Abdominal MR Imaging at 3.0 T: The Combination of Parallel Radiofrequency Transmission and B1 Shimming Eliminates Patient-to-Patient Variations in Image Quality

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Introduction The integration of higher field magnetic resonance imaging (MRI) with clinically acceptable and consistent abdominal image quality has been challenging over the past three decades. Recently, parallel radiofrequency transmission (multitransmit, MTX) was introduced to fundamentally address the standing wave artifacts that are present at 3.0 T. MTX provides independent control over the RF frequency, phase, and amplitude of the transmit coil elements, allowing for B1 shimming. Initial clinical studies using commercially available MTX 3T systems that perform patient-specific B1 shimming have shown significant improvements in overall abdominal and pelvic image uniformity and quality relative to standard quadrature transmission image quality. To the best of our knowledge, to date no studies have been published that have utilized a combination of parallel radiofrequency transmission and patient-specific B1 shimming to eliminate the patient-to-patient variations in image quality in routine abdominal MRI at 3.0 T. Therefore, the purpose of this study is to see if parallel radiofrequency transmission and patient-specific B1 shimming can eliminate the patient-to-patient variations in the image quality of abdominal MRI at 3.0 T.

Materials and Methods Institutional review board permission was obtained for this study. Fifty-three consecutive liver patients (24 men, 29 women; mean age ± standard deviation, 50.4 ± 17.0 years) were imaged using quadrature transmission over a period of four weeks, while forty-six consecutive liver patients (25 men, 21 women; 51.8 ± 14.3 years) were imaged with MTX over a second four-week period. Abdominal imaging was performed with a 3T MR imaging system (Achieva 3T TX; Philips Healthcare, Best, The Netherlands). The prescribed MR imaging protocol for each patient included respiratory triggered (RT) T2-weighted single shot turbo spin echo (SSTSE) coronal and axial images, axial diffusion weighted imaging (DWI) with b=20 and b=500, and dual gradient echo in- and opposed-phase axial images. For the patients imaged without MTX, the b=500 series was added to the protocol after 31 patients had been imaged. Pre-contrast, post-contrast, arterial, and delayed phase breath hold (BH) axial 3D fat-suppressed TI-weighted gradient echo (eTHRIVE) images were obtained, with contrast bolus triggering performed using an MR fluoroscopic sequence (BolusTrak, Philips Healthcare). Post contrast images also included a respiratory-triggered multishot TSE T2-weighted fat-suppressed delayed phase images were obtained, with contrast bolus triggering performed using an MR fluoroscopic sequence (BolusTrak, Philips Healthcare). Post contrast images also included a respiratory-triggered multishot TSE T2-weighted fat-suppressed (FS) set of axial images. For the MTX patients, B1 shimming was performed per patient at the beginning of the study to optimize the phase and amplitude of the dual body coil transmit channel. Sensitivity encoding (SENSE) was utilized in all imaging sequences. The typical imaging parameters such as the Field-of-View (FOV) and/or the number of slices were adjusted to provide adequate coverage of anatomy for each patient. BH time was typically 22 seconds or less. An experienced abdominal MR radiologist scored each imaging sequence in a random order on a digital viewing station (Mckesson, San Francisco, USA). The radiologist had only access to the patient's medical record numbers to load the MRI exams. The radiologist did not have access to the clinical or ordering information. There were no image identifiers that explicitly mentioned the imaging methodology. Each MRI exam was digitally loaded and the individual images were evaluated based on an image quality (IQ) scale that varied between 1 and 5 (1= unacceptable; 2= poor; 3= fair; 4= good; and 5= excellent). The mean and standard deviations were calculated for the patients imaged without MTX, the b=500 series was added to the protocol after 31 patients had been imaged. 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