Quantitative DCE Analysis for Breast Imaging: The Benefit of Dixon Fat-Water Separation in an ultrafast TWIST-VIBE Protocol

Elisabeth Weiland[1], Sandra Peter[2], Dominik Nickel[1], Rolf Janka[2], Michael Uder[2], and Evelyn Wenkel[2]
[1]*MR Application Developement, Siemens Healthcare, Erlangen, Germany,* [2]*Radiology, University of Erlangen, Germany*

Target audience: Scientists and clinicians interested in novel approaches of dynamic contrast enhanced breast imaging for screening and diagnostics.

Propose: Standard dynamic contrast enhanced (DCE) breast MRI is typically performed in around five minutes with a temporal resolution of one to two minutes[1]. Additional diagnostic information in DCE breast MRI might be achievable by applying techniques with high temporal resolution below five seconds in the initial phase of the contrast medium (CM) wash-in[2], thus facilitating the option to implement MRI in a screening program[3]. View sharing techniques allow the reconstruction of highly time resolved phases. Combined with Dixon methods, excellent fat-water separation[4] can be obtained even though the dual-echo acquisition extends the minimal repetition time in a GRE sequence compared to a conventional single-echo acquisition and therefore might affect kinetic accuracy. In this study we evaluated the potential of the Dixon technique in a prototypical ultrafast TWIST (Time-resolved imaging With Interleaved Stochastic Trajectories) VIBE (Volumetric Interpolated Breath-hold Examination) sequence to differentiate between benign and malignant lesions using the initial phases of the CM wash-in.

Methods: 32 women (mean age 49.8 years) underwent breast MRI on a 3 Tesla scanner (MAGNETOM Verio Dot, Siemens Healthcare, Erlangen, Germany) using a 16 channel bilateral breast coil. An ultrafast non-product TWIST-VIBE sequence with Dixon fat-water separation[4] was added to a conventional dynamic scan and inserted directly after the administration of the contrast medium (CM). Imaging parameters included: 0.9 x 0.9 x 2.5 mm^3/voxel, 4.9 s/phase, 17 phases, FA 15°, TR/TEs 5.64/2.46/3.69 ms. Overall this measurement scenario allows to compare conventional evaluation of DCE breast exams directly with the new approach based on data acquisition with high temporal resolution.
All lesions were evaluated under the precondition that they were contrast enhancing masses and either histopathologically verified or stable on long-term follow-up. The enhancement curves of the CM uptake were analyzed on water-only images using the non-product software TWIST Breast Viewer (Siemens Healthcare, Erlangen, Germany). Maximum slope (MS) of the relative enhancement and time-to-enhancement (TTE) of mass lesions were derived from the region of interest, containing the maximum lesion enhancement. MS was defined as the maximal slope between three proximate time points, TTE was deduced from the time when the relative enhancement in the ROI surpassed 30%, relative to the enhancement time in the aorta. ROC analysis was performed for MS and TTE.

Results: A total of 37 mass lesions were evaluated (16 benign, 21 malignant). All mass lesions seen on the conventional dynamic sequence were also detected on the in-phase and water-only images of the TWIST-VIBE protocol. A representative case of an invasive carcinoma is depicted in Figure 1 showing the last contrast enhanced phase of the water-only images with correspondent time curve. Both MS and TTE yielded a good differentiation between malignant and benign mass lesions (Figure 2: MS: 0.914 AUC, TTE: 0.902 AUC, both $p < 0.001$).

Discussion: Although our data pool is limited, the diagnostic performance of MS is encouraging and corresponds to results from TWIST measurements[2]. Further patient measurements are ongoing and will improve the statistical significance of our results. A strong superior classification potential of MS over TTE has been reported earlier[5], which we do not see in our preliminary results. The different TTE performance might be partly related to the different TTE calculation methods applied and to the different data pools. As all included lesions are clearly visible on both in-phase and water-only images, a combined analysis might lead to additional morphologic information, regarding e.g. fat and glandular structures.

Conclusion: We demonstrated the benefits of fat-water-separation based on the Dixon method for the quantitative evaluation of contrast kinetics of the first minute after contrast administration. Due to its short acquisition time and its robust image quality, the application of exams with high temporal resolution during the wash-in phase of the contrast agent may be beneficial for MR-based breast screening.

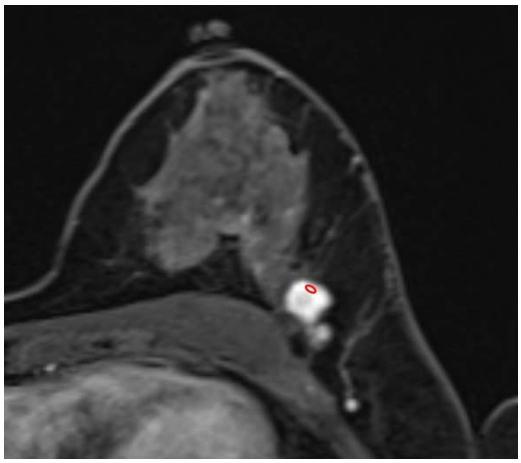

Figure 1: 51-year old woman presenting histopathologically verified invasive carcinoma: Last contrast enhanced phase of water-only images (left) with correspondent time curve of the ROI (right).

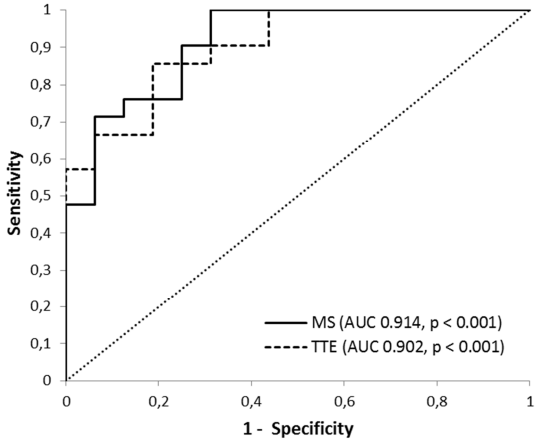

Figure 2: ROC curves of MS and TTE with respective AUC values and probability.

References:
1. Mann et al, Eur Radiol. 2008;18(7):1307-1318. 2. Mann et al, Invest Radiol 2014;49:579-585. 3. Kuhl et al, J Clin Oncol 2014; 32:2304-2310.
4. Lee et al, JMRI, 2013;38:1033-1042. 5. Platel et al, IEEE Trans Med Imaging. 2014;33(2):225-32.