Improving the resolution of SPRITE for *in vivo* ^{23}Na Imaging: A comparison of Conical-SPRITE vs Sectorial-SPRITE

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Introduction

The local Tissue Sodium Content (TSC) (1) is an important indicator of disease grade and tissue viability and therefore its measurement with *in vivo* sodium MRI is very promising. However, the large quadrupolar moment of the ^{23}Na nucleus (I = 3/2) causes biexponential signal decays of the order of a few milliseconds when it is found in tissue. Therefore special imaging methods such as TPI, 3D Radial imaging and more recently SPRITE are required (2-4). In this work, *in vivo* ^{23}Na images of the human brain acquired using Conical- and Sectorial-SPRITE are compared in terms of their final resolutions. The Conical-SPRITE images show very good signal-to-noise ratios but are characterized by blurring which prevents precise anatomical identification. Sectorial-SPRITE in contrast, provides images with finer anatomical details but need slightly longer acquisition times. Sectorial-SPRITE has the advantage of a reduced gradient duty cycle.

Methods

The SPRITE sequences were programmed on a whole-body 4T Unity *Inova* scanner (Varian, Palo Alto, CA) with a maximum gradient amplitude of 40 mT/m and 200 mT/m/ms of slew rate. The RF probe was a home-built 4-rung birdcage coil. Experiments were carried out on a healthy volunteer.

Conical SPRITE trajectories

Figure 1A shows the k-space trajectories used for Conical-SPRITE. A series of N nested cones (N=13 in this work) were used. Each trajectory started from the centre of k-space and spiraled out on the surface of a cone (5). The pitch angle varied from cone to cone. The number of k-space points sampled varied with the cone from a minimum of 12 to a maximum of 667. The percentage of available point sampled was 16%

Sectorial SPRITE trajectories

Figure 1D shows the k-space trajectories used for Sectorial-SPRITE. Here, each trajectory started from the origin and sampled a small sector of k-space (6). The same trajectory was then repeated with different orientations to sample the whole k-space. In this work N=149 orientations were used and the number of k-space points acquired per sector was 94. The percentage of available k-space point sampled was 44%.

In both SPRITE sequences, *M* multiple FID points were acquired at each location in k-space at a time tp following a non-selective RF excitation pulse. The excitation-detection paradigm was repeated for each k-space point of each trajectory. A dynamic reduction of repetition time was used in both cases to cancel the effects of residual transverse magnetization. The acquired data produced *M* independent k-spaces of slightly different fields-of-view (FOV). By means of a chirp-z transform the images were re-zoomed to a common FOV and signal averaged. For both acquisitions the following parameters were used: FOV=240×240×240mm, matrix size = 32×32×32 (voxel volume of 421.87mm^3), t_p=0.3 ms, TR=10 ms, flip=3°, sw=29kHz, *M*=20, dwell time=18.8 µm. The acquisition times were 16 and 20 min for Conical- and Sectorial-SPRITE respectively.

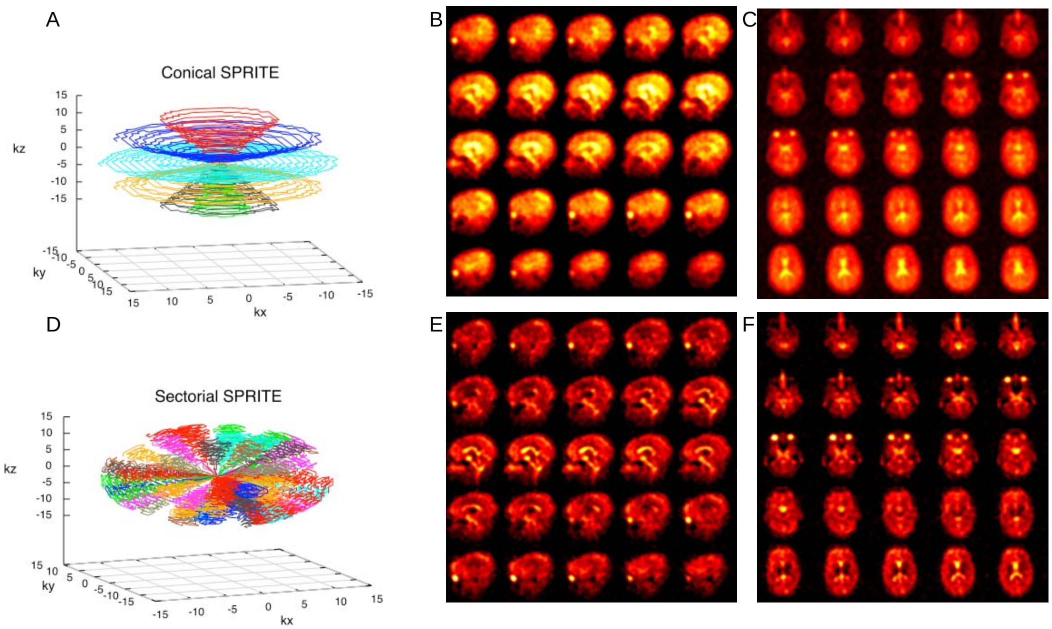

Fig. 1. A) Cartesian trajectories for Conical SPRITE. B-C) Conical SPRITE images in the sagittal and transaxial orientations. D) Sectorial SPRITE trajectories; E-F) Sectorial SPRITE images in the sagittal and transaxial orientations.

Results

Figure 1B and 1C show *in vivo* images of the distribution of ^{23}Na in healthy human brain in two different orientations obtained using Conical-SPRITE. The images are characterized by a relatively high SNR of 34, 24 and 29, in the CSF, brain tissue and the eyes respectively. The standard deviation of a background region-of-interest (ROI) was used for noise determination. The images show blurring determined by the low sampling of the extremes of the k-space.

Figure 1E and 1F show *in vivo* ^{23}Na images of the same brain obtained using Sectorial-SPRITE. The SNR calculated in the same ROIs was 32, 18, 30, respectively. To determine noise, the standard deviation of a background region-of-interest was used. Higher resolution allows for accurate detection of anatomical structures. Although a small matrix size was used, anatomical details such as the corpus callosum can be delineated.

Discussion

In this work we demonstrate that Sectorial-SPRITE significantly increases the resolution of *in vivo* ^{23}Na images compared with Conical-SPRITE. The Conical-SPRITE sequence provide images of good SNR but at a low-resolution which only allows one to delineate details such as CSF, and the eyes where the signal is very strong. This might require an overlay with a high-resolution ^{1}H anatomical image for fine anatomical identifications. In contrast, Sectoral-SPRITE provides finer anatomical details of the brain that may be critical to monitor and diagnose pathologies leading to change of local TSC. At the present stage, Sectoral-SPRITE requires slightly longer measurement times but, through k-space undersampling and/or the use of parallel acquisition methods, this drawback could be significantly reduced in the future. In conclusion, Sectoral SPRITE provides high resolution, quantitative measurement of the TSC in the brain.

References: 1.Thulborn *et al.*, Radiology 213:156(1999), 2. Boada *et al.*CTDB 70:77(2005), 3. S. Nielles-Vallespin *et al.* MRM 57:74(2007), 4. S.Romanzetti *et. al,* JMR 179:64(2006), 5. M. Halse *et. al,* JMR 169:102(2004), 6. A.Khrapitchev *et. al,* JMR 178:288(2006).