Dual Tuned Proton/Lithium RF array Development; Feasibility Study at 7T MRI

Junghwan Kim[1,2], Kyongtae Ty Bae[1,2], Narayan Krishnamurthy[1], Tiejun Zhao[3], Hoby Hetherington[2], and Tamer S. Ibrahim[1,2]

[1]*Bioengineering, University of Pittsburgh, Pittsburgh, PA, United States,* [2]*Radiology, University of Pittsburgh, Pittsburgh, PA, United States,* [3]*Siemens Medical Solutions, Inc, pittsburgh, PA, United States*

[Target Audience] Researchers who are interested in X-nuclei/dual-tuned RF coil development at high field MRI.

[Purpose] Detection of Lithium-7 (^{7}Li) can be critical for understanding many psychiatric diseases. Generally, Li_2Co_3 is taken orally to treat manic-depressive disorder (1). There has been a steady effort to measure the serum/brain ratio of ^{7}Li (1, 2). However, despite the long history of ^{7}Li MR research, Li imaging suffers from low sensitivity and resolution (average ^{7}Li level in the brain level is 0.4-1.2 mMol.) (1). Recent advances in MR techniques at high field strength (7T), such as dual-tuned RF system/sequences with increased SNR, has made detection of ^{7}Li more promising and provide the possibility to directly measure its concentration and distribution in-vivo (3). The dual-tuned RF array system can offer proton localizers for morphology references as well as B_0-shimming, while X-nuclei can provide pathophysiological information. In this study, we have developed eight-channel transceiver dual-tuned ^{7}Li /^{1}H RF array and tested the feasibility of ^{7}Li MR spectroscopy at 7T.

[Methods] All scans were performed using a 7 T scanner (Siemens Medical Solutions, Germany).

Eight-Channel transceiver ^{7}Li /^{1}H RF coil: each nucleus array consists of eight loops with trap circuits and inductive decoupling applied, transmission (S12) and reflection (S11) coefficient of Proton/Lithium was ~-15/-20dB. Constant phase shifters with increment of 45 degree were added to produce approximate circular polarization mode at both nuclei (figure 1.) ***Lithium MR imaging:*** Five Lithium phantoms were used; 100, 1, 0.8, 0.3 and 0.1 mM/L [^{7}Li]. ^{1}H localizer was acquired for reference and shimming (figure 2A). 1) spherical phantom (100 mM/L [^{7}Li]) MR images using a GRE sequence were acquired for SNR evaluation (figure 3 B and C); three different ROIs with diameter 160, 110, and 60 mm were used to measure SNR decrease toward the center (figure 2D and E). GRE sequence parameters were TR/TE = 500/12.5 ms, FOV = 300*300 mm^2, matrix = 64 * 64, FA = 30^o, thickness = 20 mm and total scan time = 12 min. 2) Sensitivity of different ^{7}Li concentrations/imaging thicknesses were evaluated using CSI (Chemical Shift Imaging) 2D sequence (figure 3B) with four phantoms (0.1, 0.3, 0.8, and 1 mM/L [^{7}Li]). Spectra at different concentrations and thicknesses were compared. CSI 2D parameters are; TR/TE = 3000/2.3 ms, FOV = 300*300 mm^2, matrix = 8 * 8, thickness = 70/50/30 mm and total scan time = 48 min.

Figure 1 Eight-channel transceiver dual-tuned ^{7}Li /^{1}H RF array. A) Front and B) back. Each array loop is 90 * 65 mm^2 (height * width). Intra/Inter-nuclei array has S12 of ~-20/-30dB. Each nucleus has S11 of ~-20dB at each port. Inner diameter of Lithium/Proton array is 190/220 mm.

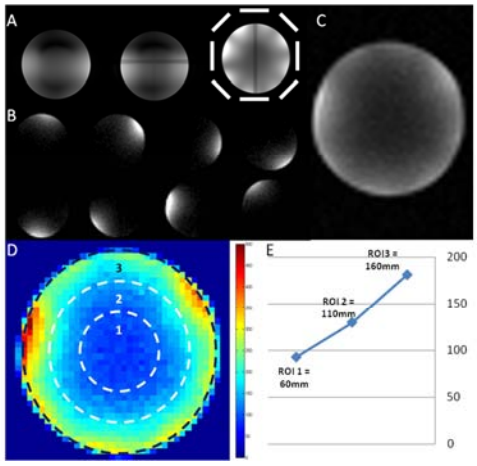

Figure 2 MR imaging of a phantom (100 mM/L [^{7}Li]). A) A proton scout was used for localization and shimming (coronal, sagittal, and axial). Note that each white line represents the location of the array. B) Eight receive sensitivity map of ^{7}Li transceiver array and C) Combined ^{7}Li MR image. D) SNR map with three ROIs, ROI1=60mm (diameter), ROI2=110mm, and ROI3=160mm. E) SNR at different ROIs were calculated pixel by pixel.

[Results and conclusions]

SNR measurement: SNR measured in ROI 1-3 (diameter; 60, 110, and 160 mm) was ≡ 93, 130 and 180. ~30% SNR was decreased between each ROI from periphery to center and ~50% SNR was decreased from ROI3 to ROI1.

Lithium sensitivity: SNR of the phantoms at different concentration and thickness are summarized at table 1. Signal intensities that were lower than twice the background noise were discarded. If the total number of pixels in a corresponding phantom was less than 15 pixels for SNR measurements, the results were denoted as N/A (0.1 and 0.3 mM/L [Li^7].)

In summary, we developed an eight transceiver dual-tuned ^{7}Li /^{1}H RF coil at 7T MRI, and measured and compared SNRs at different concentrations/thickness to evaluate the RF coil efficiency/sensitivity. Considering the mean lithium level in the brain is 0.4-1.2 mM, further development/optimization in sequence/B1 correction and in vivo study are required for quantification of lithium levels in the brain to validate the coil performance.

[References] (1) R.AKomoroski et al. MRM 18 (2000) 103-116. (2) Fiona E.Smith et al. MRM 66 (2011) 945-949. (3) JH. Lee et al. MRM 68 (2012) 363-368

	0.1 mM/L	0.3 mM/L	0.8 mM/L	1 mM/L
70 mm	N/A	N/A	38	54
50 mm	N/A	N/A	32	46
30 mm	N/A	N/A	20	34

Table 1 SNR measurements at different concentrations and thicknesses.

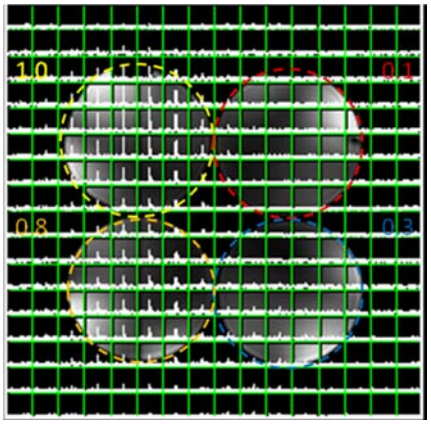

Figure 3 CSI-2D acquired at 30mm thickness. Exponential filter was applied and matrix was zero filled to 16*16.