# Comparison of Parallel Image Reconstruction Methods to Acquire High Resolution ADC-Tensor Images of 3He in Human Lungs.

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## Introduction

Many lung diseases, such as emphysema, leads to severe destruction of the lung's alveoli walls. Determining the Apparent Diffusion Coefficient (ADC) of hyperpolarized $^3$He-gas in lungs is a proven method of non-invasive probing the integrity of the lung's microstructure [Morb1]. Due to sophisticated configuration of small airways the diffusion in lungs is anisotropic and can be characterized by ADC-tensor. The characteristics of the ADC-tensor symmetry may provide valuable additional information on the pathological changes of lung microstructure integrity [Schr1, Mor1]. The essential problem of the efficiency of $^3$He ADC evaluation of lungs is the poor localisation of integrity defects caused by typically low spatial resolution of ADC-maps. The ADC-tensor symmetry characteristics i.e. different combinations of tensor main values are even more sensitive to the low SNR and artefacts. The low resolution of ADC-images originates from (i) breath hold time restriction limiting the amount of phase encodings and (ii) limited SNR of diffusion encoded image. The solution of both problems can be achieved by using multi-channel phased arrays parallel imaging acquisition. The principal advantage of using phased arrays for hyperpolarized $^3$He is the possibility to compensate the unavoidable for conventional MRI parallel acquisition SNR penalty by increasing the magnetisation flip angle. The purpose of current work is to demonstrate the possibilities, which provides the phased array parallel acquisition for improving the efficiency of ADC-tensor measurements with hyperpolarized $^3$He as well as to make comparison of different methods of reconstruction of the imaging datasets to get optimal quality ADC-image.

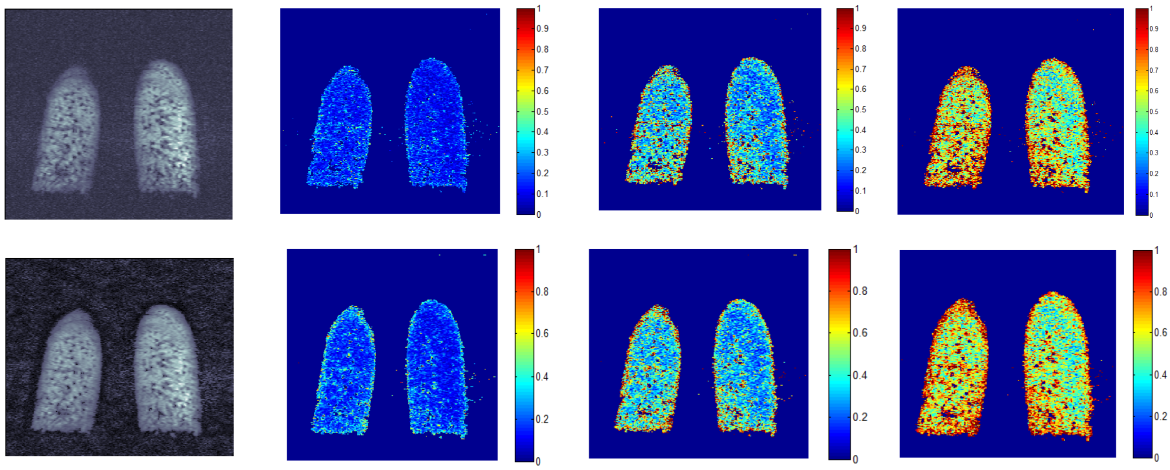

**Fig 1.** Reconstruction mode: **sum of square (top)** and **adaptive-combined (bottom)**. Reference image (grayscale) and calculated ADC-tensor symmetry parameters map: „**Fractional Anisotropy»**, «**Relative Anisotropy»** and «**Anisotropy»** (left to right)

## Materials and method

The $^3$He ADC measurements were performed on Siemens **Avanto Tim** MR-scanner (Erlangen, Germany) with in-house built 32 channel phased array. In-vivo measurements were done on healthy male volunteer with approval of local ethic committee. 300/500 $^3He/N_2$ mixture was applied using Tedlar bag. Bipolar diffusion encoding SGRE-sequence was used to acquire images 9 images per slice (3 references + diffusion encoded for 6 directions). The image parameters were: TR/TE/TD/FA=9.6ms/7ms/3ms/3$^0$, matrix 256x128, slice thickness=10mm, FOV=310mm$^2$, acquisition time 6 sec per slice. Images were reconstructed from multiple channel data using different combining modes (sum-of-square and "adaptive combine") and algorithms based on image data (mSENSE) and k-space combining (GRAPPA).

## Results

The human lung ADC-Tensor map images reconstructed using to different channel data combining modes are demonstrated on Fig 1 and 2 respectively. The averaged reference image and tensor anisotropy parameters are shown for adaptive-combined and sum-of-square channels combining mode. For each combining mode several standard ADC-tensor symmetry parameters were calculated (see Fig)

## Discussion

The results of the experiments show that using multi-channel phased array acquisition allows essential increase of SNR, spatial resolution and time performance for 2D ADC-Tensor measurements therefore providing reliable tensor parameters map. The sum-of-square images have more homogeneous profile of image intensity and noise distribution, which is important for artefact free ADC-images. In turn, the adaptive-combine images provide higher effective SNR and therefore better precision of tensor asymmetry parametric maps. However, the high inhomogeniety of the noise profile characteristic for adaptive-combine mode especially in low SNR diffusion encoded images may lead to large distortions in tensor parameters maps. One should remark, however, that the calculated anisotropy values are merely «technical names» of corresponding tensor parameters [Mor1] and its real physical meaning, as well as possible physiological interpretation is still question under discussion for community.

## References

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