Analysis of musculoskeletal and breast tumours by fast field-cycling MRI

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Purpose

Fast-field cycling MRI (FFC-MRI) is a new imaging technique that allows varying the main magnetic field during a scan in order to explore tissue properties over several decades of magnetic field strength. This technique opens up many possibilities for new molecular-based contrast in images [1] and benefits from active research in NMR that has shown its great versatility. In particular, field-cycling allows non-invasive and contrast-agent-free detection of certain immobile proteins thanks to cross-relaxation effects between water protons and ^{14}N, which is already being used in other studies [2, 3]. It is also possible to measure the evolution of T_1 with the magnetic field strength and the dispersion curve obtained provides information at molecular scale [4].

Here we present the results of a pilot study that aimed to exploit the molecular information provided by FFC-MRI in order to analyse the contrast obtained *ex* vivo from tumours extracted from human musculoskeletal or breast tissues.

Methods

Specimens were obtained from surgery after patient consent with a target of 10 samples of musculoskeletal and 10 breast tumours. The specimens were fixed in formalin for 4 to 7 days as normal procedure and then scanned by FFC-MRI using a pre-polarised spin-echo sequence on a 59 mT field-cycling scanner developed at the University of Aberdeen [5]. Then normal histology procedures followed during which several samples were taken from well-defined areas and analysed by FFC-NMR in order to obtain precise dispersion profiles between 0.2 mT and 0.2 T using a benchtop FFC-NMR relaxometer (SMARtracer, Stelar, Italy). The features measured from the dispersion curves were then analysed and correlated with anonymous data from the patients such as age, sex or tumour type and grade.

Results

The data collected showed two particularly relevant features: a quadrupolar signal is present in all tumour samples, indicating protein agglomerations, and the profile of the dispersion curve over 3 decades of magnetic field varies greatly between tissue types, as expected from the correlation between the dispersion curve and the cellular organisation within the tissue. Tumours also showed dispersion profiles with similar shapes regardless of their origin, with a marked offset between sarcoma and carcinoma.

Conclusions

FFC-MRI demonstrated capabilities in the detection of tumours and presents some interesting contrast that relates directly to tumour type. More studies will performed to test this imaging platform as a potential tool for non-invasive characterisation of tumours.

References

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Study approved by the North of Scotland Research Ethics Committee.