Clinical applications of Fast Field-Cycling techniques

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Fast Field Cycling (FFC) has been used for more than half a century in NMR research. This technique consists in changing the magnetic field experienced by a sample in a time shorter than T_1, typically by the use of sample shuttling or by careful control of a resistive magnet. With such a device one can measure how T_1 fluctuates with the magnetic field (Figure 1). This apparently simple strategy provides a surprising quantity of information, from the characterisation of materials [1] to the optimisation of imaging contrast [2].

One particular mechanism that can be detected by FFC NMR is the cross-relaxation between quadrupolar nuclei and protons. In particular, nitrogen 14 in biological tissues is known to generate localised dips in the T_1 dispersion profile that are quantitative markers of the presence of proteins [3]. This signal has been observed in a wide variety of tissues and appears consistently in the same region of the T_1 dispersion curve.

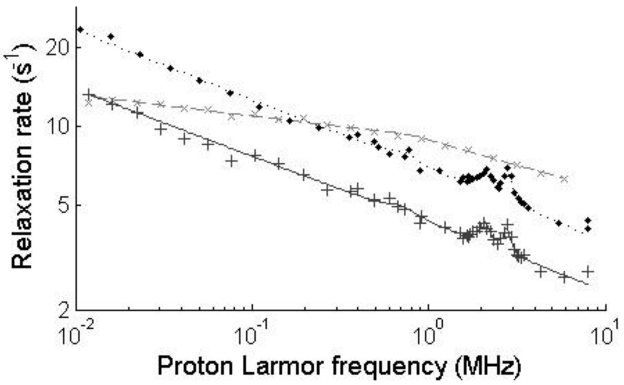

Figure 1: Dispersion curves from breast samples taken far from (light crosses), next to (dark crosses) and within (dots) a lobular carcinoma after fixation. Large variations can be seen in the shape of the dispersion curve even though the samples of breast tissues presented similar appearance under the microscope

Our research team has started a series of translational works aiming to bring FFC MRI into clinics thanks to novel designs of MRI scanners that allow flexible use of the magnetic field [4]. We have successfully used FFC techniques in the context of cancer, muscle damage, thrombosis and osteoarthritis in several pilot studies [5,6] that showed great potential for the detection of protein aggregates. In particular, we found that the quadrupolar cross-relaxation can be used to quantify the weakening of the cartilage structure in the context of osteoarthritis, shows the diffusion of proteins around tumours and can differentiate between healthy, damaged and swollen muscle tissues. It also appeared that the general shape of the dispersion curve, which relates to the microstructure of the tissue, is a likely predictor of survival rate in breast cancer.

This presentation will focus on the results obtained from these pilot studies, their interpretation and how we can apply FFC MRI in clinical context.

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*These references are available at http://www.ffc-mri.org/publications

British Chapter ISMRM 20th Annual Scientific Meeting, Edinburgh, September 2014, pPP1A.