

Signal-to-noise ratio optimization for radial acquisition in ^{23}Na magnetic resonance imaging

Authors: Minne Romane, Lamalle Laurent, Phillips Christophe, Zubkov Mikhail

Introduction

Sodium MRI suffers from inherently low signal-to-noise ratio (SNR), making acquisition sequence adjustment critical. Conventional SNR optimization relies on the Ernst angle, which maximizes signal for given T_1 and repetition time (TR), but does not address practical constraints such as specific absorption rate (SAR) and total acquisition time (TA). We propose a framework to maximize SNR while accounting for these constraints.

Methods

A theoretical model describing SNR in a steady-state sequence as a function of TR, flip angle (FA), and number of radial projections (N_p) was supplemented by TA and SAR constraints, reducing the optimization problem to a single variable (TR). From the optimal TR, determined numerically, FA and N_p were derived. The model was validated experimentally using a homogeneous phantom ($T_1 \approx 50\text{ms}$) on a 7T MRI system with a k-space sampling density-adapted 3D radial acquisition.

Discussion

Experiments confirmed the predicted relationships between SAR, FA, TR, N_p , and SNR. Under fixed TA (6min13s) and SAR (3.2 W/kg), the optimal parameters were TR = 25ms, FA = 38° , and $N_p = 14698$. The optimized acquisition achieved 93.8% of the theoretical SNR obtained using the Ernst angle while satisfying SAR and acquisition time constraints. It outperformed all non-optimized acquisitions.

Conclusion

This framework enables practical SNR optimization in ^{23}Na MRI by considering both SAR and TA. Reducing the optimization to a single parameter simplifies sequence design and improves acquisition efficiency, with potential applications in both clinical and research sodium MRI.