7T human liver imaging using microstrip surface coil

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Introduction: MRI can provide clinically-valuable images for hepatic diseases and has become the most accurate noninvasive method in evaluating liver lesions [1]. At high and ultrahigh field, liver images may be acquired within breath-hold period using very short TE, essentially reducing the scanning time and motion artifacts. However, B_1 variation can cause significant problems at high field [2]. This requires RF coils with deep penetration and relatively homogeneous B_1 field at high frequency. In this work, T1 weighted human liver images at 7T were acquired using a fast gradient echo sequence and a $\lambda/2$ microstrip surface coil on GE whole body 7T scanner.

Material and method: A capacitor terminated $\lambda/2$ microstrip surface coil was built to excite and detect the MR signals of the human liver. As shown in Figure 1, the microstrip coil is circular shaped with 12.5cm ID, 15.3cm OD and 1.4cm strip width. On one end of the coil, a capacitor DLC2R7 (Dalian Cap Co) with nominal capacitance of 2.7pF was used as termination to reduce the current phase variation along the coil. On the other end, a variable capacitor (NMAP25HV, Voltronics Co.) ranging from 1pF to 25pF acted as tuning capacitor. Another distributed capacitor DLC2R7 was placed at the center of the coil. The matching capacitor was NMAP19HV ranging from 1pF to 19pF. This circular strip conductor was built on the top of a square, low-loss Teflon substrate with permittivity of 2.1, side length of 20cm and thickness of half inch. The ground was a single piece copper adhered to the bottom of the substrate. Bench testing of this coil was performed using an Agilent network analyzer. At 298.2 MHz the S11 parameter in the loaded case reached -50dB as shown in Figure 2. The unloaded and loaded Q factors were 330 and 40 respectively. To obtain deep penetration, the substrate was made thick, therefore in loaded case most power was delivered into human body and the Q factor dropped significantly, indicating a high loading efficiency.

In vivo experiments were performed on a GE whole body 7T scanner with maximum gradient strength of 4 Gauss/cm and maximum slew rate of 15 Gauss/cm/ms. The subject position was supine, entry was feet-first and the surface coil was positioned over the liver. A fast gradient echo sequence was used for imaging 8 sequential coronal slices of the liver of a health volunteer in a breath-hold. Receiver bandwidth = 23.4*k*Hz, FOV = 20cm, slice thickness = 5mm, slice spacing = 3mm, matrix = 384×256, phase FOV = 1, flip angle = 30°, TR = 6ms and TE = 1.64ms, NEX = 2. The phase encoding direction was Superior-Inferior.

Results: Each imaging set was performed within a breath hold with an acquisition time of up to 23 s. High resolution images of 8 coronal plane slices were acquired and are shown in Figure 3. The SNR of each slice is shown in table 1. In the image of the deepest slice *a*, the SNR can still reach 33.4.

Tab. 1 SNR of each slice at different coronal positions.

Slice	a	b	c	d	e	f	g	h
Superior(mm)	5.5	13.5	21.5	29.5	37.5	45.5	53.5	61.5
SNR	33.4	36.6	61.3	51.6	59.4	63.5	78.8	96.1

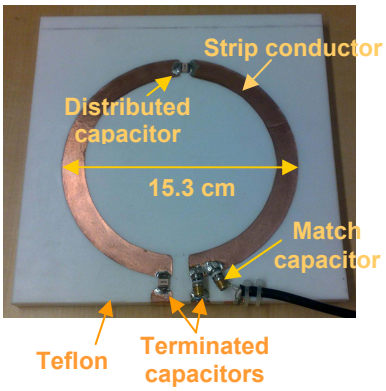

Fig. 1 prototype of the capacitor terminated $\lambda/2$ microstrip surface coil for human liver imaging.

Conclusion and discussion: MR imaging of the human liver was performed at 7T with a gradient echo sequence using a $\lambda/2$ microstrip surface coil with a large size for better coverage. With breath holding the motion artifact was minimal allowing high SNR 7T images of the liver. This experiment has demonstrated the feasibility of liver imaging at 7T. Further investigations with higher resolution, better sequences and optimized imaging parameters are now being pursued.

References: [1] Halavaara J, academic dissertation, Helsinki 2002. [2] Padormo F, et al, ISMRM 2009: p754.

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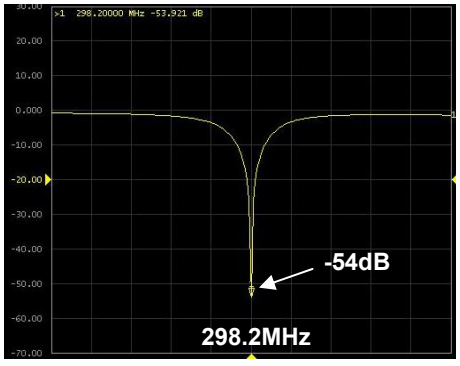

Fig. 2 Benchtest of S11, at 298.2MHz, S11 could reach -54dB or better.

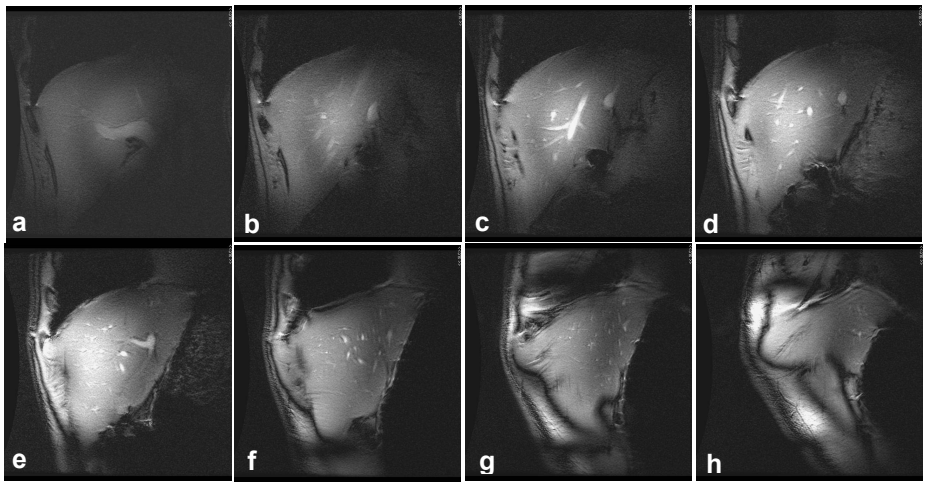

Fig. 3 8 coronal slices at different positions (superior 5.5mm to 61.5mm) using fast gradient echo. Imaging parameters: bandwidth = 23.4*k*Hz, FOV = 20cm, slice thickness = 5mm, slice spacing = 3mm, matrix = 384×256, phase FOV = 1, flip angle = 30°, TR = 6ms and TE = 1.64ms, NEX = 2.