Continuous moving table whole-body MRI on a 3T magnet: sequence feasibility and optimization (preliminary results)

R. H. Baroni[1,2], I. Pedrosa[1], C. McKenzie[1], R. P. Marquis[1], C. Dumoulin[3], G. Kenwood[3], N. M. Rofsky[1]

[1]Radiology, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, United States, [2]Radiology, Hospital das Clinicas da FMUSP, Sao Paulo, Brazil, [3]GE Global Research Center, Niskayuna, NY, United States

Introduction: The idea of using extended field-of-view images arises naturally when one thinks of whole body MRI screening and MR angiography. Historically, a multi-station approach has been used to obtain multiple regional images that are then "stitched" to produce a single large image; this approach has the disadvantages of discontinuity artifacts at the image's edges and spending additional time moving the cradle between each station[1]. More recently, methods of acquiring longitudinally extended FOV images with continuous table translation in the z-axis have been developed[2]. We describe the feasibility and sequence optimization of a new extended FOV imaging method with frequency encoding along the z-axis, called "frequency-adapted sliding table acquisition" (FASTA).

Materials and Methods: The FASTA method was recently described by Zhu and Dumoulin[3]. The method uses continuous table translation along the subject's longitudinal axis, body coil transmit and receive, sequential image acquisition, and rectilinear 2D *k*-space filling with z-direction frequency encoding. To minimize translation-induced artifacts, each acquired view (i.e., a *k*-space line) is spatially registered after *k*-z direction Fourier transformation, and the center frequency of the receiver is changed from view to view at a rate matching the table's speed (using the formula $\mathbf{\Delta f = \gamma\ Gz\ V\ TR}$, where Δf is the frequency change, Gz is the strength of the readout gradient, V is the table translation velocity and TR is the sequence repetition time). Therefore, a coherent k-space data matrix (i.e., a regional image) is obtained with negligible effects from the concurrent table translation; repeating the process after a reset of the center frequency using a multiplanar approach allows the achievement of a series of contiguous regional images covering the whole body on either the sagital or coronal planes (Figure 1).

We studied 18 volunteers (3 men, 15 women) in a 3 month period on a 3T magnet (GE Medical Systems, Milwaukee, WI) using the FASTA software. All volunteers were imaged using the gradient-echo sequence available in the latest release of the software. In order to obtain the best image quality for full-body coverage with the shortest possible acquisition time, and considering the previous experience with this software on a 1.5T magnet[3], we obtained a total of 125 sets of coronal images, with a combination of the following parameters ranges for T1-weighted images: TR (7.9 – 13.6 msec.), TE (3.5 – 8 msec.), flip angle (8 - 45º), image overlap (50 – 85%), slice thickness (7 – 10mm), phase-encoding steps (128 – 256), bandwidth (16 – 62 kHz), table speed (0.62 – 1.4 cm/s). Twelve to fourteen images were usually necessary to obtain full-body coverage on the AP axis, with data acquisition taking between 2 and 5 minutes.

Twenty-one images were excluded due to mal-positioning of the patient in relation to the length of image acquisition, leading to insufficient body coverage.

An experienced body-MR radiologist, blinded to the imaging parameters, evaluated the 104 sets of coronal images, and graded them on a 7-point scale (from "poor" to "excellent") for the following criteria: T1 contrast, in-plane resolution, signal to noise ratio (SNR), absence of "ghost" artifacts, absence of frequency-related artifacts, absence of discontinuity artifacts, absence of breathing artifacts, and overall image quality. Additionally, all images were independently reviewed by two radiologists, who were requested to select the best overall image of the whole dataset.

Results: Ten sets of coronal images achieved the highest score ("good/excellent") for overall image quality. Of those, 8 (80%) were obtained with the following parameters: TR= 12-13 msec, TE= 7.8-8 msec, FA= 20º, overlap= 70-80%, slice thickness= 10mm, phase-encoding steps= 192-256, bandwidth= 62 kHz, table speed= 1 cm/s. Both radiologists selected the set of coronal images displayed in Figure 2 as the best of all, which was obtained with the following parameters: TR= 13 msec, TE= 7.9 msec, FA= 20º, overlap= 75%, slice thickness= 10mm, phase-encoding steps= 224, bandwidth= 62 kHz, table speed= 1 cm/s. One interesting observation is that 67% of images were considered "good" or "excellent" in relation to the absence of breathing artifacts, even though all volunteers were breathing normally during image acquisition.

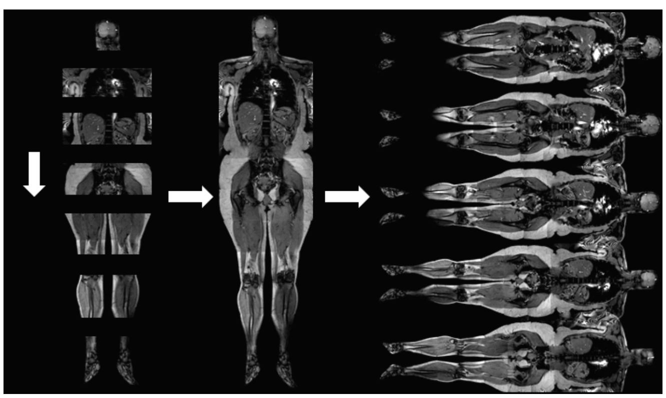

Figure 1: Using continuous table translation, multiple regional images are sequentially obtained to compose a full-body coronal image. With a multiplanar approach, more images can be achieved at different AP levels.

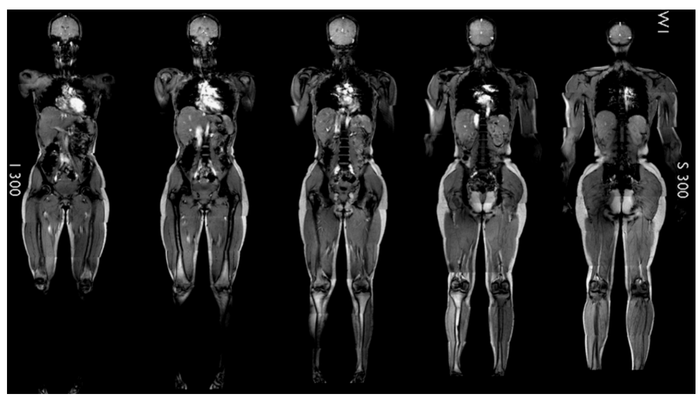

Figure 2: Set of 5 contiguous coronal images selected by both reviewers as the best of the whole dataset, and graded for overall image quality as "good/excellent". Imaging parameters are described on the "results" section of this abstract.

Conclusion: We defined the best parameters for T1-weighted GRE images with the "FASTA" method for continuous moving table imaging. The method is robust, and full-body exams can be obtained in less than 5 minutes with no need for breath-holding. We anticipate that, with the use of contrast-enhanced images and development of higher "lesion-to-background" sequences (like STIR), FASTA will be a useful tool for whole-body screening.

References:
1- Earls JP, De Sena S, Bluemke DA. Gadolinium-enhanced 3D MR angiography of the entire aorta and iliac arteries with dynamic table translation. Radiology 1988; 209: 844-849.
2- Kruger DG, Riederer SJ, Grimm RC, Rossman PJ. Continuously moving table data acquisition method for long FOV contrast-enhanced MRA and whole-body MRI. Magn Reson Med 2002; 47: 224-231.
3- Zhu Y, Dumoulin C. Extended field-of-view imaging with table translation and frequency sweeping. Magn Reson Med 2003; 49:1106-1112.