BreastVIEW: Isotropic 3D High Resolution T2-weighted Breast Imaging at 7T

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INTRODUCTION

The Breast Imaging Reporting and Data System (BI-RADS) Lexicon for MRI utilizes standardized terminology to describe the morphologic characteristics of abnormal breast findings to facilitate characterizing their appearance as malignant versus benign. These MRI descriptors currently include mass shape, margin, and internal enhancement characteristics. Prototypical malignant masses display an irregular shape with irregular or spiculated margins. Benign masses, such as fibroadenomas or cysts, will often display a round or oval shape with smooth margins. The ability to accurately classify lesion margins with improved resolution and decreased edge smoothing will ultimately allow for better diagnostic recommendations. Ultra-high field MRI offers the promise of increased image SNR and concomitant higher spatial resolution. Confounding these advantages however, decrease in tissue T_2 at higher field results in increased blurring, especially for T_2-w 3D TSE sequences which rely on long echo trains. Modulated refocusing echo trains that reach a pseudo steady state (PSS) generate signal plateaus that remain relatively constant even for long refocusing trains. This results in sharper point spread functions (PSF) and decreased blurring [1,2]. Optimal refocusing modulation is achieved if the calculation of PSS takes into account the tissue-specific T_1 and T_2. We present high-resolution isotropic 3D T_2-weighted breast imaging at 7T with improved edge detection achieved by this approach, with evaluation of image quality by breast radiologists.

METHODS

This study was performed on a 7T scanner (Philips Medical) equipped with a custom-built breast quadrature coil capable of forced current excitation (FCE) [3-5]. The coil consists of a Helmholtz pair (i.d. 16 cm, spacing 8.0 cm) driven in FCE-mode, and, orthogonal to that, a saddle-coil pair (diameter 15.3 cm, length 8.7 cm, aperture 120°) also driven in FCE. The Helmholtz and the saddle pairs were driven in quadrature. Five volunteers were scanned under a protocol approved by the local IRB. Optimizing the refocusing angle train was performed using the approach to PSS as described by Busse et al. [1]. For the tissue-specific optimization, we focused on optimizing the PSF for breast parenchyma which, at 7T, has a reported T_1 = 2265 ms and T_2 = 35.5 ms [6]. The optimized 3D TSE sequence (3D BreastVIEW) was acquired with FOV 180×140×120mm, resolution 1×1×2mm, sagittal, TR 2.5 s, no fat suppression, echo spacing 4.6 ms, linear profile order, DRIVE, flow compensation set to sensitized, echo train 113 (train duration 553 ms), six startup echoes, α_{min} 15°, α_{center} 80°, α_{max} 120°, TE 240 ms (TEplateau = 249 ms; TEequivalent = 49 ms), for a total acquisition time of 2:32 min. Figure 1 shows the refocusing echo train and its corresponding signal for BreastVIEW. The inset in figure 1 shows the expected point spread function based on the signal decay during the echo train. High-resolution BreastVIEW was also acquired, with isotropic resolution of 0.7×0.7×1.4mm (reconstructed over-contiguous to 0.7mm), with train 139 (train length 719 ms, echo spacing 4.9 ms), α_{min} 20°, α_{center} 100°, α_{max} 120°, for a total acquisition of 4 min. Image quality from the five volunteers was scored independently by two radiologists, using a scale of 1-3 (1: non-acceptable, 2: acceptable, 3: excellent). The following criteria were ranked: margins, contrast, artifacts, and overall diagnostic quality. High-resolution BreastVIEW were also marked as to whether their SNR was sufficient for diagnosis.

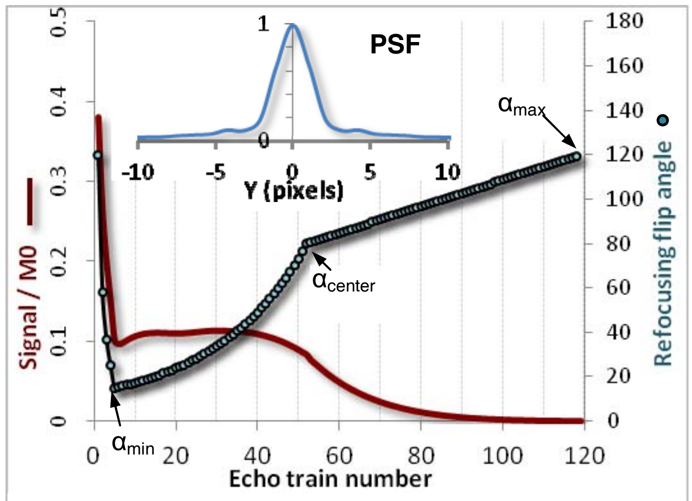

Figure 1. BreastVIEW signal (in red) as a function of the refocusing echo train (in blue circles) A distinct plateau lasting approximately till k=0 is observed. **Inset:** PSF of BreastVIEW.

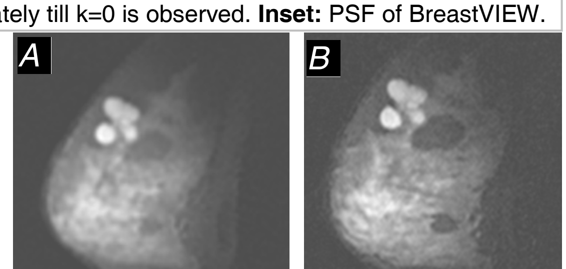

Figure 2. ***(A)*** 7T BreastVIEW images show good cist conspicuity, excellent parenchymal margins, and partial fat suppression. ***(B)*** High-resolution (0.7mm isotropic) BreastVIEW is judged to have sufficient SNR for clinical diagnosis.

RESULTS AND DISCUSSION

Image scoring by the radiologists resulted in BreastVIEW being judged to be between acceptable and excellent (2.2), with the margins being judged to be acceptable (2.0) The level of artifacts were negligible for all volunteers, and the high-resolution BreastVIEW were judged to have SNR sufficient for clinical diagnosis. It was noted that the sequence displayed some intrinsic fat suppression (as compared to a standard 2D TSE), the reasons of which are under investigation. Figure 2 shows excellent margin sharpness resulting from the narrow PSF.

References: [1] Busse R., et al., *MRM* 55: 1030–1037, 2006. [2] Busse R., et al., *MRM* 60: 640–649, 2008. [3] McDougall M.P., *Proc. IEEE EMBS 30th Annl. Conf.*, 2043-2046, 2008. [4] Wright S.M., et al., *Proc. ISMRM* 19, 3847, 2011. [5] Rispoli J., et al., *Proc. ISMRM* 20, 2635, 2012. [6] Haddadin I.S. et al., *NMR Biomed* 22: 65–76, 2009.