Enhancing Fluorine-19 MR Signal Sensitivity at 21.1 Tesla for Better Detection of Brain Inflammation

Waiczies, S. (Max Delbruck Center for Molecular Medicine, Berlin Ultrahigh Field Facility); Rosenberg, J.T. (NHMFL); Starke, L., Delgado, P.R., Prinz, C., Millward, J.M. (Max Delbruck Center for Molecular Medicine, Berlin Ultrahigh Field Facility); Kuehne, A., Waiczies, H. (MRI Tools GmbH, MRI Coils); Pohlmann, A. (Max Delbruck Center for Molecular Medicine, Berlin Ultrahigh Field Facility) and Niendorf, T. (Max Delbruck Center for Molecular Medicine, Berlin Ultrahigh Field Facility, Experimental & Clinical Research Center)

Introduction

Although the absence of background signal is an advantage in ^{19}F MRI, the low abundance of ^{19}F nuclei *in vivo* poses a major challenge for MRI detection. We have reported on sensitivity gains achieved using a cryogenic quadrature RF probe (^{19}F-CRP)[1]. Another way to improve signal sensitivity is to increase the strength of the static magnetic field (B_0)[2], a strategy actively pursued for clinical application[3]. Here we investigated SNR changes when increasing B_0 from 9.4 to 21.1 T together with TR and flip angle dependency in phantoms and in *ex vivo* tissue of an experimental autoimmune encephalomyelitis (EAE) animal model.

Experimental

Experiments were carried out at 9.4 T (B.U.F.F, Berlin Germany) and at 21.1 T (NHMFL). Two volume coils and a ^{19}F-CRP were used at 9.4 T and one volume coil at 21.1 T. SNR measurements were performed with perfluoro-15-crown-5-ether (PFCE) using a 2D-FLASH with varied TR (14-5000 ms) and TE=4.2ms (FA=5°-90°). SNR was calculated by dividing the magnitude images signal (S_m) by the background standard deviation (σ_m). Animal experiments were carried out in accordance with local animal welfare guidelines. EAE was induced in SJL/J mice and *ex vivo* brain tissue was scanned with 3D-RARE ^{19}F MR using TR/TE=800/4.9ms and 256 averages. ^{1}H scans were acquired using FLASH with TR/TE=150/7.5ms and two averages.

Results and Discussion

^{19}F MRI at 21.1 T revealed greater detection of inflammation in the brain and lymphatic system of EAE mice compared to 9.4 T (**Fig.1**). T_1 for PFCE decreased with increasing B_0 $T_{1|9.4T}$=778ms and $T_{1|21.1T}$=409ms (**Fig.2A &B**). The gain in effective SNR for 21.1 T compared to 9.4 T was a factor of 6.95-7.29, depending on the parameters used. Since higher B_0 resulted in lower T_1 values, we distinguished between B_0 and T_1 influencing factors by comparing SNR_{eff} for both fields. The B_0 effect on SNR_{eff} gain was 5.25 (SNR_{eff} $max_{|21.1T}$=505 and SNR_{eff} $max_{|9.4T}$=96) while the T_1 shortening effect was 1.3. SNR of phantoms acquired with the two body coils are shown in Fig 2 and show increased SNR at 21.1 T.

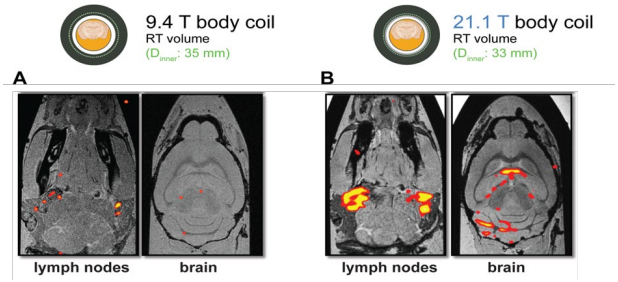

Fig.1: More regions of inflammation are visible at 21.1 T (**B**) compared to 9.4 T (**A**) using the same acquisition methods.

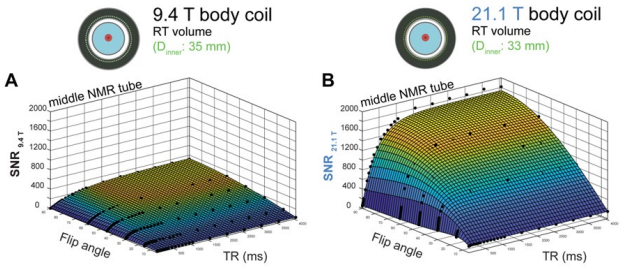

Fig.2: Comparison of SNR between 9.4 (**A**) and 21.1 T (**B**) for PFCE using 2D-FLASH

Conclusions

An increase in B_0 resulted in increased SNR efficiency, partially due to a T_1 effect but mainly due to the B_0 effect. Because of the SNR increase, inflammatory regions in brain and lymph nodes not detected at 9.4 T were revealed at 21.1 T.

Acknowledgements

The NHMFL is supported by the NSF through NSF/DMR-1157490/1644779 and the State of Florida. Support also provided by the NHMFL Visiting Scientist Program and, the Deutsche Forschungsgemeinschaft (DFG WA2804, DFG PO1869).

References

[1] Waiczies, S., *et al.,* Scientific reports, **7**, 9808 (2017).
[2] Ladd, M.E., *et al.,* Zeitschrift für Medizinische Physik, **28**, 1-3 (2018).
[3] Niendorf, T., *et al.,* MAGMA, **29**, 309-311 (2016).