Acquisition of 7T Human Spine Imaging

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Introduction Intervertebral disc disease is an emerging health concern and afflicts more than 10 million people in the United States. MRI has a critical role in imaging the disc, but it is still a challenge to assess disc degeneration and pain [1] partly due to the limitation of signal to noise ratio. Ultra-high magnetic field spine image may provide sufficient SNR for high resolution imaging of the human disc and thus better quantitative assessment of disc health may be achieved. In this work, initial images of the human spine were acquired at a GE whole body 7T scanner. Some issues regarding 7T human spine MR imaging are discussed in this abstract.

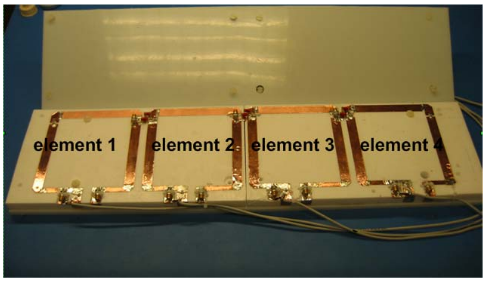

Fig.1 Photos of four-channel transceiver array at 7T.

Methods For ultra-high field MR disc imaging, a four-channel microstrip transceiver array was fabricated and tested using a GE 7T whole body scanner (Figure 1). This array includes four parallel placed non-overlapped microstrip loops, each loop is 12*12cm^2 in size. Those loops were implemented on a low loss Teflon substrate with 1.2cm thickness. A proposed adjustable inductive decoupling scheme was utilized to isolate the nearest loops. All experiments were performed on a GE whole body scanner equipped with two quadrature transmit channels and sixteen receive channels. Spinal images at sagittal plane were acquired from healthy volunteers. Due to the limitation of transmit channels, the four coil elements were connected to Tx channels in turns and the acquired images were combined off-line. To avoid phase cancellation between the nearest neighbors, coil element 1 and 3 were connected at first and then element 2 and 4 were connected. B_0 shimming was performed manually on a large field of view of 35*35cm. The coil elements were tuned to 298.1MHz and matched to 50 ohm after loading. To avoid SAR problem, the initial images were acquired using gradient echo sequences with 30^o flip angle. To investigate the impact from motion artifact, several conditions under "normal breathing", "deep breathing" and "without breathing" were performed for sagittal thoracic disc imaging with different repeat times (TR) at 4.9ms, 50ms and 117ms respectively. T1 weighted images of the lumbar spine were also acquired.

Results: Images in Fgure 2 show a sagittal image of the thoracic disc acquired using a GRE sequence with different TR. When TR is equal or longer than 117ms (scan time is around 32s), the image with "normal breathing" may have serious artifact at the depth where the disc is located, even though saturation bands (SAT bands) were placed. The arrow in Figure 2b emphasizes the motion artifacts visible in the image. The experiment was repeated within one breath-holding with the result that the intervertebral discs were now depicted much clearer (Fig 2a). Comparisons were also made with TR=50ms under "deep breathing" conditions (Figure 2d) and compared to that from breath-holding imaging (Figure 2c). When TR was further reduced to 4.9ms, the impact from breathing was negligible (Figure 1d). Fig.2 indicates that breath-holding is unnecessary for lumbar spine imaging (GRE Flip angle 30, 256*256, Slice Thickness 4mm, TE/TR 4.2/600, FOV 20*20cm, around 2min 34s) as we expected.

Conclusions and discussion: Initial MR imaging experiments on human spine were performed at 7T. Based on our images, it seems that motion artifact from breathing may significant degenerate thoracic disc images when TR is longer than 117ms. But for a TR less than 50ms, breath holding is unnecessary. Thus, most of T1-, T2- and $T_{1\rho}$ [2] applications in which TR are longer than 500ms seem challenging at 7T for the thoracic spine unless ECG is utilized. For lower intervertebral disc disorder detection, however, the motion from human breath may be negligible. Thus quantitative T1, T2 and $T_{1\rho}$ imaging can be applied for in vivo studies.

Acknowledges: This work was supported in part by NIH grant EB004453, AG017762, and QB3 opportunity award.

References: [1] S. Majumdar. NMR in biomedicine (2006) 19:894-903. [2]C.W. Phrrmann et al. Spine 2001; 26:1873-1878

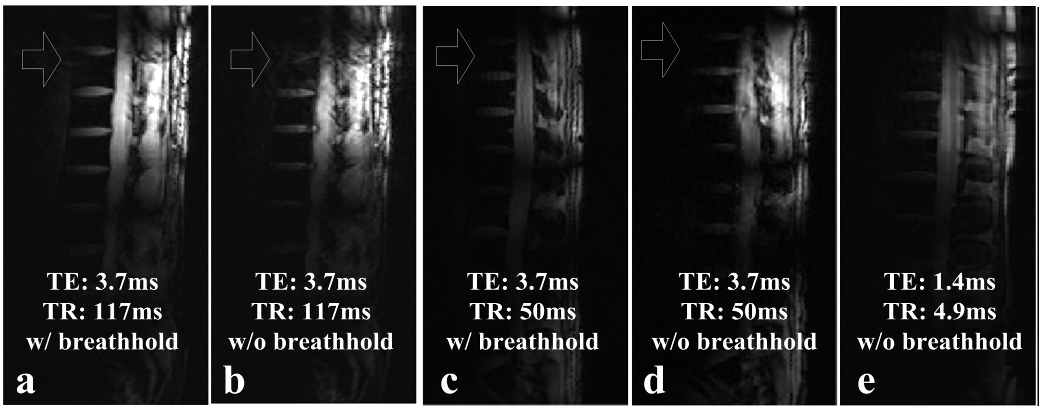

Figure 1. GRE images of human thoracic spine with different TR and breathing conditions.

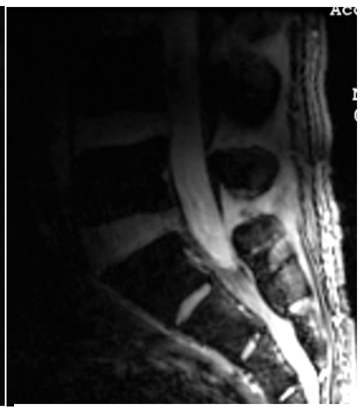

Figure 2. Lumbar disc imaging with free breath (2'34").