Effect of reordering on dynamic contrast enhancement

V. Deshpande[1], G. Acevedo-Bolton[2], H. Schultze-Haakh[3], D. Saloner[2], and G. Laub[3]

[1]Siemens Medical Solutions USA Inc., San Francisco, CA, United States, [2]VA, San Francisco, CA, United States, [3]Siemens Medical Solutions USA Inc., CA, United States

Introduction

Dynamic contrast enhanced imaging is routinely used for breast MR imaging (1). Multiple measurements of a fat suppressed gradient-echo sequence (VIBE) are used to image the contrast dynamics after injection. Typically, linear reordering is used in the gradient echo sequence. Centric reordering may also be used to improve fat suppression, or a radially center-out strategy in ky-kz space to reduce breathing motion. Each reordering scheme offers certain benefits, but their impact on sampling of the contrast dynamic is relatively unknown. The goal of this work is to study the contrast enhancement dynamics with a VIBE sequence with segmented linear, centric, and radially centric-out trajectory in k-space.

Methods

Sequence development occurred on a 3T scanner (Siemens TIM Trio, Erlangen, Germany) based on the VIBE sequence. For linear and centric reordering, the data were segmented and interleaved in the partition-encoding direction. All partitions (kz) were acquired for each ky phase-encoding line before the phase-encoding gradient was incremented. The reordering in the phase-encoding direction (ky) was linear. For the radially centric-out trajectory, the distance from the center of k-space of each point was calculated and k-space was split into bins representing the number of k-space steps per fatsat pulse. Sampling then occurred by picking a point along a radius in each of the bins after each fatsat pulse. The imaging parameters used were: TR/TE = 5.99/1.82 ms, flip angle = 10 deg., readout bandwidth = 490 Hz/pixel, FOV = 300 x 300, matrix = 180 x 256, numbers of partitions = 32, slice thickness = 1 mm, scan duration = 25 s.

A flow phantom was setup to study the contrast-enhancement dynamics. Tap water was used as the medium in the flow phantom. Contrast (Magnevist, Berlex) was injected into the stream using a power injector (Medrad). Two injection schemes were used to study the dynamics: a shorter injection of 5 ml at 1 ml/s, and a longer injection of 7 ml at 0.5 ml/s, respectively. A turbo-FLASH (fast low-angle shot imaging) sequence was used as a test bolus sequence to determine the transit time of the contrast from start of injection to volume of interest. Head and neck coils were used for imaging.

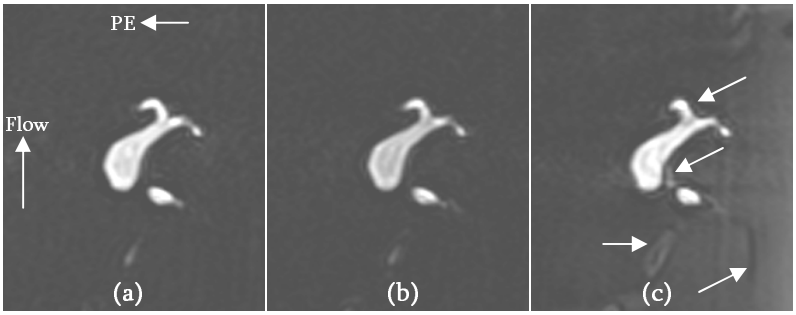

Figure 1. Images acquired with **(a)** linear, **(b)** centric, and **(c)** radial centric-out trajectories with shorter injection. Note artifacts in the radial reordering scan (arrows).

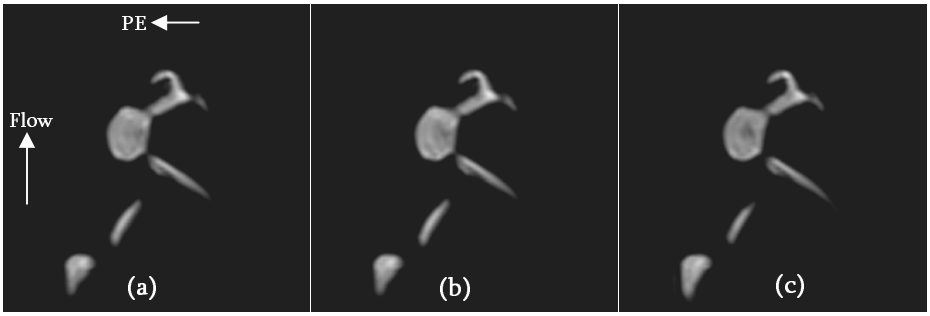

Figure 2. Images acquired with **(a)** linear, **(b)** centric, and **(c)** radial centric-out trajectories with longer injection.

Results

For the shorter bolus of contrast agent, the radially centric-out trajectory shows artifacts (see arrows, Fig. 1) because the T1 is rapidly changing through the data acquisition and the central part of k-space is being sampled throughout the scan. Linear or centric reordering on the other hand sample the central k-space at a unique time and do not show these artifacts. The effect of varying T1's in these reordering schemes is spatial blurring. For the slower injection, the total injection duration is much longer and some signal enhancement lasts for almost the entire scan duration. The data in this case do not show obvious artifacts.

The SNR enhancement over pre-contrast was 179% for linear reordering (73.81 post vs. 26.41 pre), 105% for centric reordering (75.98 post vs. 37.05 pre), and 65% for radially centric-out reordering (65.42 post vs. 42.29 pre). Radial reordering shows lower signal enhancement compared to linear or centric for the same reason that central k-space region is sampled throughout the scan. The baseline SNR for linear reordering is less due to saturation, which explains the higher percent increase for linear reordering, despite the absolute post-contrast SNR being similar to that of centric (73.81 vs. 75.98).

Discussion

Results show that the radially centric-out trajectory is sensitive to T1 (or signal) changes during acquisition because the central area of k-space is sampled throughout the scan duration. If the T1 is not changing significantly during the scan duration, then the artifacts are minimized. Post-contrast signal enhancement is reduced in radially centric-out acquisition, as compared to linear or centric, if the T1 is changing during the scan.

References

1. Jansen SA, et al. Med Phys 2008, 35(7):3102-9.