Feasibility of contrast-enhanced and high resolution MR-imaging in patients with suspicious breast lesions at 7 Tesla.

Bertine L. Stehouwer[1], Dennis W.J. Klomp[1], Peter R. Luijten[1], Karel A.F. Houwert[2], Paul J. van Diest[3], Willem P.Th.M. Mali[1], Maurice A.A.J. van den Bosch[1], and Wouter B. Veldhuis[1]

[1]Radiology, University Medical Center, Utrecht, Utrecht, Netherlands, [2]Radiology, Zuwe Hofpoort Hospital, Woerden, Utrecht, Netherlands, [3]Pathology, University Medical Center, Utrecht, Utrecht, Netherlands

Introduction 7T breast MRI offers new diagnostic possibilities that have the potential to improve the staging of breast cancer patients. For instance the ability to study phase-related changes for the detection of calcifications or ultra-high resolution imaging for improved morphology assessment. However, higher field strengths are also associated with limitations[1], such as increased B_1-field inhomogeneity, which may interfere with the interpretation of enhancement kinetics that is central to the currently achieved diagnostic accuracy at lower field strengths[2]. The purpose of this study is to assess the feasibility of 7T contrast-enhanced breast MRI using a sensitivity optimized RF coil setup and its amenability to BI-RADS-MRI conform analysis.

Materials & Methods 18 women with 21 suspicious breast lesions on mammography or ultrasound were included; BI-RADS IV (n=4), and BI-RADS V (n=14). MRI was performed on a 7T whole-body scanner (Philips Health Care, Cleveland, USA) using a two-channel unilateral RF breast coil. Patients were placed in prone position with the breast coil positioned below the breast of interest. The protocol included a dynamic series consisting of 7 consecutive 3D T1w turbo field echo sequences with fat suppression [TR/TE 5.0/2.0ms, binominal FA 20°, FOV 160x160x160mm^3, acquired res. 1mm isotropic, temp. res. 63s]; and a high resolution T1w 3D Fast Field Echo SPAIR sequence [TI 120ms, TR/TE 7.0/2.9ms, FA 12°, FOV 120x120x120 mm^3, acquired res. 0.45x0.57x0.45 mm^3]. During the dynamic series 0.1mmol/kg Gadobutrol was administered. Two experienced Breast MRI radiologists scored the exams without clinical information. First, the dynamic series was assessed for image quality using a 4-point scale: insufficient, sufficient, good and excellent. Also, presence of MRI artefacts, B_1-field inhomogeneity and insufficient fat-suppression were scored as 'no', 'a little' or 'a lot' including whether this influenced image assessment or not. Next, all detected lesions were scored according to the ACR BI-RADS-MRI criteria. In patients with multiple lesions, a separate form was filled out for each lesion. The high-resolution images were similarly assessed for image quality, artifacts, B_1-field inhomogeneity and fat-suppression. The additional value of these images was assessed using the options: None; Increased reader confidence; Change in interpretation; or Additional value for other reasons. MRI-results were compared to histological outcome. Only pathologically-proven lesions were included in further analysis.

Results Figure 1 shows a representative case. In the quality assessment of the dynamic series, in 3 cases at least one of the radiologists found the artifacts to influence image assessment. B1-inhomogeneity influenced image assessment according to at least 1 of the radiologist in 6 cases. Inhomogeneous fat-suppression was scored to influence image assessment in 5 cases. In one other case no fat-suppression was applied due to technical reasons. Image quality of the dynamic series was scored sufficient (n=8/8, radiologist 1/radiologist 2), good (n=9/10), with one case scored excellent by one radiologist. All 18 biopsy-proven malignant lesions were detected by both radiologists. BI-RADS-MRI descriptors of these lesions are shown in Table 1. The first radiologist scored 1 large biopsied lesion as 2 separate entities and in another case, 2 separately biopsied lesions as 1 which results in 18 lesions in total. The second radiologist scored the same large lesion as one. Another case, with 3 biopsied lesions, he scored as 2 lesions with spiculations. Therefore he scored 16 lesions in total.
High-resolution images were obtained in 15 patients. They showed great detail of the lesions morphological features. For one case, artifacts negatively influenced image assessment for one radiologist. In one other case one radiologist deemed the B1-inhomogeneities to influence image assessment. Image quality of the final high-resolution sequence was scored sufficient (n=1/0), good (n=2/9) and excellent (n=12/6). The additional value of this sequence was increased reader confidence (n=13/9 cases). Moreover, in 3 cases for one radiologist and in 5 cases for the other, the radiologist changed his interpretation of BI-RADS-MRI descriptor(s). Histological outcome is shown in Table 1.

BI-RADS-MRI descriptor		No.	No.
Mass		**17**	**15**
Shape	Oval	0	2
	Lobular	0	2
	Irregular	17	11
Margin	Smooth	1	0
	Irregular	8	9
	Spiculated	8	6
Enhancement	Homogeneous	0	1
	Heterogeneous	15	10
	Rim enhancement	2	4
Non-mass		**1**	**1**
Distribution	Ductal	1	0
	Multiple regions	0	1
Internal Enhancement	Clumped	1	1
Kinetics Mass+Non-mas		18	16
Curve, initial phase	Rapid		
Curve, delayed phase	Plateau	1	0
	Washout	17	16
BI-RADS-MRI Classification	4	1	1
	5	17	16
Histology	Ductal carcinoma	13	
	Lobular carcinoma	2	
	Ductulolobular carcinoma	3	

Table 1; BI-RADS-MRI desciptors, -classification and histopathology results.

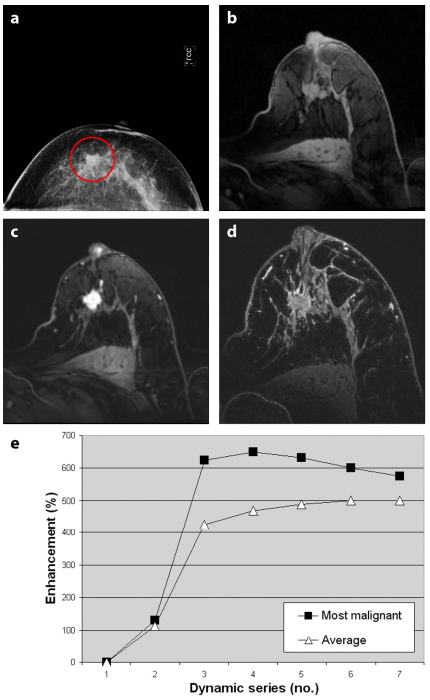

Figure 1
X-ray mammography and 7T CE-MRI results obtained from a 62 year old patient.

a) X-ray mammography (Cranio-Caudal view, rotated to correspond to the MRI orientation), showed a BI-RADS V lesion (circle).

b) Pre-contrast T1 weighted MRI (voxel size 1x1x2mm3) showed a irregular mass.

c) After administration of contrast agent the mass showed heterogeneous enhancement (T1w imaging, voxel size 1x1x2mm3).

d) High resolution T1w SPAIR (voxel size 0.45 x 0.45 x 0.57mm3) showed good fat suppression and fine morphological details.

e) The most malignant curve (squares) showed a rapid initial rise, followed by a plateau in the delayed phase. The average curve showed a similar "type-2" pattern (triangles).

Conclusion
In conclusion, the technical feasibility, sufficient, good or excellent image quality and amenability to BI-RADS-MRI conform analysis allows for future individual comparison between 7T and 3T MRI. Furthermore, the true potential of high field breast imaging may be explored while providing BI-RADS conform diagnoses at 7T at the same time.

Reference [1] Umutlu et al. Dynamic contrast-enhanced breast MRI at 7 Tesla utilizing a single-loop coil: a feasibility trial. [2] Kuhl et al. Effect of B1 inhomogeneity on Breast MR Imaging at 3.0T.