

MR Mammography at 7 Tesla: Preliminary Results

L. Umutlu^{1,2}, S. Maderwald^{1,2}, O. Kraff^{1,2}, J. M. Theysohn^{1,2}, S. Kuemmel³, E. A. Hauth^{1,2}, M. Forsting^{1,2}, G. Antoch^{1,2}, M. E. Ladd^{1,2}, H. H. Quick^{1,2}, and T. C. Lauenstein^{1,2}

¹Department of Diagnostic and Interventional Radiology and Neuroradiology, University Hospital Essen, Essen, NRW, Germany, ²Erwin L. Hahn Institute for Magnetic Resonance Imaging, Essen, NRW, Germany, ³Department of Gynecology and Obstetrics, University Hospital Essen, Essen, NRW, Germany

Introduction

Within the last three decades, contrast-enhanced magnetic resonance breast imaging has gone through substantial developments, evolving to become the imaging modality with the highest sensitivity for breast cancer detection. 1.5 Tesla (T) MR mammography is considered to be the current clinical standard. After overcoming RF-related limitations of SAR and higher susceptibility effects, recent studies have demonstrated the higher image quality of highfield MR mammographies in comparison to 1.5 T imaging. The aim of this study was to establish a specific MR mammography protocol for a 7 T whole-body MRI system and compare the first ultra highfield breast imaging results with standardized clinical 1.5 T MR mammography.

Methods

10 healthy subjects and 10 patients with breast cancer were enrolled in this study. All subjects were examined on a 7 T whole-body MRI system (Magnetom 7T, Siemens Healthcare, Erlangen, Germany) and a 1.5 T MR system (Magnetom Espree, Siemens Healthcare, Erlangen, Germany) within 48 hours. For imaging of a single breast at 7 T, a unilateral linearly polarized (LP) 10-cm-diameter single-loop transmit / receive coil (Rapid Biomedical, Wuerzburg, Germany) was used.

The examination protocol for 7 T imaging included 1) T2-weighted TSE sequence: TR/TE = 15000/147 ms, FOV 180 x 107 mm, flip 150°, BW 198 Hz/pixel, 35 slices, ETL 15, matrix 320 x 191 interpolated to 640 x 382, resulting in an uninterpolated in-plane resolution of 0.56 x 0.56 mm², a slice thickness of 2 mm, and an acquisition time of 5:32 min; 2) 6 dynamic T1-weighted spoiled gradient-echo sequences (3D FLASH): TR/TE = 5/1.21 ms, FOV 156 x 156 mm², flip 10°, BW 960 Hz/pixel, 160 slices, matrix 192 x 192 interpolated to 384 x 384, resulting in an uninterpolated in-plane resolution of 0.81 x 0.81 mm², a slice thickness of 0.81 mm, and an acquisition time of 1:39 min per measurement. The 3D T1-weighted sequence was acquired before (measurement 1), during (measurement 2) and after (measurements 3-6) the i.v. administration of a gadolinium-based contrast agent (Gadobutrol, Bayer Schering Pharmaceuticals, Germany) with a dose of 0.2 mmol/kg body weight.

For the 1.5 T examinations a standard circularly polarized (CP) bilateral breast coil (Siemens Healthcare, Erlangen, Germany) was used for imaging. The standardized clinical protocol included the same sequence types as for the 7T examination. Subtraction images were generated both at 1.5T and 7T. Each sequence at 1.5 T was correlated with the corresponding 7T data regarding image quality including signal homogeneity, signal penetration depth, and depiction of anatomical structures.

Results

T1-weighted imaging at 7 T could be obtained at a higher spatial resolution with shorter acquisition times, providing higher image accuracy and conclusively a better delineation of small anatomical structures (Fig. 1, 2). After the intravenous administration of gadolinium, the correlation of the contrast enhancement of suspicious lesions revealed a stronger enhancement and superior conspicuity of the tumor lesions at 7 T. Even smaller satellite lesions could be depicted at 7 T that were not seen at 1.5 T. T2-weighted imaging could also be obtained with a higher spatial resolution at slightly longer acquisition time. However, a gain in clinical diagnostic value could not be established. Due to coil limitations, 4 out of the 17 highfield MR mammographies showed decreased diagnostic value (Figure 3).

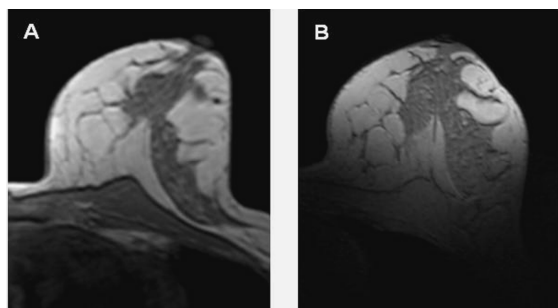


Fig. 1: T1w pre-contrast imaging, showing the higher image accuracy and better delineation of small anatomical structures at 7T (B) over 1.5 T(A).

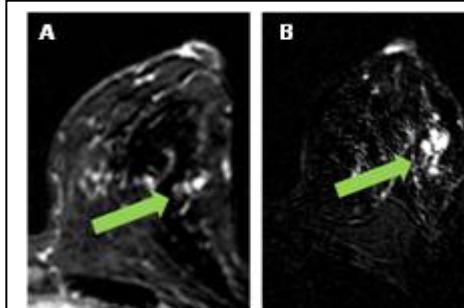


Fig. 2: T1w subtraction imaging, demonstrating the better delineation of a tiny malignant lesion in the 7T mammography (B) than at 1.5 T (A).

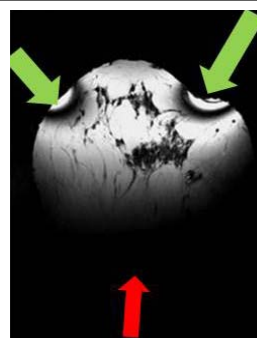


Fig. 3: Coil-related limitations:1] signal voids due to flip angle inhomogeneities near coil surface (green arrows) 2] inhomogeneous signal penetration decreasing the assessment of the chest wall regions of the breast as well as the axilla (red arrow).

Discussion

Our study demonstrates the feasibility and high diagnostic potential of ultra highfield MR mammography. The higher SNR could be successfully transformed into higher spatial resolution at high temporal resolution, revealing highly detailed anatomical and pathological features. However, the implementation of further advanced bilateral coil concepts is needed to circumvent current coil-related limitations, including suboptimal penetration depth, SAR limitations, and the inability to perform parallel imaging.

References:

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