Breast-MRI at 3T and 7T in patients and healthy volunteers: Diagnostic accuracy, SNR and B1+-homogeneity.

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INTRODUCTION: Magnetic resonance imaging (MRI), in particular, dynamic contrast-enhanced (DCE) MRI of the breast is an important clinical tool for detection and characterization of breast lesions. In the last years high field MR systems have become available in clinical routine (3T) and for clinical research (7T). They offer increased SNR which can be used to increase spatial and/or temporal resolution. On the other hand, increased B1-inhomogeneities may hamper the advantages of high field strengths [1-3]. In this study, diagnostic accuracy and SNR in different regions of the breast were evaluated in the same 24 patients at 3 and 7T. In addition, B1+-maps of five healthy volunteers were measured at both field strengths.

MATERIAL AND METHODS: All experiments were performed at 3T and 7T MRI systems (3T Trio, 7T Magnetom, Siemens Healthcare, Erlangen, Germany) using dedicated bilateral breast coils with four 1H-channels (3T: In vivo, Orlando, FL, USA; 7T: 1H/31P-coil, H. Stark, Erlangen, Germany). 24 patients (57±17yo) were measured at both field strengths within one week. Inclusion criteria for enrollment in this study were: 18 years or older; not pregnant or breastfeeding; presented with an abnormality at mammography or ultrasound (asymmetric density, architectural distortion, suspicious microcalcifications, or breast mass classified according to BI-RADS category 0 or 4-5); no previous treatment; and no contraindication to MR imaging or contrast agents. In pre-menopausal women, MRI was performed between day 7 and 14 of the menstrual cycle. For DCE-MRI, a T1-weighted 3D sequence (time-resolved angiography with stochastic trajectories [TWIST]) with high temporal (14s at 3T and 7T) and spatial resolution (isotropic resolution of 1.1×1.1×1.1 mm^3 at 3T and 0.7×0.7×0.7 mm^3 at 7T) and fat suppression was used (TE/TR=2.84/6.01ms at 3T, TE/TR=2.5/4.75ms at 7T, 144 slices at 3T and 176 slices at 7T, same TA=9min, same flip angle, same FOV 196 x 330 mm^2, matrix 266 x 449; one average; center k-space region with full reacquired 23%; reacquisition density of peripheral k-space 20%; temporal interpolation factor 2). Gd-DOTA (Gadoterate meglumine; Dotarem®, Guerbet, France) contrast agent (CA) was injected intravenously as a bolus (0.2 ml per kilogram body weight) after three baseline images. In addition, B1+-maps were measured in five healthy volunteers (32±9 yo) at both field strengths using a 2D Turbo FLASH (TE=2.31/1.97ms at 3T/7T; TR=6s; Bandwidth 490Hz/px; in plane resolution 2.5 mm; slice thickness 10mm (10 slices); FOV=320mm^2.

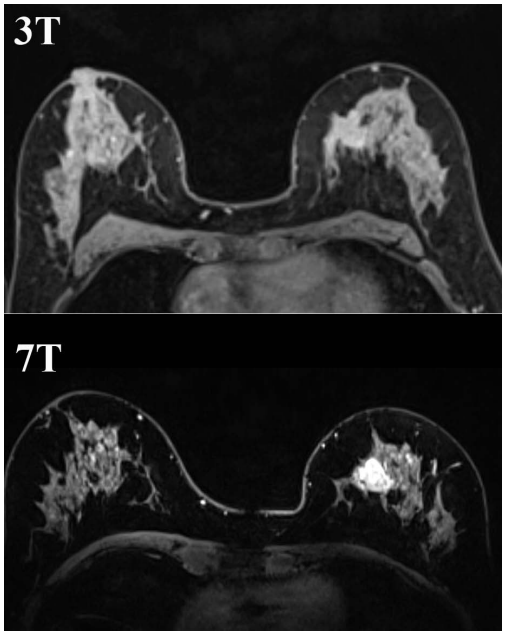

Fig.1: 52-year-old female patient with an invasive ductal carcinoma (IDC/G3) at 3T (top) and 7T (bottom).

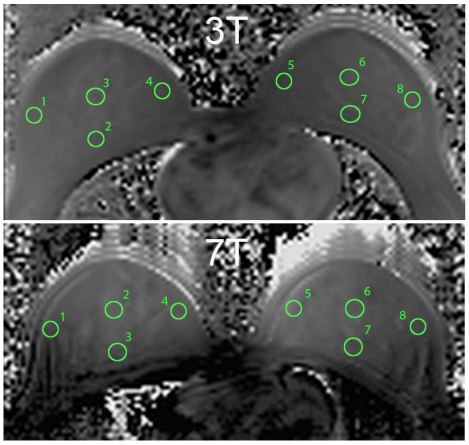

Fig. 2: B1+-maps at 3T (top) and 7T (bottom). The following regions were evaluated (green circels): 1. lateral, 2. prepectoral, 3. central , 4. medial.

RESULTS: Twenty-eight lesions (i.e., 16 malignant, 12 benign) were identified in 24 patients 57±17 years old (mean age±SD). Of these, two patients had two malignant lesions each, and one had three benign lesions. There were 26 mass-enhancing and two non-mass-enhancing lesions. With the high spatial isotropic resolution of 0.7 mm at 7T, images with more detailed information could be acquired when compared to those acquired at 3T (see Fig.1). Sensitivity was 94% and 100%, at 3T and 7T, respectively. Specificity was 92% at both field strengths. The contrast at 7T was 48% and 71% higher than at 3T for benign and malignant lesions, respectively (p=0.02). An SNR decrease toward prepectoral breast regions was observed at both field strengths, but was stronger at 7T (51%) than at 3T (19%)(p=0.0002). In healthy subjects B1+ was estimated in the center, prepectoral, lateral, and medial region (see Fig. 2). At 3T there was no drop of B1+ in the prepectoral and lateral region compared to the center region. In the medial region B1+ dropped for 16,3% compared to the other regions (p<0.05). At 7T B1+ dropped 20.7% in the prepectoral region (p<0.05), and 32.8% in the lateral region compared to the center regions.

CONCLUSION: Our study shows that breast DCE-MRI is feasible at 7T with high spatial resolution and comparable diagnostic accuracy as at 3T. SNR dropped 19% and 51% toward the chest (prepectoral region) at 3T and 7T. This may hamper the diagnostic accuracy of DCE-MRI at high magnetic fields depending on the location of the lesion in the breast. On the other hand we did not find B1+ reduction in the prepectoral region compared to the central region at 3T. At 7T B1+ dropped 12.5% in the prepectoral region compared to the central region of the breast. The transmit (B1+) inhomogeneities between central and prepectoral regions do not (3T) or only partly (7T) explain the SNR drop towards the chest wall. This promises further improvements in high-field breast MRI with advanced B1+ shimming technology provided by multi-transmit hardware..

References: 1. Umutlu et al., Academic Radiology 2010;17:1050-6; 2. Korteweg et al., Investigative Radiology 2011;46:370-6; 3. van de Bank et al. Investigative Radiology 2011 Jun;46(6):370-6

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