3T Sodium MRI of patients with Multiple Sclerosis

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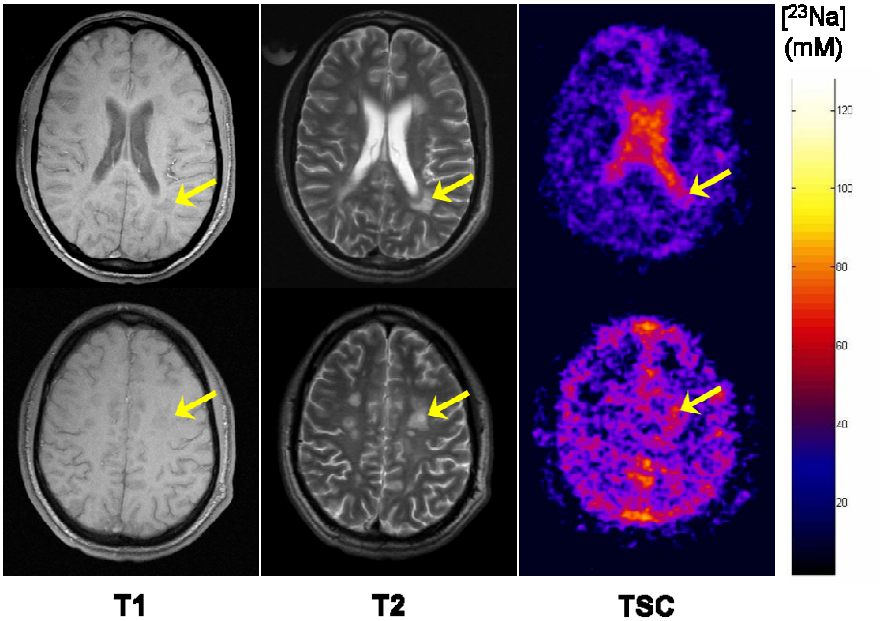
Introduction: Axonal degeneration occurs progressively from the onset of multiple sclerosis (MS) and it is thought to be a significant cause of increasing disability. Several studies have shown that the accumulation of sodium in the axons can promote reverse action of the sodium/calcium exchanger which, in turns, leads to a lethal overload in intra-axonal calcium[1]. Partial blockade of sodium channels protects axons from degeneration in experimental models of MS, and it is currently under investigation in clinical trials[2]. Sodium MR Imaging (^{23}Na MRI) provides an indicator of cellular and metabolic integrity and ion homeostasis and has been applied to the study of patients with brain tumors and stroke[3,4]. Sodium MRI at 3T provides high-quality images in acceptable acquisition time[5]. This application is made feasible by a 3D radial GRE sequence with extremely short echo time values. The aim of this study was to demonstrate the feasibility of performing sodium MRI of the brain in patients with MS and to report preliminary results of the changes of tissue sodium concentration in MRI-visible lesions and normal-appearing white matter (NAWM).

Material and methods: Three patients with MS (mean age 40±11 years) and three healthy controls (mean age 36±6.5 years) underwent MRI on a 3T imager (Tim Trio, Siemens Medical Solution, Erlangen, Germany) equipped with spectroscopic broadband capabilities. All MR experiments were performed using a dual tuned ^{1}H/^{23}Na TX-RX head coil (Stark Contrast, Erlangen, Germany). The MRI protocol for the MS patients included: TSE PD/T2-weighted (T2W) images (TR/TE1/TE2 4610/10/94 ms, 36 axial slices with 4 mm thickness; in plane resolution 0.9 × 0.9 mm), pre- and post-contrast 2D FLASH T1-weighted (T1W) images (TR/TE 258/3.16 ms, 36 axial slices with 4 mm thickness; in plane resolution 0.6 × 0.6 mm). The same protocol excluding contrast-enhanced MRI was applied to the control subjects. In all patients ^{23}Na MRI was performed prior to contrast-enhanced ^{1}H MRI to avoid any potential effect of contrast agent on the ^{23}Na images. The sodium MRI parameters were: 3D radial GRE sequence TR: 120 ms, TE: 0.05 ms, 960 radial views, Flip Angle: 90°, 10 averages, BW: 130 Hz/pixel, FOV: 240 mm^2, matrix size: 60×60; nominal resolution: 4×4×4 mm^3, acquisition time: 20 min. Two tubes of Agar 4% with two different known concentration of sodium (100 mM and 50 mM) were placed in the field of view as references and allowed the tissue sodium concentration (TSC) to be calibrated [6]. The B_1 inhomogeneity effects produced less than 10% variation in signal intensity across the field of view and were not corrected by means of B_1 mapping.

Results and discussion: Representative axial T2W, T1W, and 3D radial images overlaid with color coded tissue concentration maps obtained from a patient with MS and a healthy control are shown in Figure1. In all subjects, T1W images were used to determine regions of interests (ROIs), which were superimposed onto the TSC maps. In MS patients, TSC was calculated in the following ROIs: T1 hypointense lesions, T1 isointense lesions, NAWM, and gray matter (GM). In healthy subjects, TSC was calculated in WM and GM regions. Mean TSC values for each region in MS patients and controls are reported in Table 1. TSC values from healthy subjects are consistent with those reported in the literature with the highest values being in the CSF and humor vitreous. In MS patients, T1 hypointense lesions showed higher TSC values than T1 isointense lesions and NAWM.



Mean TSC (mM)	MS Patients	Controls
T1 Hypointense lesions	59.5 ± 5.8	-
T1 Isointense lesions	40.0 ± 6.5	-
NAWM	23.8 ± 3.2	18.6 ± 2.4
NAGM	33.7 ± 1.9	30.5 ± 1.3
CSF	70 ± 10.0	65.5 ± 5.0
Humor Vitreous	110 ± 10.0	91 ± 9.0

Table 1. Tissue Sodium Concentrations (TSC).

Conclusion: This study demonstrates the feasibility of ^{23}Na MRI at 3T in patients with MS. Further studies to establish the accuracy of TSC values in lesions and normal-appearing tissue are in progress at our Institution.

Figure 1. Selected axial T1W, T2W images and TSC maps from a 29-year old patient with MS. Note the higher TSC value in some of the lesions which appear hypo-intense on T1W images (arrows).

References: 1. Waxman SG, Brain 2005. **2**. Kapoor R, Current Opinion in Neurology 2006. **3**. Ouwerkerk R *et al.*, Radiology 2003. **4**. Thulborn KR *et al.*, Radiology 1999. **5**. Thulborn KR *et al*, Neuroimaging Clin N Am 2005. **6**. Christensen JD *et al.* Magn Reson Med 1996.

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