Simultaneous 23Na/1H Imaging with Dual Excitation and Double Tuned Birdcage Coil

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Introduction

The tissue concentration of sodium is sensitive to disease as an indicator of cellular and metabolic integrity [1]. Due to the low 23Na MR signal level, however, relatively long scan times are required. Furthermore, an additional 1H image in needed for an anatomic co-registration. In this context, a truly simultaneous acquisition of the 23Na and 1H signal would be helpful to reduce the scan duration and avoid misregistration between the sodium and proton image. Furthermore, dual-tuned coils eliminate the need for retuning the coils, or replacing coils during examination, which would require some sort of mechanical fixation of the subject [1]. In this study, an MR sequence with dual Nuclei excitation and simultaneous sampling on the 23Na and 1H frequency was implemented, and a dual-tuned transmit/receive coil was used to enable simultaneous 23Na/1H imaging. First *in vivo* examples were obtained in a human knee to demonstrate the basic feasibility of true simultaneous 1H/23Na imaging.

Methods

Sodium and proton images were acquired simultaneously on a clinical 3T scanner (Philips Healthcare, Best, The Netherlands) equipped with a modified acquisition software and a dual-tuned 23Na/1H birdcage transmit/receive coil (Rapid Biomedical, Würzburg, Germany). A 3D Cartesian spoiled gradient echo sequence (FFE, TR/TE=8ms/2.25ms, α=15°, matrix size 256 x 256, 10 slices, 24 averages, total scan time 11 minutes) was used, where a dual RF excitation and sampling on the 23Na and 1H frequencies was performed. A schematic plot of the employed MR sequence is shown in Fig. 1. Due to the simultaneous acquisition of two nuclei within a single readout, the individual FOV and resolution are scaled with the respective gyromagnetic ratios (γ_{23Na}= 17.25 MHz/T, γ_{1H} = 42.58 MHz/T). The resulting spatial resolution was 0.8 x 0.8 x 10mm for the proton image, and 2x2x10mm for the sodium image. First *in vivo* images of the knee were acquired in 3 healthy adults. Written informed consent was obtained from all participants. The images were re-scaled retrospectively to a uniform FOV using the known gyromagnetic ratios of 1H and 23Na.

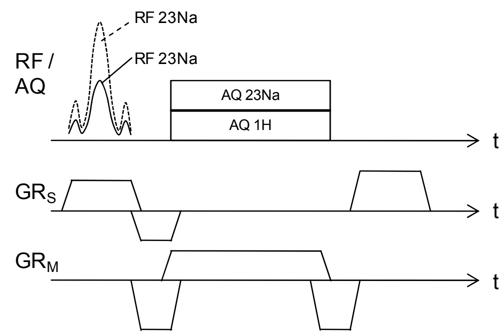

Fig. 1 Schematic plot of simultaneous 1H /23Na sequence. The RF pulses are played simultaneously on the respective resonance frequencies. Sampling is performed simultaneously on separate receive channels.

Results and discussion

All experiments were completed successfully, and selected *in vivo* results, where 1H and 23Na images were simultaneously obtained, are shown in Fig. 2[a] and [b], respectively. A fusion image of the proton image and the color-coded 23Na image is shown in Fig. 2[c]. The elevated 23Na levels in cartilage were clearly visualized.

Conclusion

So far, simultaneous dual-frequency sequences have been used for spectroscopy (proton decoupling), or Overhauser imaging, or recently for the simultaneous acquisition of 19F and 1H [2]. In this study, first results for true simultaneous 1H/23Na imaging using a dual-tuned coil are shown. The simultaneous technique overcomes the need for an additional 1H scan and eliminates the risk of misregistration of the sodium and proton image. The basic sequence implementation used in the present study offers a large potential for further optimization. Non-Cartesian FID sampling strategies should be employed to reduce the echo time (TE) and allow to assess fast decaying sodium components [3]. Furthermore, non-Cartesian sampling may be favorable with respect to potential backfolding artifacts in the proton image with inherently smaller FOV. Alternatively, multi-element 1H coils in concert with parallel imaging could be employed to unfold the proton image.

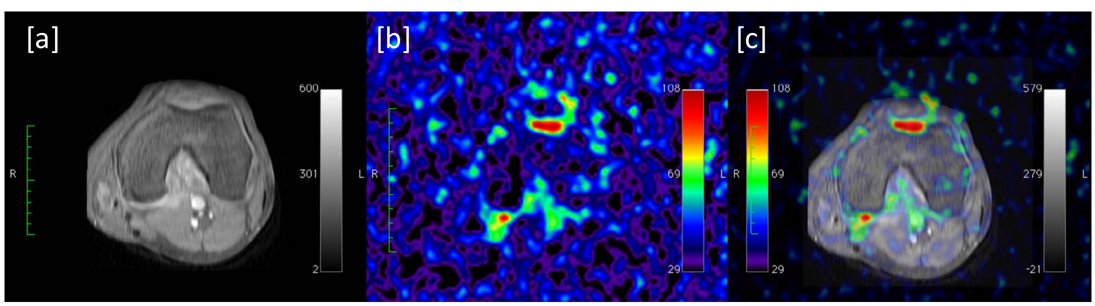

Fig. 2 Simultaneously acquired proton image [a], color-coded 23Na image [b], and overlay of anatomy and 23Na level [c]. The elevated 23Na level in cartilage is clearly visualized in the overlay image.

References:
[1] Ouwerkerk R et al, Radiology 2003; 227(2):529-37
[2] Keupp J et al, Proc ISMRM 14, p. 102 (2006)
[3] Rahmer J et al, Magn Reson Med. 2006; 55(5):1075-82