7 Tesla MRI of the Female Pelvis

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Introduction

With the introduction of ultra-high field MR imaging at 7T, the initial interest has transitioned from neuro imaging and musculoskeletal imaging to whole-body investigations. First approaches in 7T whole-body MRI have recently been published (1,2), demonstrating the potential of ultra-high field imaging and the need for coil and sequence optimization. The aim of this study was to investigate the feasibility of 7 Tesla MR imaging of the female pelvis in humans, with optimization and implementation of a dedicated, clinically usable examination protocol utilizing a custom-built body coil and RF shimming.

Methods

Six healthy volunteers (average age: 28.7 years, range 26-33 years) were enrolled in this trial. Examinations were performed in supine position on a 7T whole-body MR system (Magnetom 7T, Siemens Healthcare Sector, Erlangen, Germany). For image acquisition, a custom-built 8-channel RF transmit/receive body coil was used, constructed of two arrays with 4 elements each placed ventrally and dorsally on the lower half of the abdomen. The examination protocol included (1) fat-saturated 2D FLASH sequences in transverse and sagittal views (TR/TE = 130/3.57ms, FOV 400 x 400 mm, flip angle 70°, BW 410 Hz/pixel, 13 slices of 2 mm thickness each, matrix 512 x 512, and an acquisition time of 31 sec), (2) a fat-saturated 3D FLASH sequence in sagittal view (TR/TE = 2.9/1.02 ms, FOV 400 x 400mm, flip angle 10°, BW 920 Hz/pixel, 27 slices of 1.6 mm thickness each, matrix 320 x 320, and an acquisition time of 27 sec), and (3) T2w TSE sequences in transverse and sagittal views (TR/TE = 3500/89 ms, FOV 400 x 262 mm, flip 150°, BW 246 Hz/pixel, 9 slices of 3 mm thickness each, matrix 384 x 252, and acquisition time of 81 sec). Conventional phase settings of the eight transmit channels (a 45° phase increment and a 90° phase increment) were compared to subject-specific RF shimming based on relative B1 maps obtained in vivo. The specific absorption rate (SAR) was calculated for the optimized phase settings. Visual qualitative image analysis was performed by two senior radiologists in consensus to compare the aforementioned sequences with regard to overall image quality using a 5-point scale (5 = excellent organ delineation, 4 = good organ delineation, 3 = moderate organ delineation, 2 = poor organ delineation, 1= non-diagnostic). Furthermore, the presence of artifacts including 1) B_1 inhomogeneities, 2) in-flow effects, and 3) overall image impairment was assessed using a three-point scale (3 = no artifact present or insignificant, 2 = moderate impairment, 1 = strong impairment).

Results

Via dedicated RF shimming, impairing artifacts and B1 inhomogeneities could be effectively reduced with only minor effect on the SAR limits. 2D (mean score 4.4) and 3D (mean 3.8) FLASH imaging provided highly defined delineation of anatomical structures, with 3D FLASH imaging being least impaired by artifacts (mean 1.9). Furthermore, T1w imaging yielded an inherently high signal intensity of the arterial vasculature, enabling reasonable assessment of non-enhanced pelvic vessels. T2 TSE imaging (mean 3.2) enabled a high-quality analysis of cystic structures such as bilateral ovarian cysts, which was an incidental finding (Figure 2).

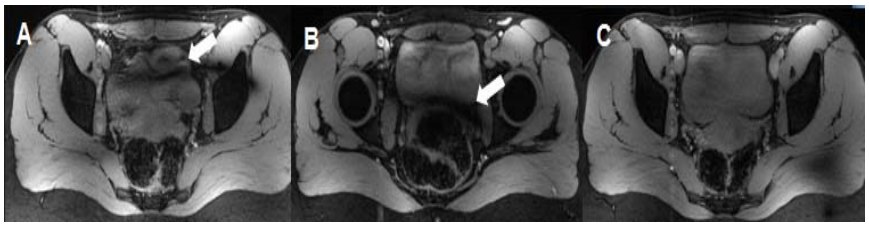

Figure 1: B_1 inhomogeneites within the region of interest after applying 45° phase increments (A, arrow), and 90° phase increments (B, arrow). Figure part C shows a more homogeneous image after dedicated RF shimming on the basis of individual B1 maps.

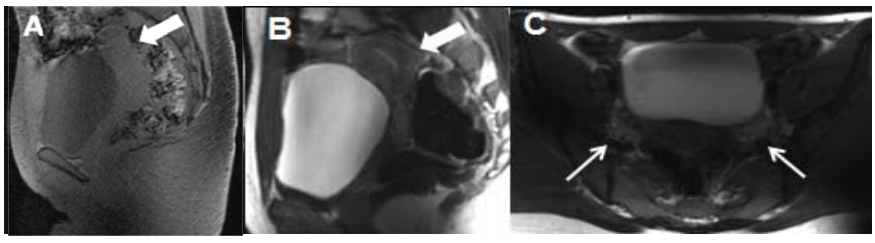

Figure 2: 3D FLASH (A) and T2w TSE (B) imaging in sagittal orientation with arrows pointing at the uterus. (C) shows a T2w TSE image in transverse view. Here, arrows point at bilateral ovarian cysts.

Discussion

This pilot study of dedicated 7 Tesla MRI of the female pelvis demonstrates the feasibility of in vivo ultra-high field pelvic imaging, providing good overall image quality and coverage. B1 inhomogeneities were successfully reduced with individual RF shimming. Not only gradient echo but also typical clinical and SAR-intensive sequences such as TSE performed quite well. Work is underway to assess patients with various pathologies.

References

1. Snyder CJ. Initial results of cardiac imaging at 7 Tesla. Magnetic Resonance in Medicine 2009; 61(3):517-524.
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