MRI Scan Time Reduction with Combo Acquisitions: First Images Acquired on a Clinical Scanner

R. Mekle[1], E. X. Wu[2], S. G. Wetzel[3], K. Scheffler[1]

[1]Department of Medical Radiology, MR-Physics, University of Basel, Basel, Switzerland, [2]Department of Radiology, Columbia University, New York, NY, United States, [3]Department of Medical Radiology, University of Basel/University Hospital, Basel, Switzerland

Introduction The combo acquisition approach was recently proposed for MRI scan time reduction in a clinical setting [1]. In this method, acquisition protocols are designed by systematically integrating the three concepts of (1) *variable acquisition parameters*, (2) *k-space data sharing*, and (3) *multi-contrast imaging*. Its novelty is the integration of these three key concepts, though each of them has been separately applied before, e.g. variable TE and TR in [2], phase encoding (PE) view sharing for a dual-contrast fast spin echo (FSE) sequence in [3], and multi-contrast acquisitions in [4]. Moreover, in contrast to [5], only one type of sequence is used to acquire data in a combo scan. After optimizing spin echo (SE) and fast spin echo (FSE) combo acquisition protocols using simulations [1], implementation of SE combo scans on a real MR scanner was successfully completed. The first images acquired with this technique yielding scan time reductions of up to 52% are presented in this study.

Methods 2-contrast SE combo acquisition protocols were implemented on SIEMENS Sonata and Symphony scanners at B_0=1.5 Tesla. As an example, optimized variation curves for acquisition parameters TR and TE and phase encoding (PE) scheme for a T_1-T_2 SE combo acquisition are shown in Fig. 1. The design of such protocols has been described earlier [1]. In this case, PE view ordering was quasi centric down, i.e. N_{PE} = 0, -1, -2, 1, 2, etc.. Phantom data and human brain images for volunteer and patient cases were acquired with the following scan parameters: *matrix*=256x256, square *FOV*=230 mm (250 mm for phantoms), slice thickness=5 mm, *NEX*=1, and *BW*=130 Hz/pixel. To yield the desired contrast weightings in T_1-T_2 SE combo scans, TR was varied from 500 ms to 2500 ms and TE from 15 ms to 90 ms. Resulting images were compared with those from corresponding standard acquisitions. In addition, signal-to-noise ratio (SNR) and contrast measurements for tissues white matter (WM), gray matter (GM), and cerebrospinal fluid (CSF) were obtained for all brain images using selected regions of interest (ROIs).

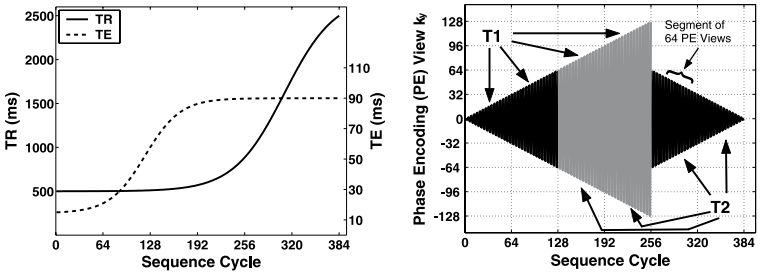

Fig. 1: Optimized parameter variation and phase encoding (PE) schemes for a T_1-T_2 SE combo acquisition with 384 sequence cycles. *Left*: curves of variation for TR (solid) and TE (dashed); *Right*: PE scheme, where data sharing between images is indicated.

Results Fig 2 shows images from the T_1-T_2 SE combo acquisition depicted in Fig. 1 and its corresponding standard acquisitions for a volunteer and a patient. Contrast was preserved in T_1-weighted (w) and T_2-w images from the combo scan. Except for some blurring of fine structures of tissues WM and GM, no major artifacts were observed at a scan time reduction of 52% (artifact in patient images stems from pulsating liquor/motion). Blurring is due to the relative attenuation of high spatial frequency data induced by the specific variation of TR and TE. Decreasing the amount of data sharing would reduce it. SNR and contrast measurements for the brain images shown in Fig. 2 are presented in Table 1. Results for combo and standard scans were very similar. Thus, the SNR and image contrast were not significantly altered with combo scans. Finally, Fig. 3 shows images of a resolution phantom from the combo acquisition in Fig. 1 and corresponding standard scans. Images of the same contrast from combo and standard acquisitions are visually almost indistinguishable due to the relatively long T_2 of the phantom rendering its signal relatively insensitive to varying acquisition parameters.

	T_1-SE Standard		T_2-SE Standard		T_1- SE Combo		T_2- SE Combo	
Case	**SNR**	**CR**	**SNR**	**CR**	**SNR**	**CR**	**SNR**	**CR**
Volun-teer	23.37	1.14 2.44 2.13	15.22	0.69 0.44 0.64	23.03	1.14 2.25 1.97	14.83	0.69 0.44 0.65
Patient	24.98	1.15 2.39 2.08	19.07	0.84 0.50 0.60	25.84	1.13 2.92 2.59	23.55	0.93 0.53 0.57

Table 1: SNR measurements and contrast ratios (CR) of tissues WM, GM, and CSF in images from a T_1-T_2 SE combo scan and corresponding standard acquisitions.

Discussion The technique of a combined acquisition of multi-contrast images was successfully implemented on a clinical scanner. Images acquired with T_1-T_2 SE combo acquisition protocols did not exhibit any major artifacts, while yielding scan time reductions of up to 52%. The SNR and image contrast were well preserved. Similar results were obtained in phantom studies for T_1-*PD* (proton density) SE combo scans. These findings confirmed the outcome previously predicted by simulations. Implementation of 3-contrast SE and FSE combo acquisitions is currently underway to make this technique clinically more useful. In contrast to certain other approaches to reduce scan time, no special scanner or gradient hardware is required for the implementation of combo scans. In addition, due to inherent image registration combo acquisitions are well suited for applications, such as multi-spectral image segmentation.

References [1] R. Mekle et al., *IEEE TMI*, 22, 806-23, 2003;
[2] R. K. Butts et al., *Radiol.*, 180, 551-6, 1991; [3] B. A. Johnson et al., *AJNR*, 15, 667-73, 1994;
[4] K. Oshio et al., *J. Com. Ass. Tom.*, 17, 333-8, 1993; [5] C. Hillenbrand et al., *Magma*, 10, 183-99, 2000.

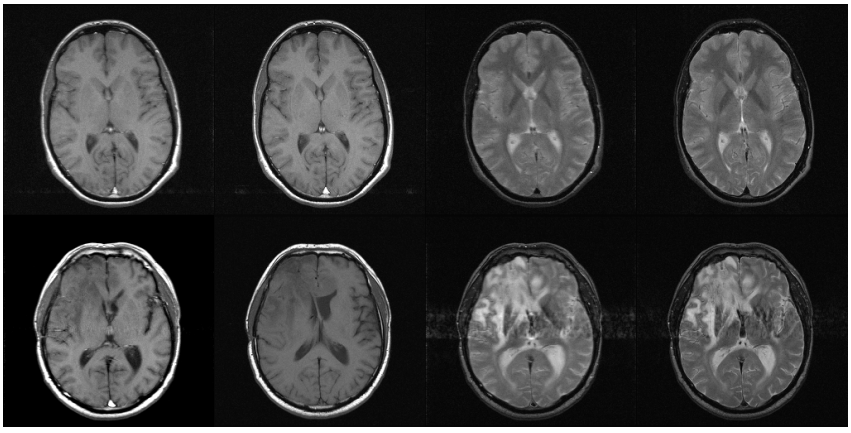

Fig. 2: Axial brain slice data from volunteer (*upper row*) and from patient (*lower row*).
Left to right: combo T_1-w, standard T_1-w (TR/TE=500/15), combo T_2-w, and standard T_2-w images (TR/TE=2500/90). The combo acquisition shown in Fig.1 was used yielding a scan time reduction of 52%.

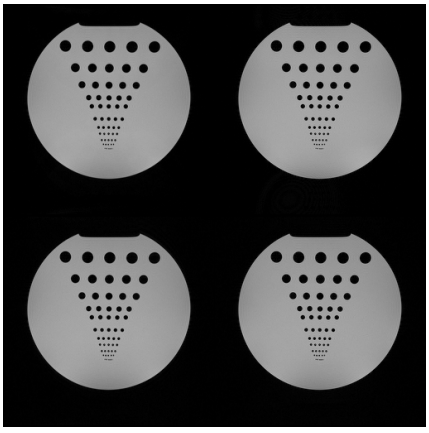

Fig. 3: Images of resolution phantom.
Upper row: combo T_1-w and standard T_1-w images.
Lower row: combo T_2-w and standard T_2-w images.