Continuously Moving Table Whole-Body MRI using Variable Field of View

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Introduction.

The systemic nature of diseases can require a longer longitudinal field of view (FOV) than can be imaged using the homogeneous region of the magnetic field. Continuously moving table (CMT) acquisitions have been proposed whereby data is collected in a hybrid space as the patient is moved through the scanner[1]. CMT acquisitions are preferable to multi-station approaches due to their decreased acquisition time and increased patient comfort. In CMT acquisitions the table velocity and therefore scan duration is proportional to the image resolution and the in-plane FOV. If the imaged FOV is decreased, either the table velocity can be increased or the image resolution can be improved. Hu et al. kept the table velocity constant, and increased the spatial resolution in the legs where the required FOV was smaller[2]. This work investigates the alternative strategy of maintaining spatial resolution throughout the scan, and instead increasing table velocity in regions with decreased FOV requirements in order to reduce scan time.

Methods.

All imaging was performed on a 3T scanner (Magnetom Verio, Siemens Healthcare, Erlangen Germany) with readouts and table movement along z, the longitudinal axis of the magnet. Table movement was achieved using a custom-built drive motor with positional feedback. FOV requirements were obtained from a low-resolution, 5x5 mm^2 in-plane resolution moving-table scout scan. To separate the patient from the background in the scout image, the image was thresholded and region-filled to remove any holes before area open filtering to remove spurious noise points. The FOV requirements were used to generate a phase-encode (PE) table as a function of patient position. By adjusting the sampling spacing for each cycle through k_y, it is possible to vary the imaged FOV across the patient. Figure 1 illustrates the hybrid k_y-z space readouts in a single k_x plane at a location that transitions between a region with a larger FOV and a region with a smaller FOV. Within the transition region between the two FOVs sample points from both FOV encodings are intermixed and no longer lie on a uniform grid. It is therefore necessary to perform gridding prior to the Fourier transform along k_y-k_x. This results in a single image at each z-location, which may be placed in the final large FOV image.

For comparison we also acquired a constant FOV scan using the smallest single FOV offset that could encompass the entire patient. Both the constant and variable FOV acquisitions yielded an in-plane resolution of 2x2 mm^2 (TE=3.75ms,TR=24ms,10mm slice, FA=10°). Readout lengths were limited to 20 cm to reduce the effects of gradient non-linearity. 4 averages of each readout line were used to improve the signal-to-noise to better depict artifact.

Results.

Figure 2A shows the FOV requirements obtained from the scout scan and the actual FOV imaged for the variable FOV scan. Since velocity changes are limited to transitions between cycles through *k*-space, the FOV changes can only occur at increments of the readout FOV which leads to a stepwise approximation of the FOV requirement. Figure 2B and 2C shows a comparison between one slice of the constant FOV scan and the variable FOV scan, respectively. The variable FOV scan imaged the same volume with the same resolution and SNR, but with 32 % fewer data acquisitions.

Conclusions.

Varying the FOV during the course of CMT acquisition enables the imaged volume to better track the FOV required at each slice through the body. The end result is imaging with equal resolution in less time. Aside from obvious improvements in patient compliance and throughput, this time reduction will be most effective in full body acquisitions of image contrasts that require longer TRs such as T2-weighted imaging. The only disadvantage to this new form of CMT acquisition is the need for a rapid scout image before high-resolution scanning begins. This scout could serve multiple purposes, such as measuring the frequency shift, coil loading, and receiver coil sensitivities as well as determining the FOV requirements.

References.

[1]DG Kruger, SJ Riederer, RC Grimm, PJ Rossman. MRM 47:224-231 (2002)
[2]HH Hu, AJ Madhuranthakam, DG Kruger, JF Glockner, SJ Riederer. MRM 54: 146-151 (2005)

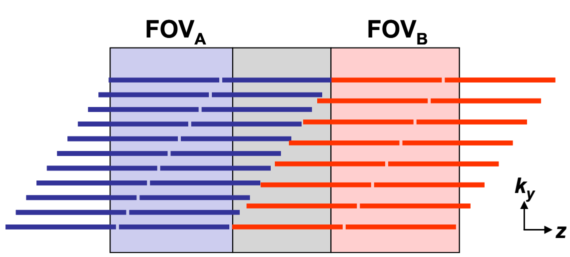

Fig. 1. Readouts in hybrid space (z,k_y) showing transition (grey) from a larger FOV region (blue) to a smaller FOV (red). Gaps along the readouts are for ease of visualization. As samples from blue readouts end, they are replaced by samples from red readouts. Since the samples are not equally spaced by 1/FOV, gridding reconstruction is required.

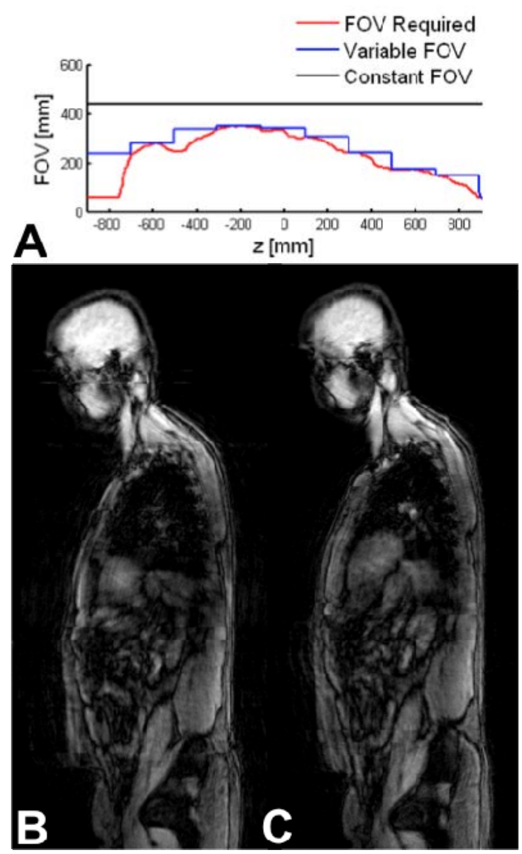

Fig. 2. Continuously moving table acquisition. (A) Required FOV (red) as a function of patient position along with FOV imaged by the variable FOV sequence (blue). The FOV from the constant FOV acquisition is in black (B) Constant FOV and (C) variable FOV free-breathing acquisitions from the head to the pelvic floor, showing equivalent scan quality.