GRAPPA-accelerated coronary MRA benefits from an outer volume suppressing 2D-T_2-Prep

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Introduction: Two dimensional (2D) spatially selective radiofrequency (RF) pulses[1,2] may be used to constrain the location[3] from which an MR signal is obtained. Meanwhile, T_2-Preparation[4], or T_2-Prep, is a magnetization preparation scheme used to improve blood/myocardium contrast. By incorporating a "pencil beam" 2D pulse into a T_2-Prep module, one may create a "2D-T_2-Prep" that combines T_2-weighting with the intrinsic spatial selectivity of a 2D pulse[5]. This may be of particular benefit to parallel imaging techniques such as GRAPPA[6], where artefacts can originate from residual foldover signal. As the 2D-T_2-Prep suppresses signal from outside the area of interest, parallel imaging artefacts may likewise be reduced. In this abstract, we present numerical simulations, phantom validation, and *in vivo* MRA of the right coronary artery (RCA), demonstrating that GRAPPA accelerated images are improved through the use of a 2D-T_2-Prep.

Methods: The first RF pulse of an adiabatic T_2-Prep[7] was replaced with a jinc pulse and spiral gradients (Fig. 1). This excites a cylindrical volume[8]. Meanwhile, the final RF pulse remains non-selective; it thus restores the cylinder of T_2-prepared magnetization, but also rotates outer magnetization into the transverse plane, where it is spoiled. This "2D-T_2-Prep", and its conventional counterpart, were used prior to normal and GRAPPA-accelerated MRI.

First, a numerical phantom, based on real image data (see below), was used to simulate acceleration factors of R=1,2,3,4,5, and 6, with random coil noise. Through repeated simulations, per pixel maps of SNR, noise, and G-factor were predicted for both T_2-Prep techniques.

Next, the actual phantom, with compartments doped to mimic blood, myocardium, and fat, was scanned 50 times for each acceleration and T_2-Prep (50x6x2=600 total scans), on a 1.5T Siemens Aera using a gated, 2D gradient echo, 16 channel chest coil, FoV 384x384 (matrix 384x384), 4.0mm slices, TE T_2-Prep = 40ms, RF angle 20°, and TE/TR/T_{acq}=3.4/8.7/69 ms. For each "tissue" (Fig 2), an ROI was chosen and the mean SNR_{multi} was calculated.

For *in vivo* experiments, the RCA was imaged in 10 healthy adult subjects, using acceleration factors of R=1,3, and 6. Parameters were as above, though a respiratory- and ECG-gated, volume-targeted 3D sequence was used with 1.5mm reconstructed slices, 24mm volume thickness, water-selective RF excitation pulses of 20°, and TE/TR/T_{acq}=5.2/11.6/93.0 ms. Both T_2-Preps were compared using Soap-Bubble[9] vessel sharpness measurements for each acceleration, and the % differences were calculated.

Results: In simulations, the 2D-T_2-Prep significantly improved image quality for accelerated acquisitions, with the peak improvement occurring at a value of R=4. Fig. 3 illustrates this through comparative maps of SNR, noise, and G-factor, at various acceleration factors. Phantoms scans also demonstrate a maximal SNR improvement at R=4 (Fig. 4). This value also corresponds to the degree of outer volume suppression of the 2D-T_2-Prep, such that ratio of excited tissue to suppressed tissue (in the phase-encoding, accelerated direction) is also ~4. For *in vivo* images of the RCA (Fig. 4), vessel sharpness improved for the 2D-T_2-Prep, though by an even greater % for highest acceleration factors (Table 1).

Discussion: Although the 2D-T_2-Prep generally improves image quality, it shows particular improvements when paired with GRAPPA-accelerated acquisitions, as demonstrated in simulations, phantoms, and volunteers. When SNR_{multi} was calculated for phantoms and volunteers, the maximal improvement of the 2D-T_2-Prep appeared to occur when the 2D-T_2-Prep suppresses signal from a volume of tissue proportional to the acceleration factor used. The reason for this may be that when "unfolded" tissue signal is suppressed, so too are the artefacts originating from such tissue signal. Regardless of the cause, the 2D-T_2-Prep has been shown to particularly benefit GRAPPA-accelerated coronary MRA and should thus be considered for such.

References:

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Figure 1: Pulse sequence diagrams for the conventional and the 2D-T2-Preps

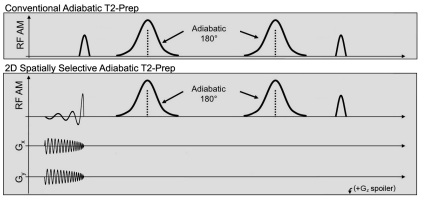

Figure 2: 50 scan average of conventional and 2D-T_2-Preps.

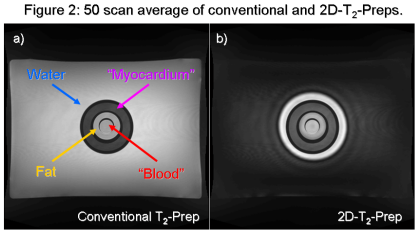

Figure 3: Simulated GRAPPA-accelerated image acquisitions (R=1..6) for a conventional and 2D-T2-Prep

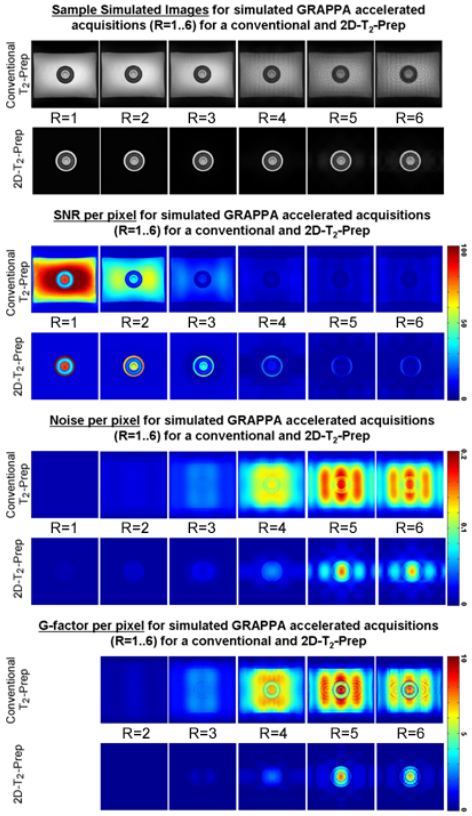

Figure 5: Comparison of conventional and 2D-T2-Preps in accelerated MRA of the RCA

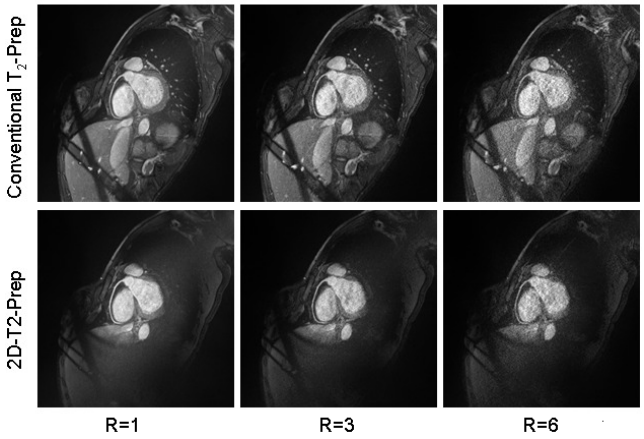

Table 1: Vessel sharpness % of the RCA in healthy volunteers, using either a conventional T_2-Prep or a 2D-T_2-Prep, for GRAPPA acceleration factors of 1, 3, and 6.

Acceleration Factor	1.00		3.00		6.00	
T_2-Prep Type	Conv.	2D	Conv.	2D	Conv.	2D
Mean Vessel Sharpness %	57.35	60.13	57.93	62.02	54.27	60.72
% Difference	4.86		7.07		11.88	
p-value	0.013		0.001		0.000	

Figure 4: % Difference in the mean SNR_multi per tissue, between the conventional T_2-Prep and the 2D-T_2-Prep, for various GRAPPA acceleration factors, as measured in a tissue-mimicking phantom