

In vivo quantification of Tissue Sodium Concentration in the human brain by means of a centric SPRITE sequence at 4T

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Introduction

Centric SPRITE has shown its ability to acquire *in vivo* images of the sodium in the human brain at ultrashort encoding times (1-4). This is a fundamental property for the quantification of tissue sodium concentration (TSC) since it reduces to a minimum relaxation effects due to the fast relaxation times of sodium in the brain (3). In this study sodium concentration maps of a phantom are shown and TSC maps of a healthy volunteer are obtained for the first time by means of this sequence.

Methods

A centric SPRITE sequence was programmed on a home-assembled Siemens 4T whole-body scanner (Erlangen, Germany). Figure 1 shows the predefined k-space sampling trajectory that was used. It started at the origin and followed a 3D Hilbert space-filling curve covering an octant of the k-space. The trajectory was then repeated 8 times to fully cover the k-space. At each k-space location 112 FID points were acquired with a receiver bandwidth of 200kHz starting at $t_p=300\mu s$. A dynamic reduction of repetition time was used to shorten the total acquisition time (5). The TR in the k-space centre was 10 ms and 1.0 ms at the k-space edges. The RF probe was a dual birdcage coil (Rapid Biospin, Würzburg, Germany) tuned to the resonant frequencies of ¹H and ²³Na. FOV=256×256×256mm, matrix 64×64×64, flip=4°. NEX = 12. The final image

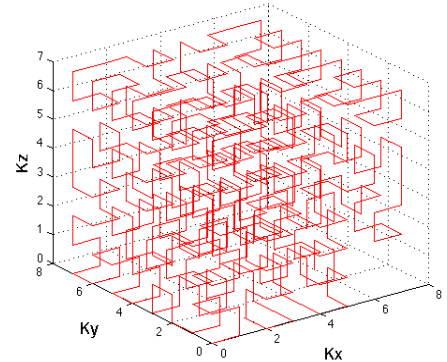


Fig. 1 3D Hilbert space-filling curve starting from the origin of k-space. Only the initial 250 of the 146864 total k-space sampled locations are shown.

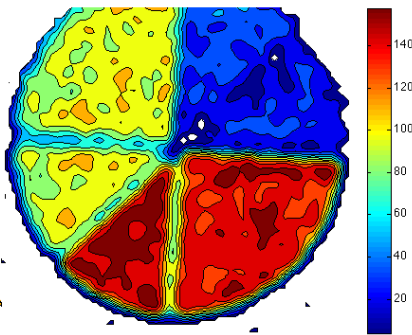


Fig. 2 Sodium concentration map of a gel phantom.

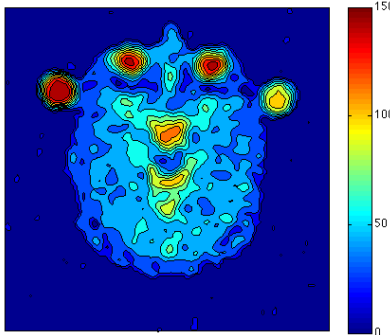


Fig. 3 Slice of the TSC map including the two calibration phantoms used.

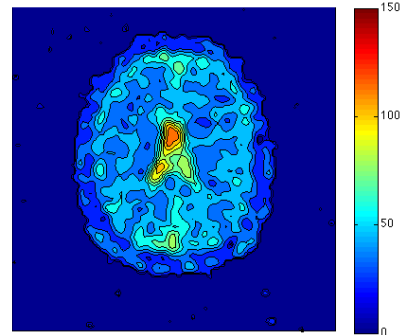


Fig. 4 The distribution of sodium in the brain is uniformly distributed in the healthy brain parenchyma

resolution was 7.5 mm isotropic. The total acquisition time was 36 minute. Two calibration phantoms of know sodium concentration of 100 and 150 mmol/l were placed near the head of an informed healthy volunteer. A B1 map of a homogeneous phantom, which loaded the coil as the human head, was used to normalise signal intensity variations across the field-of-view.

Results

Figure 2 shows a [²³Na] map of a phantom with 6 compartments filled with gels at three sodium concentrations (30, 100, 150 mmol/l) and two agarose concentrations (2%, 6% w/w). As the colour bar shows, the map obtained is in good agreement with the known concentration values. Figure 3 shows a section of the TSC map of the head of a healthy volunteer, in which the calibration phantoms are visible. Here it can be seen that the [²³Na] in the brain is in the range of 40-60 mmol/l. Figure 4 shows the TSC map of the brain parenchyma and Fig. 5 shows the corresponding histogram of the [²³Na] distribution. The distribution peaks around the 45mmol/l value, which is typical for a healthy brain, and extends over 120 mmol/l in the ventricles.

Discussion and Conclusion

Centric SPRITE sequences can acquire images at ultrashort echo times and are not affected by T2* effects. Furthermore, the insensitivity to B0 inhomogeneities and chemical shift artefacts of this sequence reduce the number of corrections to just acquisition of a single RF excitation map. Unfortunately, partial volume effects are present, but are compensated by the uniform distribution of ²³Na in the brain. Furthermore, the two-point calibration method assumes that the water concentration is the same in standards (100%) and tissue (~80%) (6). In conclusion, this study has shown for the first time that TSC maps of the human brain can be obtained with this sequence in an feasible acquisition time. Application to tumour imaging or neurodegenerative diseases for the characterisation of local [²³Na] changes is foreseen.

References

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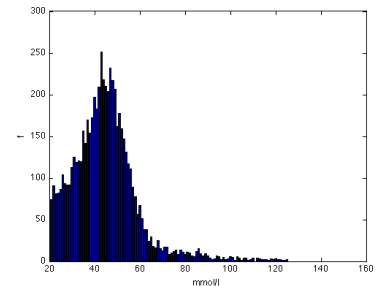


Fig. 5 Histogram of the concentration of the slice reproduced in Fig. 4. The distribution peaks around the value of 45 mmol/l which correspond to the average TSC of the healthy brain.