MR Colonography at 3T using 1D- and 2D- Accelerated Autocalibrated Parallel Imaging.

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INTRODUCTION: Magnetic Resonance Colonography (MRC) in recent years is gaining favor as a viable alternative to traditional CT colonography. Proponents of MRC favor the lack of ionizing radiation along with the excellent safety profile of MR intravenous contrast, which can further characterize colonic lesions. The challenge of MRC is to acquire high-resolution volumetric images spanning the full extent of the colon within a reasonable breathhold time. The majority of previous MRC studies have been conducted at 1.5T [1]. The purpose of this study was to investigate the feasibility of performing MRC at 3T using 1D- and 2D-accelerated autocalibrated parallel imaging. We hypothesized that parallel imaging acceleration could permit increased spatial resolution and anatomic coverage, while SNR losses from parallel imaging would be partially offset by the additional SNR available at 3T. Patient results are presented showing the initial feasibility of this technique.

METHODS: Institutional review board approval and informed consent were obtained. Seven [4 men, 3 women; age (40-60years)] MRC patients were recruited from a high-risk screening population for optical colonoscopy (OC) who had prior polyps or a family history of colon carcinoma. Patients underwent standard bowel cleansing of 4 liters of polyethylene glycol– electrolyte solution. MRC was performed the following morning at 3T (Signa® HD, GE Healthcare, Waukesha, WI) using an 8-channel cardiac coil. Spasmolytic agent (glucagon 1.0 mg) was administered intravenously. MRI protocol included oblique coronal 2D single shot fast spin echo scout images for monitoring colonic water insufflation (approximately 2000 mL), and a dedicated colonic 3D steady state free precession (SSFP) volume (Fig. 1) to obtain high-quality localization and diagnostic images. 1D- and/or 2D-accelerated 3D T1-weighted fat-suppressed spoiled gradient echo data was then acquired in the oblique coronal plane before and after (Fig 2) intravenous contrast administration (0.2 mmol gadopentetate dimeglumine per kilogram of body weight at 12 and 75 seconds). For 1D-acceleration scans, data acquisition was accelerated by 1.9x in the phase-encode direction for a 44-s breath-hold. For 2D-acceleration scans, data acquisition was accelerated in both the phase- and depth-encode directions for a net acceleration of 3x and a 31-s breath-hold.

All parallel imaging reconstruction was performed online using ARC (Autocalibrating Reconstruction for Cartesian sampling), a method that efficiently calculates and applies [2] reconstruction weights to synthesize unacquired per-coil data directly from neighboring acquired data on all coils. Typical imaging parameters for the T1-weighted gradient echo scans were: flip angle = 12°, BW = ±62.5kHz, TE/TR = 1.0/3.6ms, spatial coverage = 42x34x18cm, acquired voxel size = 1.3 x 0.8 x 1.9 mm^3.

MRC exams were reviewed by 2 expert readers of CT colonoscopy for lesion detection, and segmental colonic evaluation using a 1(poor) to 5(excellent) point scale for adequacy of bowel distension and bowel preparation. Findings were compared with OC through segmental unblinding where MRC findings are only revealed after the colonoscopist has reviewed each segment of colon. Discrepancies are resolved immediately with the radiologist at hand. 1D- and 2D-accelerated images were compared for image quality.

RESULTS: Of 7 patients, 15 suspicious lesions were found in 4 patients at OC. Histologic examination demonstrated 13 lesions were polyps (4 hyperplastic, 9 tubular adenomas) and 2 lesions were false positive mucosal excrescences. All polyps were < 6mm , in the range of 2 to 5mm. Lesions were located in all segments of colon except the hepatic flexure. Two patients had 5 lesions identified on MRC but only 2 were suspicious prospectively; one true positive (5mm tubular adenoma) and one false positive with no correlate identified on OC. Mean scores for bowel distension and bowel preparation were 4.7 and 4.6 respectively. Lowest scores were 3.7 for bowel distension in the sigmoid colon and 4.1 for bowel preparation in the cecum. Initial experience with 2D-accelerated MRC images suggests that image quality is superior to 1D-accelerated images, likely due to shorter scan times with reduced artifacts from peristalsis and/or less motion artifacts due to improved breathhold compliance. For example, Figs 2 & 3 show 1D- and 2D-accelerated post-contrast MRC images from the same patient. All imaging parameters were the same except scan time. Note the improved visualization and reduced blurring of the haustral fold (arrow) with 2D-ARC, with no appreciable degradation of image quality or SNR.

CONCLUSION: Magnetic Resonance Colonography at 3T utilizing ARC is feasible, allowing reproducible acquisition of high-resolution, diagnostic colonography images without significant motion or parallel imaging artifacts. Initial experience with 2D ARC is very promising as it may allow clinically feasible breathhold times for reduced motion artifact without sacrificing spatial resolution or anatomic coverage. As preliminary results are promising, ARC and 3T MRC may become a viable alternative to virtual CT and optical colonoscopy for screening.

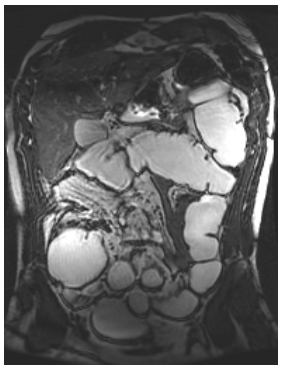

Fig. 1: 3D SSFP bright-lumen MRC.

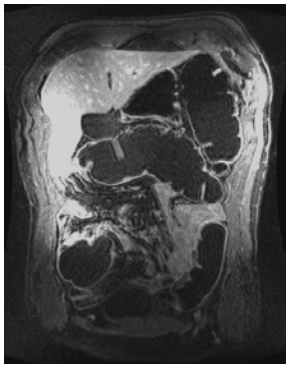

Fig. 2: Post-contrast 3D T1-weighted dark-lumen MRC with 1D-acceleration.

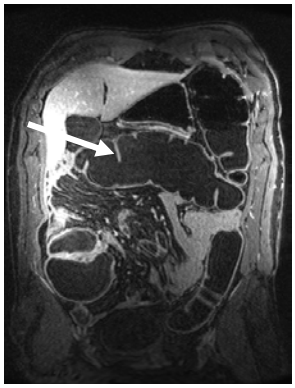

Fig. 3: 2D-accelerated post-contrast 3D T1-weighted MRC from the same patient. Note the improved visualization and reduced blurring of the haustral fold (arrow) compared to Fig. 2. All imaging parameters were the same except breathhold time.

References: [1] Hartmann et al. Radiology 238(1):143-9, 2006.
[2] Brau et al. ISMRM 2006, 2462.