Detection of tissue remodelling by fast field-cycling methods

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Keywords:

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Purpose:

Fast Field-Cycling (FFC) extends the potential of MRI by allowing measurement of T_1 over a range of field strengths, typically between 20 uT and 0.2 T. It is a rich technique that is able to characterise physico-chemical properties with applications in polymers, porous media or liquid crystals, to cite a few (1)
Our research group aims to translate FFC to MRI (2) and has developed innovative FFC-MRI scanners, two of which are whole-body scanners currently in operation. Here we describe our findings from 6 years of experimentation with clinically-relevant pilot studies using FFC-MRI and FFC-NMR on various human tissues.

Subjects and Methods:

Pilot data were collected using a benchtop FFC-NMR relaxometer (SMARtracer, Stelar s.r.l., Italy) on small (~1 mL) tissue samples obtained from surgery, focusing on the diseases listed in the table. When positive results were observed, more comprehensive follow-up FFC-MRI studies were conducted based on the relaxometry results.
All of the studies were reviewed by the local ethics committees (CERB and NoSREC).

Study	Sample size	Type of tissues	State
Osteoarthritis	90 resections	Femoral heads and knee joints	Normal and grade 3
Breast cancer	10 mastectomies	Ductal and lobular carcinomas	Low to high grades
Musculoskeletal sarcomas	10 resections	Sarcomas	Low to high grades
Muscle damage	10 volunteers	Gastrocnemius	Healthy volunteers
Thrombosis	10 *in vitro* preparations	Fibrin clots	
Liver cancer	6 resections	Healthy and tumorous liver	Low to high grade

Results:

Several biomarkers appeared from our studies: the shape of the dispersion curve, which varies dramatically from healthy tissues in all the tumours observed and particularly at very low fields, the presence of the so-called quadrupolar signal (3), which was shown to quantify the amount of fibrin and to characterise the state of the collagen matrix in osteoarthritis, and the offset of the dispersion curve, which is closely related to tumour grade in breast carcinomas.

Conclusion:

This work shows that FFC-MRI is able to detect disease-related protein modifications in tissue quantitatively. Several biomarkers have been extracted that are closely linked to biologically relevant information, and probably to the extra-cellular matrix. More work is ongoing in order to explore other pathologies and to better explain the pathways that connect the biomarkers and the diseases.

References:

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