Rapid Field-Cycling MRI using Fast Spin-Echo

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Introduction: Fast Field-Cycling MRI (FFC-MRI)[1] is an emerging technique that aims to combine the capabilities of MRI and FFC-NMR by making it possible to rapidly vary B_0 during an imaging sequence. Conventional relaxometric imaging is limited by lengthy scan times, since to estimate R_1 at least two images (i.e. IR and SR) must be acquired at each field strength. In this work we describe an adaptation of the well known Fast Spin-Echo imaging sequence[3] for FFC-MRI, named Field-Cycling Fast Spin Echo (FC-FSE) which enables relaxometric imaging in a fraction of the time that would otherwise be required.

Methods: Imaging was carried out on a home-built whole-body field-cycling imager with a 59 mT detection field[4]. The system uses a commercial console (SMIS Ltd., U.K.).
For each experiment a saturation recovery and inversion recovery image are acquired at the detection field. A single field-cycling inversion recovery image is then acquired for every evolution field of interest. R_1 is estimated at each field using a two-point method. For validation of results relaxometry was also performed on small samples using a commercial bench-top field-cycling relaxometer (SMARtracer, Stelar s.r.l., Italy).

Results: There is good agreement between the R_1 dispersion results (Figure 1) obtained using the FC-FSE sequence and those obtained using the relaxometer for a phantom consisting of crosslinked bovine serum albumin (BSA). FC-FSE images from a volunteer's thighs using an echo train length of 4 (Figure 2) exhibit virtually no artifacts from field-instability. A dispersion curve (Figure 3) obtained from the outlined region-of-interest in muscle shows pronounced quadrupole peaks, arising due to ^{1}H-^{14}N cross-relaxation in immobile protein molecules within the muscle. The total scan time was ~30 minutes compared to the 4 hours that would have been required using conventional relaxometric imaging.

Conclusions: This work has demonstrated that relaxometric imaging can be performed up to 8 times faster relative to the basic procedure, with virtually no sacrifice in the accuracy of R_1 determination. This paves the way for clinical relaxometric studies with acceptable scan times.

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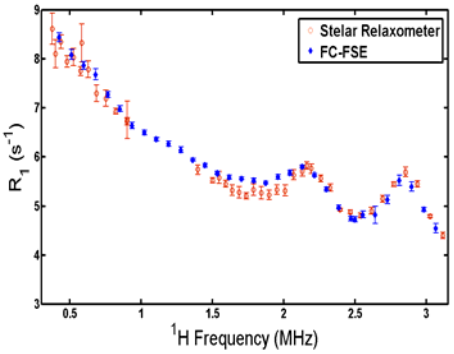

Figure 1: Dispersion curves for a phantom of cross-linked BSA obtained using the FC-FSE sequence (solid dots) show good agreement with results from a commercial relaxometer (open circles).

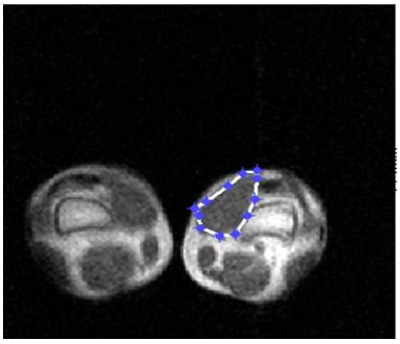

Figure 2: Image of a volunteer's thighs obtained using the FC-FSE sequence with a speed up factor of 4. RoI delineates muscle, from which a dispersion curve was obtained.

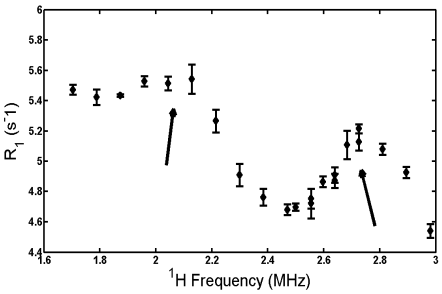

Figure 3: R_1 dispersion curve for the RoI shown in Figure 2. The quadrupole peaks arising due to immobile proteins in muscle are clearly visible (see arrows).

References

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