SEGMENTED T2-PREPARED SSFP FOR MYOCARDIAL T2-WEIGHTED IMAGING AND T2-MAPPING

J. A. Stainsby[1], and G. A. Wright[2]
[1]Applied Science Laboratory, GE Healthcare, Toronto, Ontario, Canada, [2]Imaging Research, Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada

Introduction: Recent studies demonstrate that hyperintense regions in T2-weighted images in acute myocardial infarction (AMI) reflect the presence of edema [1] indicating area at risk. Single-shot T2-prepared SSFP methods have been presented for T2-weighted imaging in AMI [2]. Here a segmented SSFP approach suitable for multi-slice, multi-echo imaging of the myocardium is presented.

Methods: Even with accelerated imaging methods the acquisition window for single-shot SSFP techniques can be long (>200-250ms). A segmented SSFP method is proposed, allowing for shorter acquisition windows and a corresponding capability to acquire multiple slice locations per heart beat as illustrated in Fig 1. If the number of segments is limited, the entire acquisition can be repeated with different preparation durations (TE's) in a single breath-hold, enabling T2-mapping. Such a segmented approach presents a number of challenges:

Figure 1: Sequence schematic. Following a T2 preparation, a multi-slice segmented acquisition is acquired.

Minimizing phase encode ordering-based artifacts: Due to the transient SSFP signal following the T2-preparation, standard segmented linear phase encode ordering schemes result in periodic intensity variations across k-space and image ghosting. Standard centric ordered schemes are sensitive to eddy-current effects [3]. To address this and to maximize T2 contrast an even-odd, centric phase encode ordering scheme was implemented which combines the concepts of centric ordering and equal phase encoding steps across each segment.

Degradation of T2 contrast with increasing slice number: Following the T2prep, prepared magnetization loses its prepared contrast due to T1 signal recovery. To preserve the prepared T2 contrast across multiple slices an RF chopping scheme [4] consisting of two averages with an inversion pulse following the T2-preparation on even averages was implemented. This enables subtraction of contaminant signal that recovers with time constant T1.

Cross slice contamination: Normally multiple slices are imaged sequentially so that the steady state can be maintained one slice at a time. To preserve in-slice signal integrity when acquiring multiple slices per heartbeat, in-slice signal is catalyzed prior to, and spoiled following, data acquisition to minimize cross-slice contamination.

Fat contamination: Fat saturation was integrated into the preparation [5] to reduce contributions of recovering fat signal. T2 values are estimated using a 2-parameter exponential fit or a 3-parameter fit including baseline offset.

Results: Example images at different T2-preparation durations are illustrated in Figure 2. Example T2 maps across 3 slices acquired in a healthy volunteer in a 20-second breath hold are illustrated in Figure 3. The impact of the contrast maintenance scheme on T2 mapping data obtained in a gel phantom is illustrated in Figure 4. Use of a 3-parameter fit stabilizes T2 values across multiple slices but demonstrates sensitivity to noise, TE selection and the reduced degrees-of-freedom in the fit. RF chopping with a simple 2-parameter fit best estimated the true T2.

Discussion: A segmented, T2-prepared, multi-slice, multi-echo imaging sequence is presented that can be applied to edema identification in AMI patients.

References: [1] Abdel-Aty et al, JACC, 53, 2009, [2] Kellman et al, MRM, 57, 2009, [3] Bieri et al, MRM, 54, 2005, [4] Wright et al, Proc ISMRM, 1474, 1996, [5] Nezafat et al, MRM, 61, 2009.

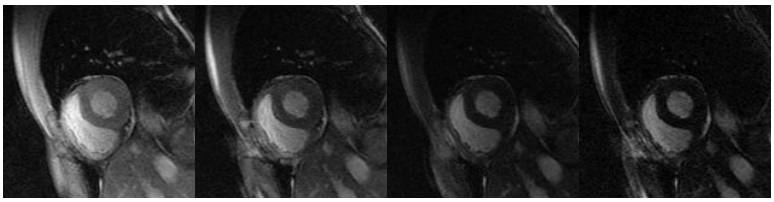

Figure 2: Images obtained as part of a multi-slice, multi-echo acquisition in a single breath hold. Images at a single slice at different TE times from left to right TE=20. 40. 80. 120ms.

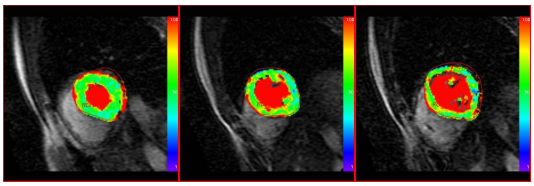

Figure 3: T2 maps from a healthy volunteer generated from a 4-echo, 3 slice acquisition acquired in a 16 heart-beat breath hold.

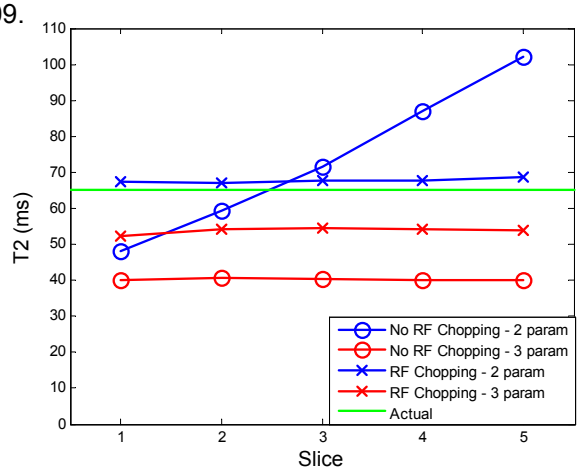

Figure 4: T2 mapping results from a phantom (T2=62ms). Without RF chopping (o's), contaminant signal resulting in elevated T2s. T2-fits with a baseline offset (3 param) yields uniform, but erroneous values. With RF chopping (x's) the T2-contrast is better preserved across slices.