Accelerated whole-body diffusion weighted imaging with blipped CAIPIRINHA based simultaneous multislice acquisition

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TARGET AUDIENCE: Clinicians/researchers interested in using whole-body DWI.

PURPOSE: Whole-body diffusion-weighted MR imaging (DWI) is a promising tool for cancer staging [1, 2]. Whole-body DWI is typically performed over multiple stations, with a 2D multislice single-shot EPI sequence with multiple b-values and averages acquired at each station. The scan time for each station is usually 4-5 minutes. This makes the total scan time of whole-body diffusion MRI relatively long (~20-25 minutes for a 4-5 station exam). Recently, the blipped CAIPIRINHA slice acceleration method has been demonstrated for reducing the scan time of 2D multislice EPI [2]. This technique relies on exciting multiple slices simultaneously and reconstructing them individually using the slice GRAPPA method. Since multiple slices are excited simultaneously the overall TR for a desired spatial coverage is reduced, leading to scan time reduction almost by the same factor. The acceleration method is SNR preserving with no intrinsic reduction in signal due to reduced sampling. The blipped CAIPIRINHA method has previously been demonstrated for clinical diffusion imaging in the brain and liver [3, 4]. The goal of this work was to apply this slice acceleration technique to whole-body DWI and compare the results with a conventional non slice accelerated acquisition. A key innovation is the development of a simultaneous multislice STIR fat suppression scheme.

METHODS: 8 healthy volunteers and 6 patients were scanned at two imaging centers on a 1.5T scanner (MAGNETOM Aera, Siemens Healthcare). Conventional and slice accelerated single shot EPI sequences were acquired. For the slice accelerated technique two slices were excited simultaneously (Slice Acc 2) leading to scan time reduction by a factor of almost 2 (~1.7) compared with the conventional technique. To minimize g-factor noise a phase encoding shift factor of FOV/2 was used between the two simultaneously acquired slices.

Parameters for healthy volunteer studies: 4 station acquisition with coverage from head to pelvic region, FOV: 430 x 430 mm, in-plane spatial resolution: 3.35x3.35 mm^2 (reconstructed at 1.67 x 1.67 mm^2), TE = 66 ms, fat saturation with a multi-banded spatially selective inversion pulse (STIR) with TI = 180 ms, in-plane GRAPPA factor of 2, 50 slices of 5 mm thickness, b = 50 s/mm^2 with 2 averages and b = 800 s/mm^2 with 5 averages. The following coils were used: 20 channel head neck coil, 32 channel spine coil, and two 18 channel body matrix coils. The conventional scan had TR = 13400 ms and total scan time = 21:28 mins (5:22 mins/station x 4). The accelerated scan had TR = 6800 ms and total scan time = 12:40 mins (3:10 mins/station x4).

Parameters for patient studies: 4 station acquisition with coverage from neck to pelvic region, fat saturation with a spectrally selective adiabatic inversion pulse, 26 6mm slices, b = 50 and 800 s/mm^2 with 1 average. The total scan time for the conventional scan was 6:44 mins (1:41 mins/station x4), and for the Slice Acc 2 scan was 3:56 mins (0:59 mins/station x 4).

Quantitative comparison between the two techniques was done on the healthy volunteer datasets. Two metrics were used: ADC and relative SNR (relSNR, defined as the ratio of mean signal intensity to noise standard deviation). Both these metrics were measured in identical ROI's in the following organs: brain, liver, spleen, kidney and bone marrow. Qualitative comparison between the two techniques was done on the patient datasets in a subjective non-blinded fashion by a radiologist with >8 years experience in body MRI.

RESULTS: Comparison between ADC and relSNR values in healthy volunteers for different organs is shown in Table 1. Sample b=50 and 800 s/mm^2 images in a healthy volunteer and patient are shown in Fig. 1. Comparable image quality is seen with both sequences. This patient was a 25 yo female with abdominal pain and a history of Crohns disease. Concern was for active bowel inflammation, evidence of stricture, or abscess. The b50 images were used for fat suppressed t2 contrast, and the b800 images were used to look for bowel wall inflammation. In this patient no pathology was found on either of the sequences. Qualitative comparison between the two sequences showed comparable image quality and diagnosis in all 6 patients.

DISCUSSION: The goal of this study was an initial, non-blinded evaluation of whole-body DWI with the blipped CAIPIRINHA slice acceleration technique with a factor of 2. ADC values measured with this sequence matched well with those measured with a conventional sequence. Depending on organ the relSNR for the accelerated sequence was 10 to 20% lower than the conventional sequence due to g-factor related SNR loss in the slice GRAPPA reconstruction. In spite of this reduction, equivalent image quality and diagnosis was observed for both techniques. Future work will further investigate the clinical utility of this slice acceleration technique.

CONCLUSION: We demonstrated the feasibility of using blipped CAIPIRINHA based slice acceleration for a factor of 2 reduction in scan time for whole-body diffusion weighted imaging.

REFERENCES: [1] Koh et. al. AJR 199: 252–62. [2] Padhani et. al. Radiology 261(3): 700-18. [3] Setsompop et al. MRM 67(5):1210-24.[4] Bhat H. et. al. ISMRM 2013, #593.

	Brain		Liver		Spleen		Kidney		Bone marrow	
	ADC	relSNR	ADC	relSNR	ADC	relSNR	ADC	relSNR	ADC	relSNR
Conventional	841.97± 213.97	508.04± 144.8	993.07± 65.53	29.16± 22.29	896.28± 141.50	107.08± 57.36	1857.37± 122.41	124.15± 28.35	787.21± 143.33	30.07± 27.2
Slice Acc2	825.68± 208.18	431.42± 124.01	1039.34 ±120.10	26.45± 18.44	893.58± 120.63	98.62± 49.39	1902.28± 67.48	107.63± 23.92	749.88± 130.39	24.45± 19.48
p-value	0.008*	0.002*	0.26	0.18	0.94	0.12	0.41	0.03	0.12	0.10

Table 1: ADC and relSNR comparison in healthy volunteers. Values are reported as mean ± std.

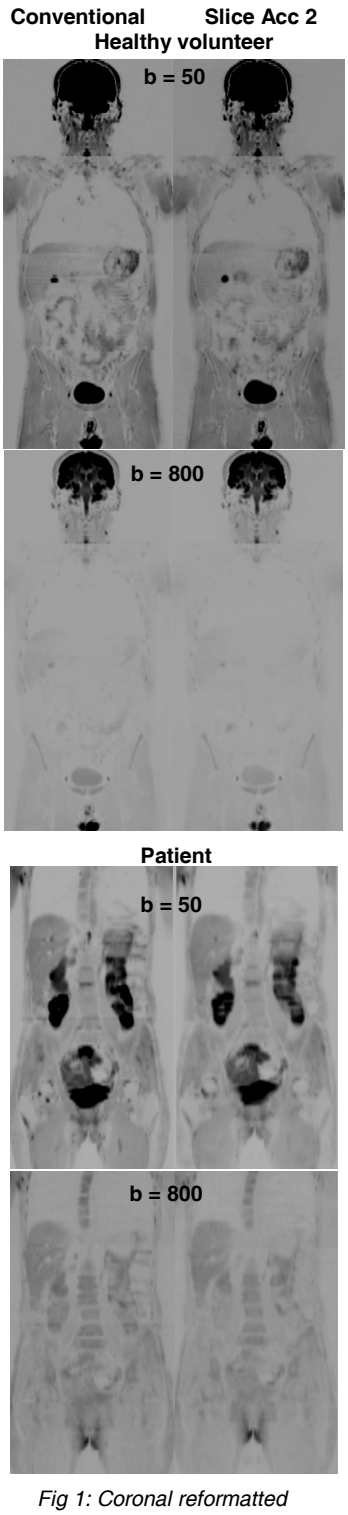

Fig 1: Coronal reformatted whole body DW images in a healthy volunteer and patient.