beyond conventional proton MR imaging [1, 2]. However, because of the low SNR due to the inherent low biological sodium content and low MR sensitivity, the image quality of sodium MR imaging is poor when compared to proton imaging..The low SNR problem may be alleviated by use of high-field MR and high-sensitive surface coil [3]. Therefore, the purpose of our study was to perform sodium imaging of female pelvis using a 7T MR scanner and a multi-channel dual-tuned ^{23}Na and ^{1}H transceiver coil, and to demonstrate the in vivo sodium signal distribution of female pelvic organs.

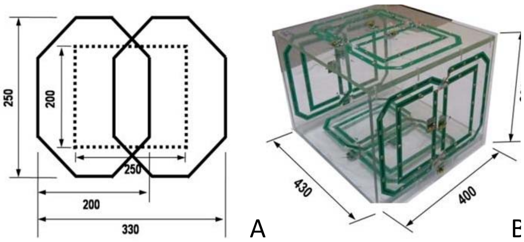

Fig. 1. Dual-tuned body RF coil at 7T. (**A**) Schematic drawing of coil loop: ^{23}Na (*solid line*); ^{1}H (*dotted line*). (**B**) Body coil assembled with four plates. Note: Measurements are mm.

[Materials and Methods]

All imaging was performed using a 7T human MR scanner (Siemens Medical System, Erlangen, Germany) with an in-house dual-tuned body RF coil designed for covering the body. The dual-tuned body coil was tuned at 78.61 Mhz (S11, -20 dB) for ^{23}Na, and 297 Mhz (S11, -15~20 dB) for ^{1}H. RF power from the system was split into four through Wilkinson splitter for the proton imaging. For sodium coil, the design was identical to the proton coil design except eight channels. A 90° phase shifter was inserted at each channel to produce circular drive. The shimming was done by using proton imaging in the same ROI. The performance of the coils was tested and confirmed on a phantom made of a plastic container filled with 60 mM ^{23}Na saline solution.

Proton and sodium imaging data were acquired from two healthy female volunteers with the dual-tuned body RF coil. The subjects were positioned foot-first and the pelvis was centered to the coil and magnet. Calibration markers (10-mm diameter tubes with 80 mM ^{23}Na saline) were also placed over the subjects and used for sodium quantification. Proton anatomical imaging of the pelvis was obtained using gradient-echo sequence (TR/TE = 300/5 ms, resolution = 1.6 × 1.6 mm^2, slice thickness = 2 - 3 mm; parallel imaging factor = 2). Sodium imaging of the pelvis was performed using a 3D spiral trajectory sequence (TR/TE = 80 – 100/0.3 – 0.5 ms, isotropic resolution = 5.7 - 6.3 mm^3, and total acquisition time = ~20 min). The RF power (250 – 300 V) for spin excitation was set within the allowed SAR limit. The sodium signal intensities of the pelvic organs were measured.

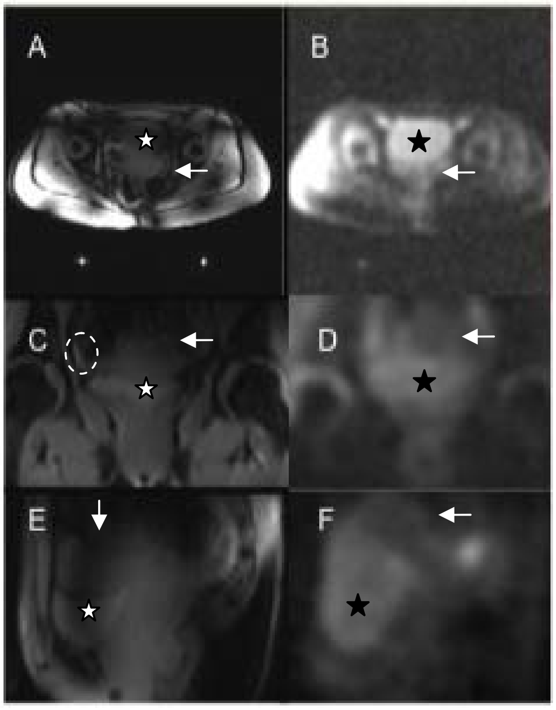

Fig. 2. ^{1}H/^{23}Na MR imaging of female pelvis of subject 1 at 7T. ^{1}H and ^{23}Na MR images on axial (**A**,**B**), coronal (**C**,**D**), and sagittal (**E**,**F**) plane of female pelvis. The anatomy of pelvic organs can be recognized on proton and sodium images: uterus (*arrow*), bladder (*star*), ovary (*dotted line* in **C**)

[Results and Discussions]

The anatomy of pelvic organs was well demarcated on the proton images acquired on axial (Fig. 2A), coronal (Fig. 2B), and sagittal (Fig. 2C) plane. Markers had a sodium signal intensity of 155. The uterus showed a diffuse moderately strong sodium signal intensity in both subjects (only one subject data shown in Figs. 2B,D,F). Sodium signal intensity of endometrium (45) was higher than that of myometrium (38) (Fig.3). Similar degrees of sodium signal intensity were observed in the ovaries (64). Intense sodium signals were detected in CSF (90) and in trace amount of physiologic pelvic ascites (80). Slightly less intense sodium signal was shown in the urinary bladder (74) and pelvic vessels (60). Weak sodium signal was observed from the small bowel (25) and pelvic wall muscles (42).

In summary, we demonstrated the feasibility of sodium MR imaging of female pelvis and distribution of sodium signal intensities in female pelvic organs in normal subjects at 7T using a multi-channel dual-tuned body RF coil. Future development of ^{23}Na MR imaging will be focused on clinical application of sodium MR imaging of the female pelvis to assess a variety of physiological and pathological conditions accompanied with changes in sodium concentration.

Fig. 3. Axial fusion (^{1}H+^{23}Na) MR image of the uterus showing the endometrium with a higher sodium signal intensity (*arrow*), compared to the myometerium (*dotted line*).

[Reference]

1. Granot et al., *Radiology*, 167:547-550 (1988).
2. Steidle et al., *MRI*, 22:171–180 (2004).
3. James et al., *ICBME 2008, Proceedings*, 23:138–141 (2009).