Interactive Contrast Switching during Real-time MRI

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Introduction:

Recent advances in hardware and pulse sequence development have led to the use of MRI to perform interventional procedures. MRI has been used to guide biopsies [1], track catheters [2] and to aid the placement of stents [3]. Recently, real-time MRI was used to guide the placement of catheters for the local delivery of drugs [4]. Especially for this application, two different image contrasts are required. Firstly, a steady state free precession (SSFP) contrast is needed for the visualization of the catheter and the anatomy and secondly, a spoiled gradient echo (SPGE) contrast for the visualization of the inflowing contrast agent. The interactive contrast switching was tested for cartesian and radial acquisitions.

Materials and Methods:

In an SSFP sequence, all gradients are balanced resulting in the superposition of spin echo and gradient echo signal contributions, whereas the spin echo contribution is destroyed in spoiled gradient echo techniques by applying gradient- and RF-spoiling. Therefore, both sequences can be converted into each other by changing the sign and amplitude of a gradient lobe as well as by toggling the RF-spoiling (Fig.1). These modifications are possible during real-time scanning in the interactive scan mode of our clinical 1.5 T MR scanner (Philips INTERA). In addition to contrast switching, the interactive mode allows the real-time control of sequence parameters such as slice position and angulation, in-plane off-center, excitation flip-angle, etc. Continuous real-time sliding window image reconstruction [5] was performed with a frame rate of 20 images per second. Interactive contrast switching was tested for radial and cartesian acquisitions. In a FOV of 300mm, images with a numerical resolution of 128^2 were obtained using a TR of 2.8ms and flip angles of 60° in SSFP mode and 45° in SPGE mode. A contrast agent (Magnevist, Schering) was injected into a vessel phantom during real-time imaging to simulate selective angiography [6]. In a second experiment, the contrast agent was injected into a piece of meat during real-time imaging to simulate a local drug delivery application [4]. The interactive contrast switching was also applied to a cardiac function study performed on a healthy volunteer. In the latter application, a flip angle of 20° was used in the SPGE mode.

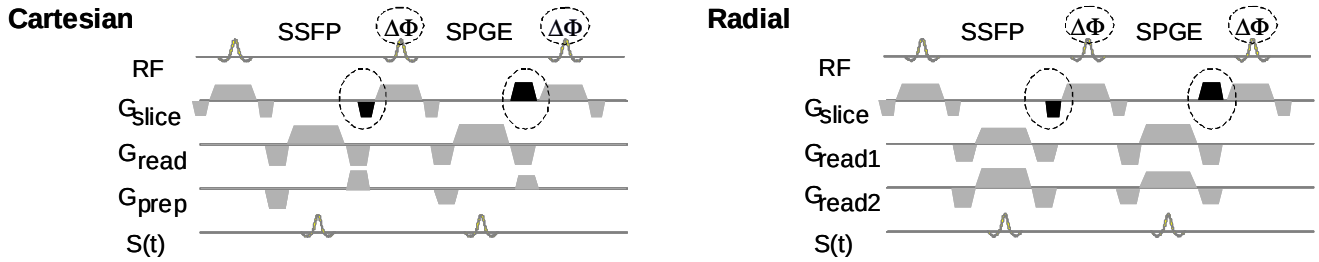

Fig 1: Real-time conversion of an SFFP sequence into a SPGE sequence by changing the slice pre-phaser gradient into a spoiler gradient and by applying RF-spoiling in form of RF-phase cycling.

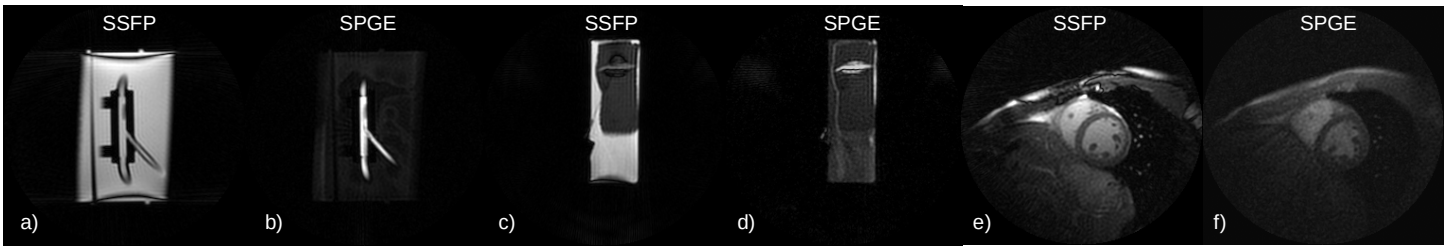

Fig.2: Real-time frames acquired with SSFP and SPGE contrast. (a,b) mimic a selective angiography application by injecting contrast agent into a vessel phantom. (c,d) simulate a local drug delivery by injecting contrast into a piece of meat. (e,f) show a cardiac function study but without contrast agent.

Results and Discussion:

Figure 2 shows frames of real-time movies using the radial acquisition method. The SSFP contrast provides superior contrast e.g. for the guidance of catheters and needles, whereas the SPGE mode provides a strong T1-contrast e.g. enhancing the injected contrast agent. In contrast to the Cartesian acquisition, radial imaging results in better image quality, since each radial readout samples the central k-space, and thus, image contrast is updated more frequently. This behaviour is also beneficial for the transient image quality when switching between the two sequences, i.e. for a fast and smooth transition from one image contrast to the other.

Conclusion:

Interactive contrast switching between an SSFP and an SPGE acquisition mode provides good image contrast for guidance of instruments as well as the visualization of injected contrast agents during real-time scanning. In comparison with a Cartesian acquisition, interactive contrast switching during radial real-time imaging results in better image quality. The technique has great potential for real-time MRI-guided drug delivery.

References:

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