MR Imaging of the Lower Extremities at 7 Tesla: Initial Experience with a 15 Channel Coil

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INTRODUCTION

At 7 Tesla, several studies have shown the feasibility of MR imaging of the knee [1-3]. Due to the limited size of the knee, standing wave phenomena only marginally affect the image quality, and thus high-quality images can be acquired without the necessity of parallel transmit technologies. Unfortunately, most studies so far have utilized only single or dual channel RF coils, and the full advantages of the higher signal strengths have only been exploited in one study [4]. In this work we present preliminary results with a novel 15 channel RF coil for imaging of the knee and the adjacent anatomy at 7 T.

MATERIALS & METHODS

All images were acquired with a 7 Tesla whole body MR system (Siemens, Erlangen, Germany) equipped with a 40/40/45 mT/m gradient system.

Coil Design

The prototype 7 Tesla coil (Rapid Biomedical, Rimpar, Germany) consists of an outer shielded transmit (Tx) birdcage coil with 16 rungs, which is tuned to the proton resonance frequency of 297 MHz. A cylindrical 15 channel receive array is integrated into the Tx coil which consists of 3 rings with 5 receive elements each. The elements enclose the imaging region at a diameter of 18.5 cm. For nearest neighbor decoupling, the elements on each ring have a shared conductor design while in z-direction the elements are overlapped and rotated against the next rings.

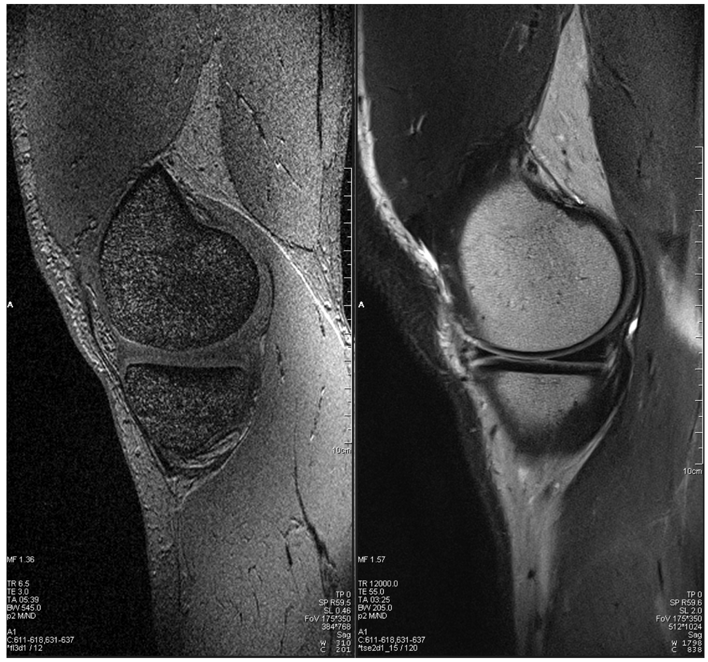

Fig. 1: 3D FLASH (left) and TSE-T2 (right) images of a healthy volunteer. Contrast variations can be seen in the FLASH image due to B1 inhomogeneities.

MR Imaging Protocols

MR images of the knee region of 3 volunteers (Fig. 1) and 3 patients (1 enchyndroma (Fig. 2), 1 knee implant repair, 1 cartilage damage) were acquired. Prior to imaging, a flip angle calibration was performed with a rapid imaging technique with non-selective preparation pulse. Among others, the following protocols were used for knee imaging:

1. 3D FLASH: TR = 6.5 ms, TE = 3 ms, FOV = 118×175×350 mm^3, matrix = 256×384×768, $\Delta x^3 = (0.46\ mm)^3$, BW = 545 Hz/px, parallel acceleration factor: 2, α = 8-12°, acquisition time = 5 min 39 s
2. 2D TSE-T2: TR = 12 s, TE = 55 ms, FOV = 175×350 mm^3, matrix = 512×1024, slice thickness = 2 mm, 41 slices, $\Delta x^2 = (0.34\ mm)^2$, BW = 205 Hz/px, parallel acceleration factor: 2, echo train length: 15, acquisition time = 3 min 25 s
3. 2D FLAIR: TR = 12 s, TE = 82 ms, TI = 2760 ms, FOV = 175×350 mm^3, matrix = 288×768, slice thickness = 2 mm, 9 slices, $\Delta x^2 = (0.46\ mm)^2$, BW = 205 Hz/px, parallel acceleration factor: 2, echo train length: 12, acquisition time = 4 min 48 s

RESULTS AND DISCUSSION

MR imaging of the knee region could be performed successfully in all subjects. During flip angle calibration, variations of the B1 over the imaging field of view of about 32% were observed. Chemical shift artifacts were visible in all data sets due to the relatively low readout bandwidths. High-quality diagnostic MR images could be acquired with all protocols, and acceleration of the acquisition with parallel imaging was always possible resulting in clinically acceptable acquisition times of less the 6 min per data set.

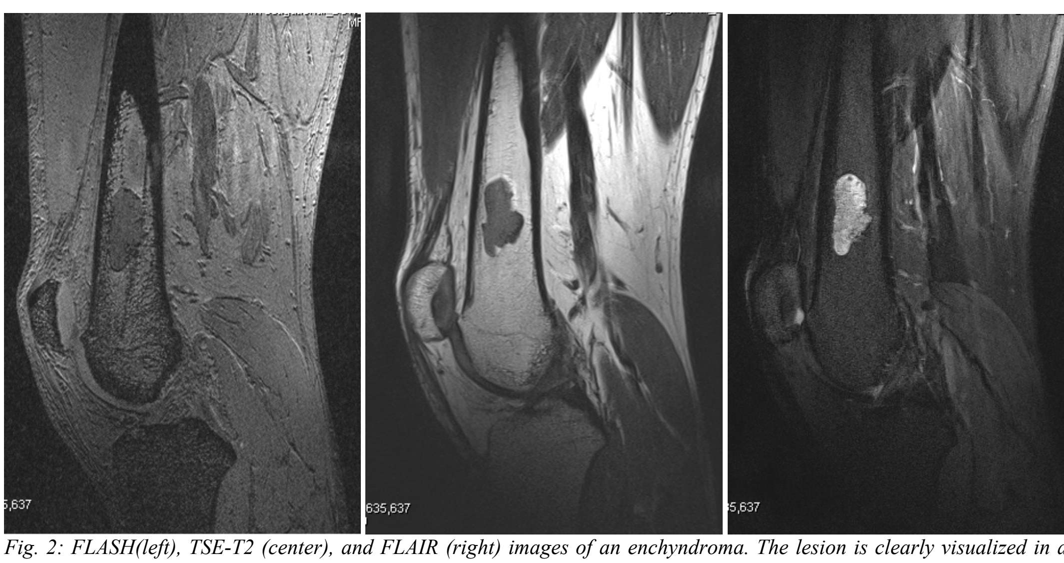

Fig. 2: FLASH(left), TSE-T2 (center), and FLAIR (right) images of an enchyndroma. The lesion is clearly visualized in all three contrasts. Note the large coverage of the coil, which allows assessing both the knee and the adjacent anatomy.

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