VERSE-SPACE

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Introduction

Use of nonselective refocusing pulses shortens the echo spacing and the echo train duration, and then improves the image sharpness in SPACE [3, 4] imaging. However, the nonselective refocusing pulses limit the application of slab selective acquisition. To overcome this limitation, a dual echo-spacing technique [1] has been presented before, using a combination of selective excitation and non-selective refocusing. As shown in Figure1, a long duration, selective excitation RF pulse provides high quality slab profile; the first echo spacing is extended to accommodate the duration of the first pulse and the remaining echo spacings are kept as short as possible concerning only the refocusing pulse duration and gradient performance. However, to eliminate the FID artifacts from non-selective refocusing pulses, a two-step phase cycling procedure is needed wherein the phase of refocusing pulses will be incremented by 180 degree between averages, which results in doubling the measurement time. More over, the use of non-selective refocusing pulses limit the multi-slab acquisition scheme, which is a promising techniques to further improve the sampling efficiency and contrast purity of SPACE, especially in PDw and T1w imaging. In this abstract, a new SPACE technique using the variable-rate selective excitation and refocusing pulses (VERSE) [2] is presented (VERSE-SPACE).

Methods

For VERSE-SPACE, both the excitation pulse and all refocusing pulses are replaced by selective VERSE pulses. These selective pulses have less than 3 side lobes to provide medium quality slab profile and very short pulse duration, which is further compressed by VERSE technique. Figure2 shows a comparison between a conventional selective pulse and VERSE pulse: the side lobes of the VERSE pulse are compressed while the main lobe is stretched.

Results

Phantom experiments were performed on a 3T clinical system (MAGNETOM Verio, Siemens, Erlangen). For the dual echo-spacing mode, the duration of the excitation pulse is 10.752ms, and the duration of the non-selective refocusing pulses is 0.9ms. Echo spacing = 3.34ms, averages =2, slice oversampling =0%; turbo factor =40; total acquisition time 1min41sec; For VERSE-SPACE, the duration of excitation pulse and all refocusing pulses is 1.024ms; Echo spacing = 4.17ms; turbo factor =38, averages =1; slice oversampling factor = 30%; total acquisition time = 1min9sec; Other imaging parameters are identical. The phantom consists of an oil and a water bottle. Figure3 shows the phantom (left), the image from dual echo-spacing technique (middle) and the image from VERSE-SPACE (right). In the middle image, a dramatic position shift of the actual excited slab can be observed in the oil phantom, which is due to the chemical shift of the oil signal and the using of long duration, low bandwidth excitation RF pulse in dual echo-spacing technique. However, this problem is not visible in VERSE-SPACE. Both techniques were then tested in a volunteer on a 1.5T clinical scanner (MAGNETOM ESSENZA, Siemens Mindit Magnetic Resonance Ltd, Shenzhen). In Figure4 shows coronal reformatted images through the 3D volume: the fat signal in the first several slices was not excited in dual echo-spacing mode. However VERSE-SPACE provides high quality excitation profile for both fat and water signals.

Discussion

Using the dual-echo spacing technique, the first several slices (about 20% in the experiments) have to be discarded due to actual excited slab shift in fat signal, which introduces aliasing artifacts if performed without slice oversampling (red arrow in Figure3). In addition, the dual-echo spacing technique needs averaging with phase cycling procedure to suppress the FID artifacts from non-selective refocusing pulses, which dramatically increases the total acquisition time. In VERSE-SPACE, the echo spacing is just increased by 0.8ms, compared to that in dual-echo spacing technique, but total acquisition time is clearly reduced by more than 30%. About 30% of slice oversampling in VERSE-SPACE (RF pulse with two side lobes) is sufficient to avoid the aliasing artifacts. In general, VERSE-SPACE is more stable against chemical shift and can provide faster slab selection acquisition compared to the dual echo-spacing technique.

References

[1] Mugler, ISMRM 2004, p695;
[2] Conolly S, JMR 1988; 78; 440-458;
[3] Mugler, MRM, 1990;
[4] Mugler, ISMRM 2006, p2429;

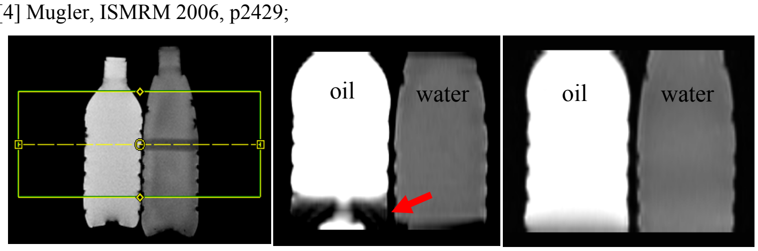

Figure3. Left: the yellow box in the localizer image shows the desired slab selection. Meddle: Using the dual echo-spacing technique, the actual excited slab was obviously shifted in the oil phantom. Right: VERSE-SPACE with very good slab profile.

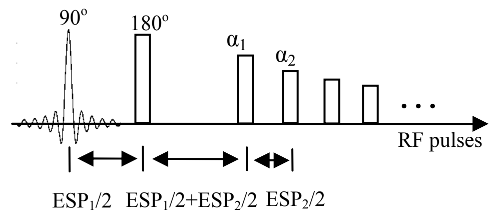

Figure1. The diagram of dual echo-spacing technique for slab selective acquisition; A two-step phase cycling procedure is needed to eliminate the FID artifacts from non-selective pulses.

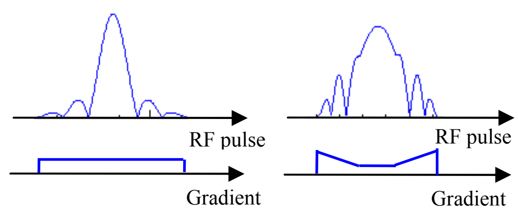

Figure2. Left: normal selective RF pulse; Right: variable-rate selective RF pulse (VERSE)

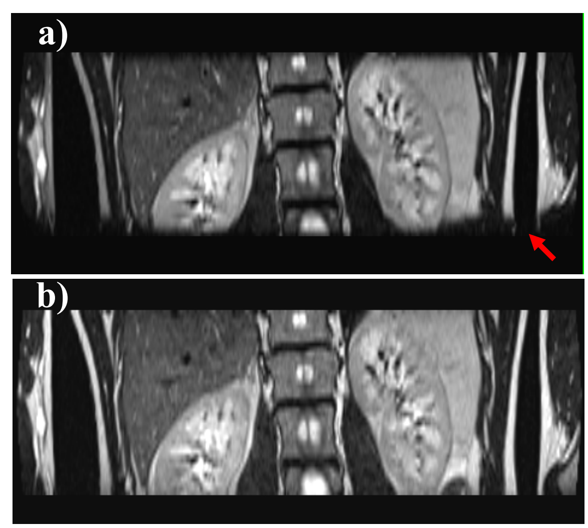

Figure4. Reformatted slab profile from T2 weighted abdomen image; a) acquired by dual echo-spacing technique. The fat signal was not excited in the first several slices (red arrow); b) VERSE-SPACE: good slab profile.