

### 3D BOLD of Kindey: Impact of high PAT Factors

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#### Introduction

BOLD (Blood Oxygenation Level Dependent) is a method in MRI to measure the local oxygen concentration in the kidney [1]. The effect is based upon the different magnetic properties of oxyhemoglobin and deoxyhemoglobin which induce a different  $T_2^*$  decay. Therefore, BOLD is an important technique to evaluate the functionality of the kidney and to detect kidney disease. However, the movement of the kidney during the measurement due to the breathing of the patient is a problem because of occurring artifacts in the image. One technique to avoid these breathing artifacts is a breathhold of the patient during the measurement. This requires an acquisition time as short as possible, to enable the examination to older or ill patients as well. Furthermore, a good image quality should be achieved to detect small sized abnormalities in the human kidney. The aim of this study was to use parallel imaging with high PAT (Parallel Acquisition Technique) factors and reconstruction with GRAPPA (Generalized Autocalibrating Partially Parallel Acquisition) [2] to reduce the acquisition time on the one hand and receive a good image and fit quality on the other hand.

#### Materials and Methods

For the study, a phantom and four volunteers (2 female, 2 male, age range of 20-30 years) were examined on a 3T Magnetom Skyra system (Siemens, Erlangen, Germany). Signal data was acquired with an 18 channel body matrix coil and 3 elements from the spine array. To receive  $T_2^*$  weighted volume images a 3D multi echo FLASH sequence was employed with  $TR = 26\text{ms}$ ,  $TE = 3.3\text{--}22.1\text{ms}$ ,  $FA = 20^\circ$ . We recorded 8 echoes with 18 slices (slice thickness = 5mm) during one breathhold with a field of view of  $340\text{mm} \times 340\text{mm}$  and a matrix size of  $128 \times 128$ . Parallel imaging with acceleration factors from 1 to 6 (1: no acceleration, 6: only every sixth k-space line is acquired) was used and reconstructed with GRAPPA [2]. The SNR of the phantom measurement was calculated with the difference method [3] and compared to the theoretical values with SNR inversely proportional to the square root of PAT.  $R_2^*$  maps were generated of the volunteer images by using monoexponential fits. Mean values of 3 slices were determined by using 3 regions of interest (ROI) in the medulla and 2 in the cortex. The fit quality was checked with  $R^2$  error maps and mean values in the same ROIs could be derived.

#### Results

The signal to noise ratio (SNR) of the phantom measurement showed a decrease at higher PAT factors and lower values than the theoretical ones (cf. Fig. 1). The measurement of the volunteers delivers constant  $R_2^*$  values which are independent from the PAT factor with values in the medulla from 42.7 to 44.71/s and 22.7 to 24.61/s in the cortex (cf. Fig. 2a). Also the fit quality does not change with higher PAT factors and varies between 0.93 and 0.95 in the cortex and 0.95 to 0.98 in the medulla (cf. Fig. 2b). The acquisition time and therefore, the breathhold time for the patient becomes shorter with higher PAT factors from 40 seconds for PAT 1 to 15 seconds for PAT 6.

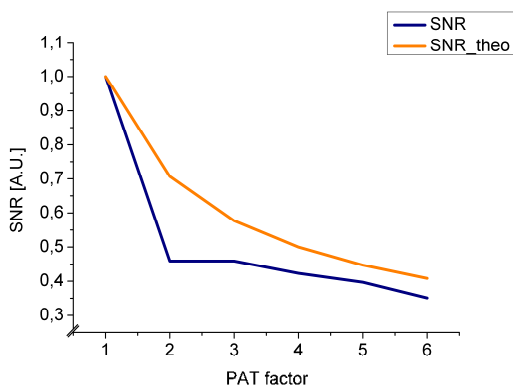


Fig1: SNR development with higher PAT factors in theory (orange) and phantom experiment (blue).

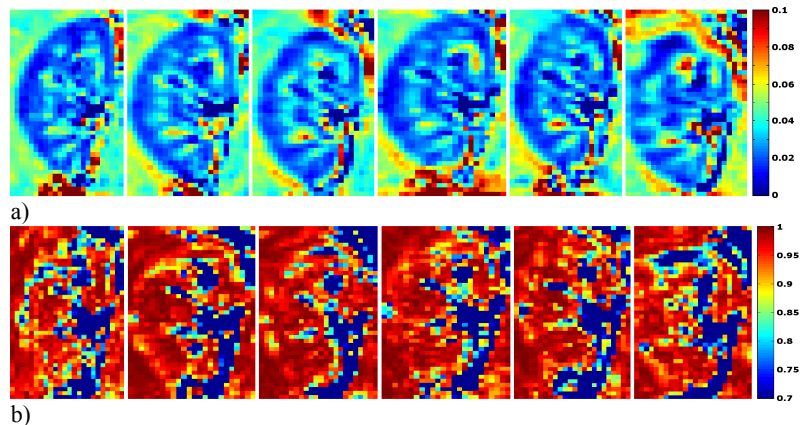


Fig2:  $R_2^*$  maps (a) and fit error maps (b) of the human kidney for different acceleration factors (left to right: PAT 1-6).

#### Discussion

The phantom measurement showed that higher PAT factors lead to a lower SNR as expected. For human volunteers it could be possible that this effect can be partially compensated: By a shorter acquisition time, the breathhold of the patient is more successful, less artifacts occur and a better SNR can be achieved. This observation is supported by the fact that the  $R_2^*$  values and the fit quality stay constant. Differences between the subjects are due to that no special diet was ordered before the measurement and possible inter-individual physiological differences of the healthy subjects, respectively. The acquisition time could be reduced up to 30% of the original value and below the threshold of 20s commonly used in clinical practice. The gained time can be applied for multiple measurements to improve the SNR or a smaller voxel size to get a higher image resolution. In conclusion, high PAT factors can help to reduce the acquisition time of BOLD measurements with a constant high fit quality and therefore, allow more patients to undergo a renal BOLD examination.

#### References

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- [2] Griswold et al., Magn. Reson. Med 47, 2002
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