T2* Weighting in Fast Spin Echo Images

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Introduction

By collecting several lines of *k* space every TR with a Carr-Purcell echo train, fast spin echo (FSE) imaging (1) provides imaging the same benefits that Carr-Purcell trains provided spectroscopy--T2 weighting and speed. T2, rather than T2*, affects spin echo amplitude. Therefore, when spin echoes in an FSE sequence occur at exactly the time of the gradient echoes (which contain the spatial information and hence lead to images) FSE images are not T2* weighted. These spin and gradient echoes have been offset from one another, e.g. to suppress fat (2) or to increase speed (3). Here we report echo offsets to add T2* contrast to FSE images. T2* weighting sensitizes images to blood oxygenation, trabecular bone density, superparamagnetic contrast agents, and endogenous iron collections. Gradient echo imaging is also fast and T2* sensitive but, in arterial wall studies, FSE combines more readily with black blood.

Method

Advancing the 90º pulse in FSE imaging offsets each spin echo from its corresponding gradient echo by the amount of the advance (Fig 1). T2* effects grow between FSE spin and gradient echoes, as during the TE period in gradient echo imaging.

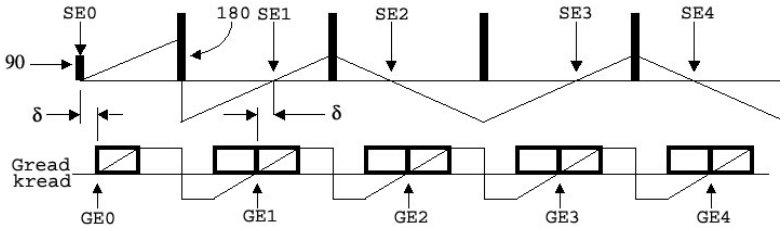


Figure 1. FSE sequence with offset between gradient and spin echoes.

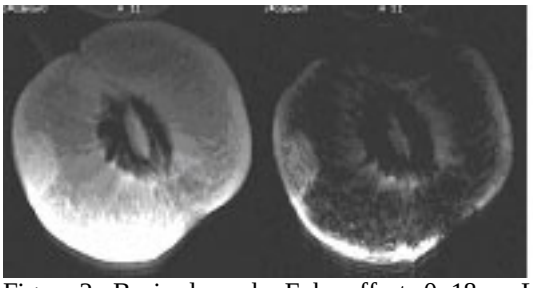
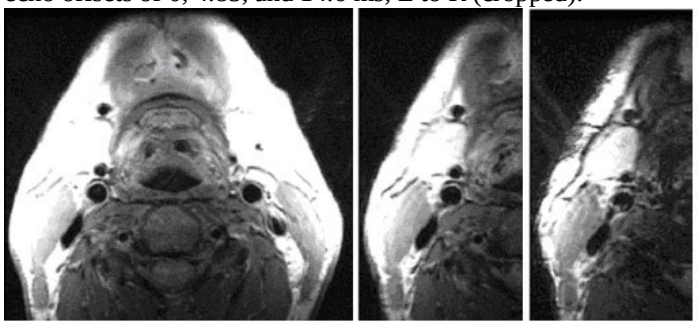


Figure 2. Bruised peach. Echo offsets 0, 18 ms L to R.

Results

The peach in Fig 2 shows a bruised portion, not noticed visually, with longer T2* than the surrounding tissue. Figure 3 shows the carotid artery of a healthy volunteer without a contrast agent. In these triggered, black blood images, the wall is easier to assess than in bright blood gradient echo images with equivalent T2* weighting (Fig 4).

Figure 3. Cardiac triggered, double IR, black blood images with echo offsets of 0, 4.85, and 14.6 ms, L to R (cropped).



Discussion

T2* weighting for FSE sequences is attractive when both T2* and the usual FSE T2 weighting are useful. Because heavy, endogenous iron deposits, superparamagentic contrast agent collections in lymph nodes or arterial walls, and moving, deoxygenated red blood cells all contribute to reversible and irreversible transverse relaxation, T2* weighted FSE is promising for these.

Shifting either spin or gradient echoes adds T2* weighting. Here, half the gradient echoes follow their spin echoes, the other half precede them. This difference leads to some ghosting, which is seen the figures. Even without correction effort, the T2* contrast may be stronger than the ghosting, as in the peach. (1/T2* is not expected to be important in arteries without disease or a contrast agent.). Offsets divisible by 4.8 ms ensure fat and water are in phase (at 1.5T) and prevent their interfaces from causing ghosts. Other ways of offsetting echoes may reduce ghosting, but limit the offset to the time between 180º pulses or half that time. There is no limit to the offset attainable with the method of fig 1.

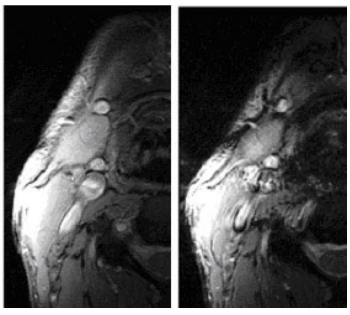


Figure 4. Gradient echo images, TE of 4.9 and 14.6 ms, L to R corresponding to Fig 3 offsets (cropped).

Literature

(1) Hennig, et al, MRM 3:823-33(1986). (2) Ma, et al, MRM 48:1021-7(2002). (3) Oshio, et al, MRM 30:251-4(1992).

This work was supported by Ohio BRTT grant BRTT02-0022.