Contrast-enhanced T1-weighted MRI of the Small Bowel at 7 Tesla in comparison to 1.5 Tesla

Maria Hahnemann[1,2], Oliver Kraff[2], Stefan Maderwald[2], Soeren Johst[2], Mark E. Ladd[2,3], Harald H. Quick[2,4], and Thomas Lauenstein[1]

[1]Department of Diagnostic and Interventional Radiology and Neuroradiology, University Hospital Essen, Essen, Germany, [2]Erwin L. Hahn Institute for Magnetic Resonance Imaging, Essen, Germany, [3]Medical Physics in Radiology, German Cancer Research Center (DKFZ), Heidelberg, Germany, [4]High Field and Hybrid MR Imaging, University Hospital Essen, Essen, Germany

Target audience: Scientists working at ultra-high field (UHF) MR imaging systems with interest in abdominal imaging.

Purpose: Magnetic resonance imaging (MRI) is playing an increasing role in the evaluation of inflammatory bowel diseases and other small bowel diseases, as tumors or bleedings.[1] Although 1.5T is still considered field strength of choice for MRI of the small bowel, improvements in image quality have been recently shown at 3T. [2] However, advantages are combined with challenges such as B1 inhomogeneities in 7T abdominal MR imaging, limited choice of sequences, SAR limitations,[3] which may appear as a limiting factor for high field strength MRI, especially in small bowel MR imaging.[4] The purpose of the present study is to implement contrast-enhanced MR imaging of the small bowel at 7T and to compare imaging results with the current standard field strength of small bowel MRI at 1.5T.

Methods: Twelve healthy volunteers prospectively underwent MR examinations on a 1.5T and 7T scanner. Small bowel was prepared with 1000 ml of an oral contrast fluid prior to each examination. Imaging at 1.5T (Magnetom Avanto, Siemens AG, Healthcare Sector, Germany) was performed using a combination of a body-array surface receive RF coil covering the whole abdomen/pelvis and an integrated spine array receive coil (total number of 12 RF coil elements). The 7T system (Magnetom 7T, Siemens Healthcare, Germany) was equipped with an eight-channel transmit-receive body RF coil and an add-on system for subject-individual static RF shimming. Coronal fat saturated T1w 3D spoiled gradient-echo sequence (FLASH; resolution 1.5T: 2.6×2.0×2.0 mm^3, 7T: 1.3x1.3x1.2 mm^3; TA 1.5T: 13 sec, 7T: 24 sec) non-enhanced, 20 s, 75 s and 120 s after intravenous contrast administration was applied, followed by a coronal and axial fat saturated 2D FLASH 180 s post injectionem (resolution 1.5T: 1.7×1.6×5.0 mm^3, 7T: 1.1x0.9x2.0 mm^3, TA 1.5T: 15 sec, 7T: 26 sec). Image quality was analyzed by visual evaluation of tissue contrast and detail detectability. In addition, signal difference between bowel wall and bowel lumen were measured and corresponding contrast ratios were calculated. Subjective ratings of image impairment due to artifacts were assessed at both field strengths.

Results:

Small bowel showed the typical high signal of the wall in contrast to the low signal of the lumen prepared by a dilating hydrosolution (Figure 1). Qualitative ratings regarding tissue contrast and detail accuracy revealed equal results between 7T and 1.5T. Quantitative measurements of signal intensity of bowel wall showed typical increase of intensity over time. Contrast between bowel wall and bowel lumen was equal in contrast-enhanced 3D FLASH, but significantly decreased in 2D FLASH at 7T compared to 1.5T due to an inverted image contrast and increase of signal intensity of the bowel lumen (Figure 2). In general, image quality was more impaired by artifacts at 7T compared to 1.5T, mainly due to susceptibility artifacts and B1 inhomogeneities. However, diagnostic images were achieved.

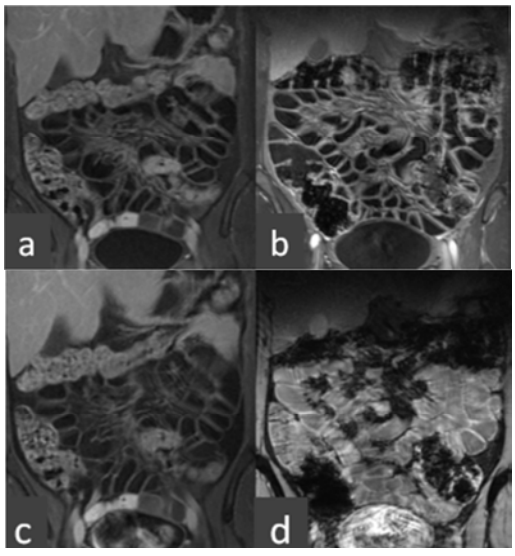

Figure 1 *Coronal 3D FLASH of the same volunteer 75 s after i.v. contrast administration at 1.5T (a) and 7T (b), and 2D FLASH 180 s after i.v. contrast administration at 1.5T (c) and 7T (d).*

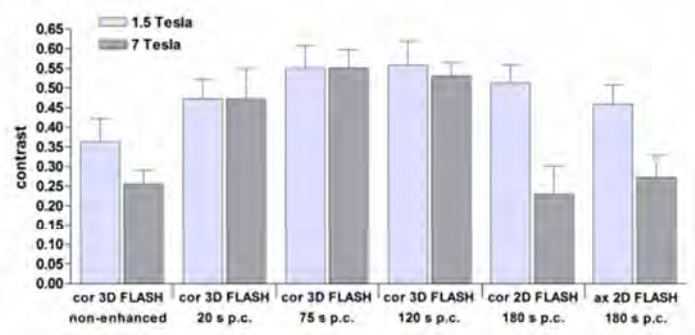

Figure 2 *Mean contrast between bowel wall and bowel lumen at 1.5T and 7T.*

Discussion & Conclusion: The present study demonstrates the possibilities and challenges of dynamic contrast enhanced MR imaging of the small bowel at 7T. MR imaging of the small bowel represents a promising new MR technique in the process of moving clinical applications towards higher field strengths. However, some challenging aspects and limitations at increasing field strengths remain. Investigations of larger cohorts with inclusion of patients with small bowel pathologies should be the focus of future studies to assess a potential diagnostic benefit of UHF MRI.

References:

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