TrueFISP Blade Imaging in the Steady State (TrueBLISS)

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Introduction: Trajectories with variable readout directions, like radial have advantageous motion and flow properties. Blade Imaging, or freely rotating keyhole strategies, such as RUKSE[1] and PROPELLER/BLADE[2] also have significant oversampling of low spatial frequencies. This feature can be used to either correct or de-emphasize inconsistencies across data segments. For example, PROPELLER has been mainly advocated in Turbo-Spin-Echo (TSE) head imaging following stroke or in patients with tremor. However, the self-correction features of blade imaging have direct applications beyond head imaging. Interventional MRI techniques, such as catheter tracking and intravascular imaging must also contend with physiological and bulk motion despite the use of rapid SSFP sequences. Therefore, this work proposes Blade Imaging in the Steady State (BLISS) with TrueFISP magnetization preparation (TrueBLISS). TrueBLISS will have the same self-correction opportunities as other blade imaging techniques and will achieve the highest SNR in the shortest time with T_2 consistency across the blades. TrueBLISS demonstrates expected image contrast and low artifact levels in the abdomen of an asymptomatic volunteer.

Materials and Methods: A rectilinear TrueFISP sequence on a Siemens 1.5T Sonata imager (Siemens Medical Solutions. Erlangen, Germany) was modified to form rotating blades of K-space coverage, as in RUKSE and PROPELLER. The blade parameters were: 256 samples per view, 21 views per blade and 19 blades per acquisition with angular spacing of 9.5°. Key imaging parameters were: TE/TR 3.1/6.1ms, FOV $(300mm)^2$, Slice 5mm, NSA 1, Flip Angle 70°, Dwell Time 6.9 µsec. To validate the reconstruction, simulated data from a uniform circular disk were created using ideal BLISS and Cartesian trajectories. All gridding and density compensation was done in Matlab (Mathworks, Nattick, MA) via the Jackson method for convolution gridding[3]. An axial slice in the abdomen of an asymptomatic volunteer was collected for offline reconstruction with the TrueBLISS sequence.

Results: Figure 1 shows the output of a simulated disk phantom with a radius of 25% of the FOV using a Cartesian (1a) and BLISS (1b) trajectory. Note that the Cartesian simulation was not gridded. The circularly symmetric modulation of amplitude for the simulated BLISS data, which is only visible with a narrow windowing of gray level about the expected value, is due to the reconstruction. Figure 2 shows the (4 channel, sum of squares combined) result obtained with BLISS in the abdomen of an asymptomatic volunteer. Contrast appears normal for TrueFISP and any artifacts in the BLISS images do not obscure key structures such as the kidneys.

Discussion: Unlike TSE magnetization preparation, each view of BLISS is acquired in the steady state. This allows all data to be combined together without addressing blade and view ordering as in TSE-based PROPELLER. TrueFISP preparation was chosen since it can achieve the highest SNR in the shortest TR. Furthermore, TrueFISP already has applications throughout the body, as in delayed enhancement studies of myocardial infarction[4] and coronary MRA[5], and the sequence can yield pure T_2 contrast with additional magnetization preparation[6].Blade imaging and its oversampling of low spatial frequencies is well-suited for abdominal imaging, for which, breathhold failure or movement of the imaging target can be detected. With automated data acceptance and rejection, image quality during interventional procedures in the abdomen, such as renal stent deployment or intravascular imaging for atherosclerotic plaque characterization is expected to improve. In this study, TrueBLISS demonstrates expected image contrast and low artifacts levels in simulated phantoms as well as in the abdomen of an asymptomatic human volunteer.

References:
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Figure 1: Simulated (a) Cartesian and (b) BLISS reconstructions of a uniform disk phantom.

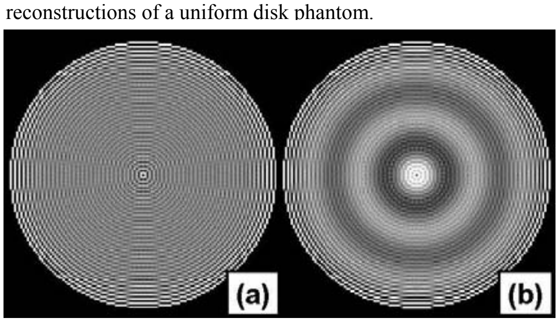

Figure 2: TrueBLISS image in the abdomen of a volunteer.