Sodium MRI of the Breast – Initial Experience at 7T

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Target Audience: Scientists specializing in breast MRI

Introduction/Purpose:

Sodium magnetic resonance imaging (^{23}Na MRI) has been investigated for more than twenty years in animal studies because of its high potential for cancer characterization, but with small success in human *in vivo* studies on clinical MR scanners (i.e., 1.5T). Low sodium concentrations, low sensitivity and short relaxation times were the main issues. However, development of ultrahigh field systems, better coils and improved imaging sequences, may enable ^{23}Na MRI to be used also in breast diagnostics and treatment monitoring [1]. Here, we demonstrate for the first time the feasibility of performing 7T ^{23}Na MRI imaging of human breast in clinically feasible protocols.

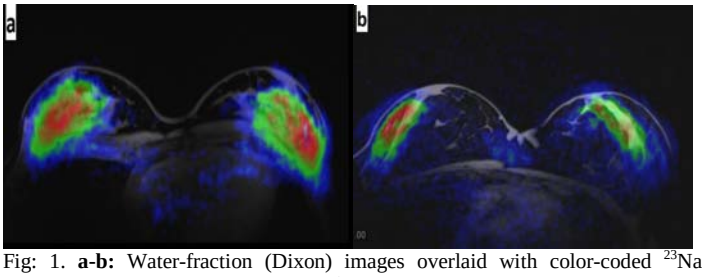


Fig: 1. **a-b:** Water-fraction (Dixon) images overlaid with color-coded ^{23}Na images obtained on (a) predominantly fibroglandular tissue and (b) predominantly fatty breast tissue in healthy volonteers.

Subjects and Methods:

Eight healthy female subjects (age 32.5±6.5) were recruited. Imaging was performed on a 7T MRI scanner (Siemens, Erlangen, Germany) with a bilateral dual tuned ^{1}H/^{23}Na phased array breast coil (14 ^{23}Na receive channels). The study was approved by our institutional review board. An ultrashort echo-time sequence, AWSOS (acquisition weighted stack of spirals) was applied for data acquisition [2]. Optimization of sequence parameters and estimation of image homogeneity was performed in phantom measurements. A sinc pulse of 0.8 ms duration was used to excite a 90 mm thick slab (slice thickness 3mm) with repetition/echo time (TR/TE) = 90/0.5 ms and flip angle 85°. An in-plane square FoV of 320 mm with 128x128, 208x208 and 320x320 sizes of matrices and optimal spiral interleaves (from 18-75) used to obtain *in vivo* data. Signal to noise ratios (SNR) calculated and ^{23}Na concentrations were measured via linear calibration based on pixel signal intensity [3].

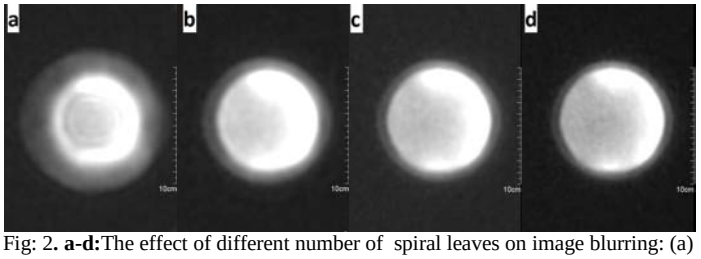


Fig: 2**. a-d:**The effect of different number of spiral leaves on image blurring: (a) 5; (b) 15; (c) 30 and (d) 40. The T_2 image blurring was improved when the spiral readout was shorter from (a) to (d).

Results:

Images obtained with the AWSOS sequence showed excellent distinction between fibroglandular and fatty breast tissue (Fig1). High quality ^{23}Na images of the breast that matched corresponding anatomical features on reference DIXON images were obtained in all subjects. Image artifacts such as off-resonance blurring were minimized due to optimizing in number of spiral interleaves and isocenter positioning (Fig. 2). Phantom and *in vivo* measurements showed good homogenity of the B1+ field on each side (±10-15) and between right/left coil elements (±10)(Fig. 3).^{23}Na images with different in-plane resolutions were achieved and corresponding SNRs were calculated (Fig.4): 47.7±8.5 for 2.5 mm, 34.0±5.0 for 1.5 mm and 22.5±4.3 for 1.0 mm resolution. The measured resolutions were 3.2±1.2, 2.1±0.9 and 1.3±0.6 at nominal 2.5 ,1.5 and 1.0 mm, respectively.

At nominal resolution 2.5 mm, calculated sodium concentration for fibroglandular tissue was 28.8±7.8 mmol/l and for adipose tissue 15.5±9.2 mmol/l.

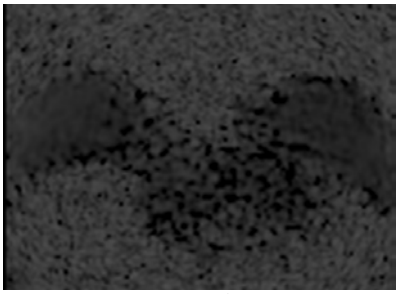
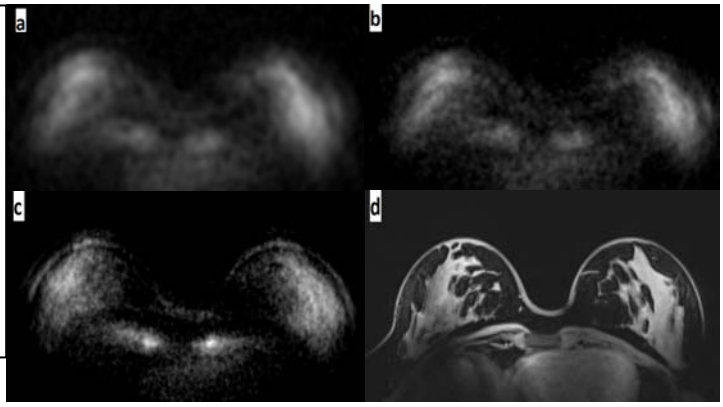


Fig:3. B1+ map obtained from *in vivo* measurement on healthy volunteer generated from AWSOS showed good field homogenity

Fig: 4. ^{23}Na images for: (a)2.5mm, (b)1.5mm and (c) 1.0mm image in-plane resolutions and calculated SNRs: 47.7, 34.0 and 22.5 respectively. High resolution images showed more clearly spatial variation of sodium content in breast then low resolution mages. d) DIXON image



Discussion/Conclusion:

Breast ^{23}Na imaging enables functional evaluations of breast tissue. Our preliminary results show that even the low ^{23}Na content in healthy glandular breast tissue can be well imaged using advanced imaging techniques/hardware at 7T. Therefore, it can be expected that the significantly higher ^{23}Na content in malignant breast lesions can be imaged with further improved spatial resolution. Satisfactory image resolution, SNR and reasonable imaging time, enable this technique to be potentialy implemented in routine protocols. In combination with other ^{1}H MRI techniques ^{23}Na imaging may become an attractive tool for the investigations of breast tumors.

References:

[1] Ouwerkek et al. Radiology 227:529-537 (2003)
[2] Quian et al. MRM 63:543-552 (2010)
[3] Quian et al. MRM 68:227-223 (2012)