Image Quality Improvements for Balanced TFE at 3.0T Using a Clinical Parallel RF Transmission MR System

T. Andrews[1,2], M. Kotys[1], M. Kouwenhoven[3], J. Gonyea[2], T. Ashikaga[2], and G. Gentchos[2,4]
[1]Philips Healthcare, Cleveland, OH, United States, [2]College of Medicine, University of Vermont, Burlington, VT, United States, [3]Philips Healthcare, Best, Netherlands, [4]Radiology, Fletcher Allen Health Care, Burlington, VT, United States

Introduction:
High field MR imaging in the chest and abdomen are typically limited by both focal heating effects [1] and B1 inhomogeneities [2]. With B1 shimming the local specific absorption ratio (SAR) can be reduced significantly, thus making shorter TR values and higher flip angles possible. For steady-state free precession sequences this can reduce the impact of banding artifacts (if TR is shortened) or increase CNR (if flip angles are increased). More directly, B1 shimming can make flip angles more homogeneous, thus making CNR more homogeneous. The purpose of this study is to assess the image quality improvements obtained from the use of a 3.0T clinical parallel RF transmission MR system.

Materials and Methods:
Images were acquired from 8 volunteers on a Philips 3.0T Achieva-TX MR scanner (Philips Healthcare, Best, Netherlands) after MultiTransmit commercial upgrade for automated B1 shimming. At the beginning of each session, a B1calibration was performed utilizing a cardiac triggered 2D dual angle method acquisition [3]. The B1-Calibration is a single breathhold 2D axial single slice acquisition containing the B1 map for both transmit channels. Subsequent RF shimming was done based on this B1-Calibration scan in a user defined local RF shimming volume, typically a rectangular box surrounding the heart. A breath-held, short-axis view cine balanced TFE acquisition was obtained without B1 shimming with the parameters: TR=4ms, TE=2ms, FOV=320 x 320mm, acquired spatial resolution= 1.6 x 2mm, slice thickness=8mm, 1 slice, flip angle (FA)=35deg, 20 phases acquired (30 recon), SENSE factor=1. The same sequence was then reacquired with the B1 shimming enabled and the maximum flip angle allowable (70deg) given a TR=4ms. The original balanced TFE sequence (with 35deg flip angle) was then acquired again with B1 shimming enabled at the minimum TR: 2.5ms (7 cases), 2.6ms (1 case). TE was always half the TR. In 4 cases an additional B1 shimmed image was acquired with TR=4ms for a more careful comparison of CNR improvements due to shimming alone. Each acquisition was repeated immediately afterward with identical receiver settings but with the transmitter and gradients turned off, to obtain a noise image for later SNR and CNR calculations. ROIs were drawn in 3 areas for each image: RV blood pool, septum, LV blood pool. A corresponding ROI was drawn in the noise image and noise was estimated as the standard deviation. To quantify banding artifacts for each subject, analysis was performed on the first acquired phase of the mid short-axis slice using the temporal enhancement analysis functionality of Cardiac Explorer (Philips Healthcare Informatics, Best, Netherlands). The image was inverted to mimic the appearance of a temporal enhancement image (Fig. 1). Contours were drawn around the epi- and endomyocardium, and the myocardial tissue was segmented into six sections. The percentage of the myocardium that was greater than two standard deviations from a segment without artifact was reported. Each image was assessed for image quality by a board-certified chest radiologist using a 5-point scale (1=undiagnostic; 5=excellent). A Friedman rank test was performed to compare the shimmed results to the unshimmed results.

Results and Discussion

	FA	N	TR	% obstruction	LV CNR increase	RV CNR increase	IQ score
non-shimmed	35	8	4	14.6			2.5±0.9
shimmed	35	8	2.5	1.1	19%-93%	15%-116%	4.5±0.5
shimmed	70	8	4	11.8	183%-465%	141%-282%	3.75±0.7
shimmed	35	4	4	7.5	28%-50%	24%-94%	4.00±1.2

For each subject banding artifacts were effectively eliminated for shimmed scans with TR=2.5. In each and every case the shimmed images demonstrated greater RV-to-septum contrast and LV-to-septum contrast (illustrated in Fig 1) versus the corresponding unshimmed image (illustrated by Fig 2). In each case, the CNR increase was largest with the FA=70deg image. The image quality for all shimmed acquisitions was scored good (4) to excellent (5) and was higher than the unshimmed acquisitions in each and every case. Image quality scored significantly higher for the first and second shimmed scans (p=0.014, for both), but third shimmed scan was not significantly different due largely to the small number of cases obtained with it.

Conclusions
All shimmed acquisitions demonstrated improved contrast relative to the unshimmed scans and radiologist-assessed image quality was improved. Using the minimum TR available, banding artifacts were effectively eliminated in all cases while still maintaining sufficient contrast to rate an image quality assessment of at least good.

References
[1] Graesslin I, et al. MAGMA 2005; 18:S251.
[2] Hoult DI, J Magn Reson Imaging 2000: 12: 46-67.
[3] Cunningham et al. MRM 2006; 55:1326-1333.

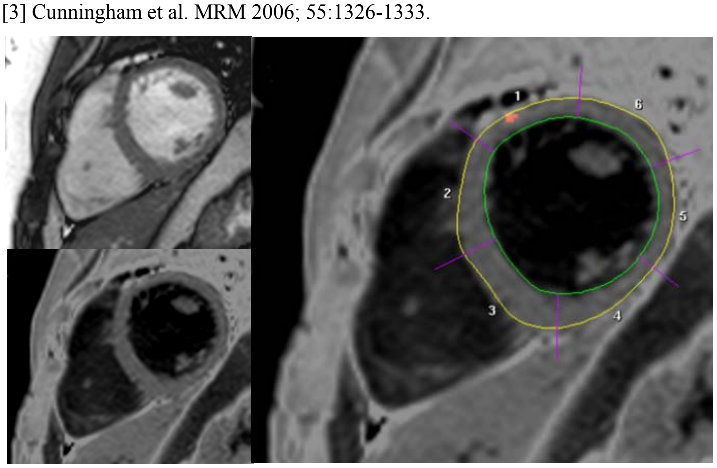

Figure 1: B1 shimmed image with TR=2.5ms (top left); inverted image (bottom left); segmented banding artifact (right)

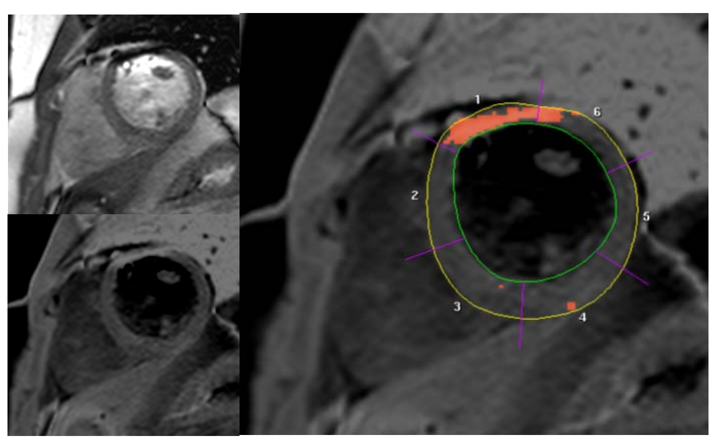

Figure 2: Unshimmed image with TR=4 (top left); inverted image (bottom left); segmented banding artifact (right)