Ultrahigh magnetic field imaging of the knee using a transmit/receive array coil

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Introduction
Muscoloskeletal (MSK) imaging aims at visualizing small details of anatomical structures, such as the characterization of cartilage degradation by its thickness and molecular composition [1]. The contrast and high SNR attainable in a high-resolution image has therefore the potential of providing better quantification of morphology [2], and improved detection of pathophysiological changes. Its significance is also augmented by ever increasing capabilities available for therapeutic interventions. Cartilage, which is known to play a central role in early osteoarthritis, is well suited for transplantation. Noninvasive postsurgical evaluation and tissue characterization can potentially be noninvasively done by MRI-techniques.
In this paper, we outline technical developments necessary for high-resolution knee imaging at ultra-high magnetic field strength and show some examples. The results were accomplished using a dedicated knee transmit and receive array driven with a multichannel radio frequency amplifier. It permits independent adjustments of the pulse phase in each array elements so as to enable B1 shimming to homogenize the transmit B1 field [3]. The method obviates the use of body coil transmit and can be used to compensates for B1 inhomogeneities intrinsic to ultrahigh field (7T) imaging.

Methods
Experiments were performed on 7 T Siemens scanner. The radio frequency coil consists of 16 strip line elements each built of 13 cm x 3 cm x 1.2 cm Teflon bars.
Turbo spin echo (TSE) and gradient echo (GRE) high-resolution images of the knee joint were acquired. The imaging parameters for the sagittal TSE were TR/TE = 4210/31 ms, resolution 0.2x0.2x3 mm, 39 slices, 1 average, echo train length 7, 10 min total imaging time and for the axial TSE TR/TE = 4680/27 ms, resolution 0.3x0.3x2 mm, 29 slices, 2 averages, echo train length 7, 11 min total imaging time. A 3D gradient echo (GRE) image was acquired using the imaging parameters: matrix size 512 x 512, voxel size 400x400x400 µm, TR 15ms, TE 5.1ms, FOV 13x13cm

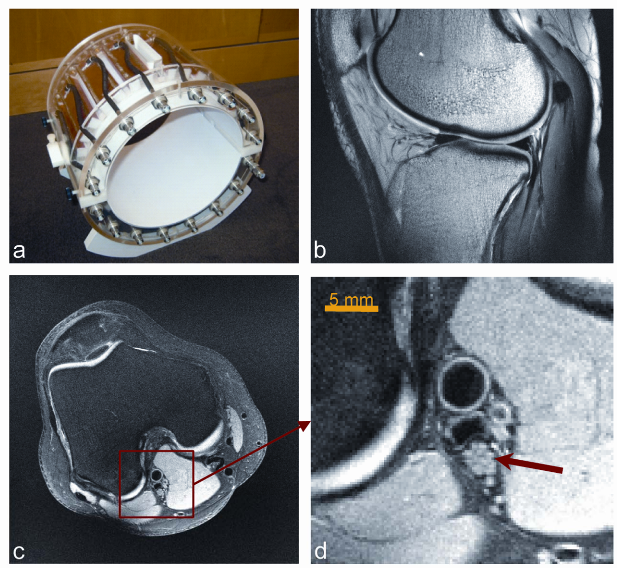

Figure 1 – Initial results in knee imaging at 7T. a) 16-element transmit/receive coil used for all knee images. b) An sagittal turbo spin echo (TSE) image . c) Axial TSE image with detail area shown in (d). The arrow in (d) shows the tibial nerve.

Results
Our preliminary studies of knee imaging at 7 T demonstrated high spatial resolution (Fig.1 and 2). The coil used for these acquisitions is illustrated in Fig1a. The high resolution imaging permits the depiction of tibial nerve internal organization (Fig.1). Epineurium lined bundles of nerve fibers are clearly seen within the perineurium enveloped tibial nerve, a 2.5 x 5 mm structure (Fig. 1d). There is high signal depicted in articular cartilage (Fig.1c) giving high contrast to noise and therefore differentiation between cartilage, synovial fluid and cortical bone based on contrast depiction. Fig. 2 illustrates a GRE image at 400µm isotropic resolution.

Conclusion
Initial results demonstrate that high resolution in knee imaging can be achieved taking advantage of the gain in SNR at ultrahigh magnetic field. However, B1-homogeneity is often compromised at high fields. To obtain homogeneous images across the whole knee B1-shimming is necessary. A dedicated multi-channel transmit/receive knee coil, in which the amplitude and the phase of the radiofrequency signal can be adjusted independently for each element, has been developed.

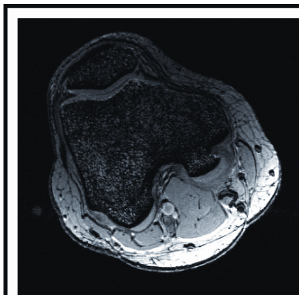
Figure 2 – Axial Slice from 3D gradient echo data set of the knee at the level of the patella

References and acknowledgments
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