Human extremity imaging using microstrip resonators at 7T

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Introduction:

MR imaging has been proven to be a promising imaging modality for studying the human extremities, and could become a robust tool to probe and gain better understanding of the biomedical basis in health and disease at the cellular and even molecular level (1,2). However, the insufficient SNR provided by the clinical MR systems limits the improvement of high spatial resolution imaging of the extremities in vivo. Ultrahigh field MRI has been proven to be advantageous due to its intrinsically high SNR although there are tremendous technical challenges in implementing the ultrahigh field MR in vivo, especially difficulties in respect to RF engineering. In this work, we present our preliminary results on human extremity imaging at a ultrahigh field strength of 7T using a variety of transmission line-type RF transceiver coils and coil arrays (3). High resolution anatomical images of human extremities obtained in this project further demonstrated the advantages of ultrahigh field MRI in human extremity imaging applications.

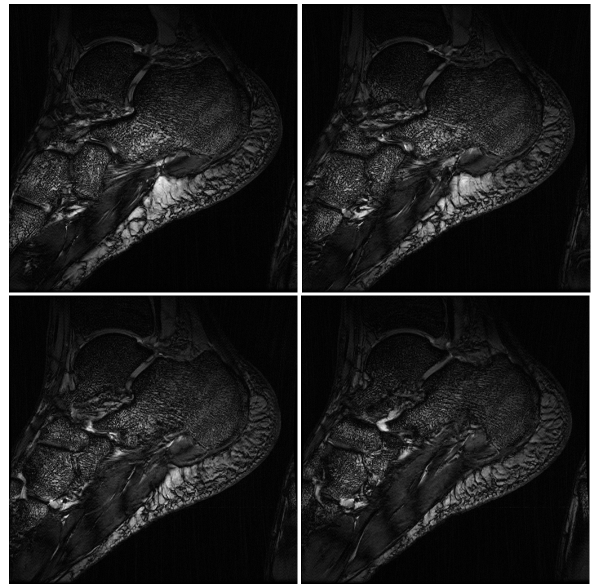

Fig 1. In-vivo human foot imaging with in-plane resolution of 0.27mm acquired using microstrip transceiver coil with a gradient recalled echo (GRE) sequence at 7T. Imaging parameters: TR 10ms, TE 2.8ms, flip 35^0, slice thickness 2mm, FOV 14cm x 14cm, matrix size 512 x 512, number of average (NEX) 1.

Method:

Various RF transceiver coils and coil arrays were designed and constructed using the transmission lines, e.g. microstrip transmission lines at 300MHz for 7T proton imaging. Due to the two-conductor structure, these types of coil provide excellent performance in terms of Q factors, reduced radiation losses and high frequency operation capabilities, and they are very suitable for ultrahigh field MR imaging applications. Gradient recalled echo (GRE) sequences and modified fully balanced steady state free precession (bSSFP) 3D sequence have been utilized and tested for acquiring high resolution human extremity images *in vivo*. All MR imaging experiments were performed on a GE 7T whole body MR system. All images were acquired with the transceiver developed in this project.

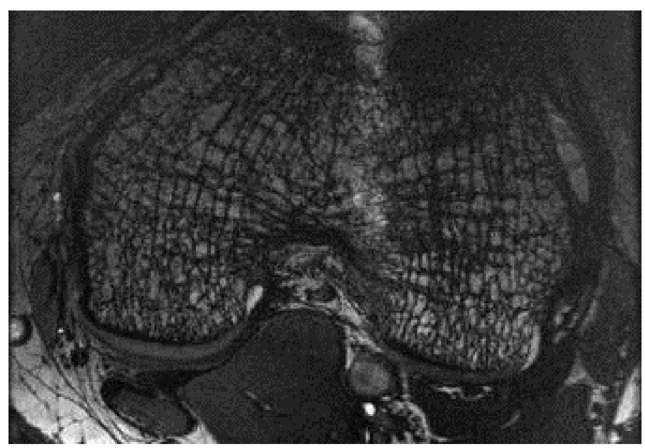

Fig 3. In-vivo human knee imaging with high isotropic resolution of 200µm acquired using a microstrip transceiver coil with a modified FIESTA 3D sequence at 7T. Imaging parameters: TR 13ms, TE 3.5ms, flip 40^0, number of average (NEX) 1. Excellent depiction of trabecular bone architecture.

Results and Conclusions:

By using the custom-designed RF transceiver coils, high resolution extremity images were acquired at 7T. Fig.1. shows in vivo 7T human foot images with an in-plane spatial resolution of 0.27mm x 0.27mm without averaging (i.e. NEX =1). By using the microstrip transceiver array and volume coils, human hand and wrist images were acquired as shown in Fig.2. In addition, we also acquired high resolution knee images. The knee image shown in Fig. 3 features a high isotropic resolution of 200um with only one average, show well the trabecular bone architecture. By using more averages, even higher resolution or SNR can be expected.

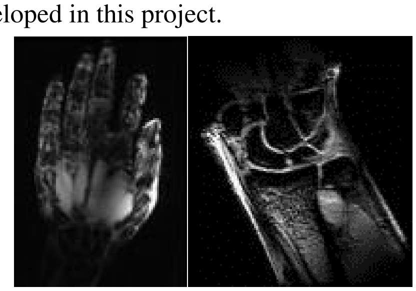

Fig 2. In-vivo human hand (left insert) and wrist (right insert) imaging acquired using a microstrip transceiver array and microstrip volume coil at 7T. Imaging parameters: SPGR sequence, TR 100ms, TE 6.9ms, flip 20^0, matrix size 256 x 256, number of average (NEX) 1, FOV 21cm x 21cm, slice thickness 3mm.

References:

1) F Wehrli, et al Radiology 1995, 196: 631-41; 2)T Link, et al, Radiology1998, 209: 531-6; 3)X Zhang, et al, MRM 2001, 46:443-450

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