Comparison of Cartesian and Radial ^{23}Na MRI for Visualization of Intracellular Sodium Concentration in Patients with Intracerebral Gliomas

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Introduction

Sodium MRI has the potential to differentiate viable from non-viable tissue [1]. The *in-vivo* ^{23}Na signal decays biexponentially, with a short component of T_{2s}=0.5-3ms, and a long component of T_{2l}=15-30ms. To measure the total ^{23}Na signal, pulse sequences with TE<0.5ms are necessary. Previous studies have used 3D radial techniques to quantify the ^{23}Na content in the brain of patients with brain tumors [2]. The purpose of this study was to compare ^{23}Na NMR images of brain tumor patients at 1.5T acquired with a cartesian and a radial gradient-echo (GRE) technique.

Materials and Methods

Four patients with brain tumors were examined on a 1.5 T clinical MR system (Symphony, Siemens AG Medical Solutions, Germany) using a double-resonant (16.84 MHz/63.6 MHz) birdcage coil (Rapid Biomed GmbH, Germany). ^{23}Na Images were acquired with a cartesian 3D GRE sequence (TR=15ms, TE=2.69ms, FOV=500mm, matrix 64×64+oversampling, partition thickness 10mm, BW=130Hz/pixel, Nacq=30, Tacq =10min). A 3D radial GRE sequence was designed to scan k-space from the center to the surface of a sphere. After a 300μs rectangular RF pulse and a 50μs delay, the radial readout gradients and signal acquisition started simultaneously (TR=4ms, TE=0.2ms, FOV=500mm, BW=500Hz/pixel, 5000 projections×64 samples/projection, Nacq=10, Tacq=10min). An online gridding reconstruction (Kaiser-Bessel window and a rho filter modified to correct for undersampling) regridded the data onto a cartesian grid followed by a conventional 3D FFT, producing an isotropic data set. ROI's were set in tumor tissue, healthy brain tissue, CSF and vitreous humor of the 23Na MR images to compare their SNR.

Results

Table 1. SNR = $Signal_{ROI}$ / $\sigma_{Bakground}$

ROI	Cartesian	Radial
Vitreous Humor	35.0	54.4
CSF	33.7	43.3
Brain tissue	18.5	32.4
Tumor Tissue	36.7	55.3

A transverse slice through the head of a patient with a low grade glioma is shown in Fig. 1. The tumor is seen as a high signal intensity area in the ^{1}H FLAIR images (Fig 1.a,d), which corresponds well with the higher signal intensity regions in the ^{23}Na images (Fig 1.b-c,e-f). Table 1 shows the SNR values of the ROI's set in the ^{23}Na MR images. As can be observed, the radial images have a 57% higher SNR in brain tissue than the cartesian images, despite their twofold higher spatial resolution. The radial images, however, are affected by blurring due to the decay of the short T_2 component during data acquisition. The cartesian acquisition occurs after the short T_2 component of the ^{23}Na signal has already decayed, and thus does not suffer from blurring. The CNR between tumor and healthy tissue is ~23% in the radial data and ~18% in the cartesian data, although the cartesian slices are 2.56 times thicker than the radial slices.

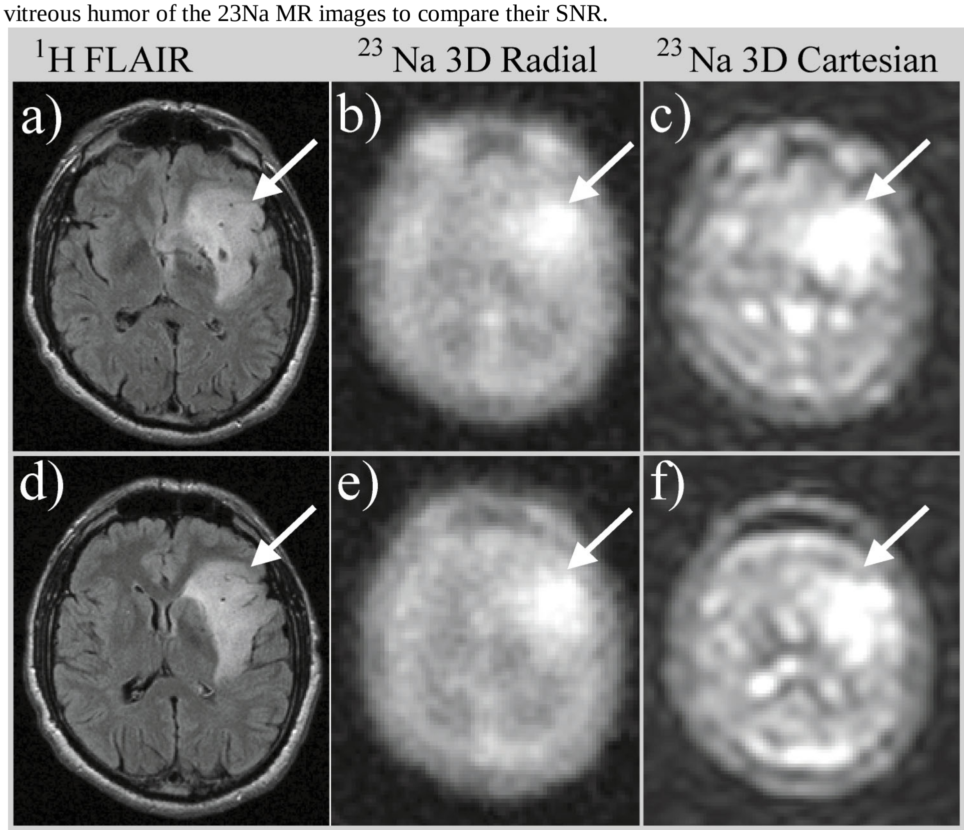

Figure 1. Images of a patient with low grade glioma: ^{1}H FLAIR images (a,d), ^{23}Na 3D radial (b,e) and cartesian (c,f) GRE images. The higher signal intensity area in the ^{23}Na images corresponds to that in the ^{1}H images.

Discussion

Sodium MRI shows increased ^{23}Na concentration in tumors relative to normal brain tissue. The CNR of the 3D radial technique is 20% higher than that of the 3D cartesian. Due to its short TE=200μs, the 3D radial GRE technique allows for the acquisition of the total ^{23}Na signal. Consequently, it is expected to be more sensitive to intracellular ^{23}Na accumulation. Further work will focus on the quantification of the ^{23}Na content in brain tissue. ^{23}Na MRI may provide early non-invasive information about response to therapy, or, in conjuction with ^{1}H MRI protocols, may provide additional functional information and improve diagnostic specificity with multiparametric analysis methods.

References

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