Clinical Implementation of Fourier Decomposition at 3T

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Target audience – This abstract targets the growing body of 3T lung imaging community in need of non-contrast perfusion and ventilation assessments.

Purpose – Fourier decomposition (FD) has shown promise as a non-contrast perfusion and ventilation assessment technique at 1.5T [1]. The main attraction of this technique is that it is a free breathing non-contrast technique. This technique has been previously attempted in volunteers at 3T [2], but only with the focus of demonstrating a gated lung Imaging technique as an alternative to avoiding issues with FD at 3T. Here, we demonstrate that with proper housekeeping, FD MRI is clinically equally applicable at 3T. Theoretically the SNR for most sequences doubles at 3T, thereby doubling the proton density signal required for FD. However, field inhomogeneities and higher susceptibility in the air-tissue interfaces of lung tend to partially destroy the signal gain at 3T [3]. Also at 3T, the usable flip angle is limited due to SAR limitations [3], thereby resulting in a reduction in CNR. Apart from these shortcomings, there are off-resonance artifacts and dielectric effects at 3T. Despite these challenges for the implementation of FD at 3T, the key to the success of this technique lies in the success of Cardiac MR at 3T [3].

Methods – In an IRB approved study, the FD sequence as described by Bauman et.al.[1] was first replicated at 1.5T and two volunteers with different body habitus were scanned to obtain baseline perfusion and ventilation data. These two volunteers were then re-scanned at 3T and the protocol was optimized for application on subjects. The 1.5T protocol with parameters TE/TR=0.8/1.9ms, FOV=450mm, data matrix=128x128 (interpolated to 256x256), $\alpha=75^{o}$, T_A/image=114ms, inter-image delay=188ms was at first imported to 3T. This immediately resulted in an increase in TR which in turn reduced the frame rate to lower than the Nyquist requirement of 3.33 frames/s. To increase the frame rate, the bandwidth was at first increased to the maximum of 1502 Hz/pixel so as to set the minimum TE/TR possible. The inter-image delay was then reduced from 188ms to 1ms to increase the frame rate sufficiently to satisfy Nyquist. After these adjustments the sequence still could not be run at a FA of 75^{0} as published at 1.5T due to SAR limitation. Rather the maximum possible FA was 40^{0}. Note that this is in fact the optimal FA for best CNR of cardiac muscle and oxygenated blood [3]. Of the two remaining optimizations, namely mitigation of B0 inhomogeneity and determination of the correct resonance frequency, only B0 correction was implemented by a technique suggested by Kellman, et.al. [4]. Frequency correction was not implemented as the target here is not the myocardium. With these modifications, the technique was successfully applied to three mesothelioma patients.

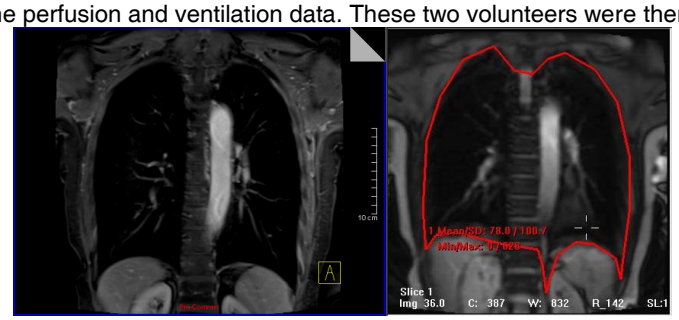

Fig 1. Artifact free pre-contrast FD image (right) from a patient in comparison to post contrast 3D VIBE image (left).

Results – As seen in Fig 1. the native 3T FD image is clean and relatively artifact free in comparison to a contrast enhanced VIBE image. To further validate the utility of the modified 3T FD imaging technique, we compared the "perfusion" map with one produced by DCE. Fig 2. shows that many of the features in the FD perfusion map are similar to that seen in the DCE map, thereby providing evidence of the potential utility of FD at 3T, especially in patients with compromised renal function.

Conclusion – We have demonstrated with proper optimization the FD technique can be extended to 3T. It is also planned to acquire VQ scan data on the patients for comparison and also to extend the qualitative assessment achieved so far to a quantitative validation in the next cohort of patients.

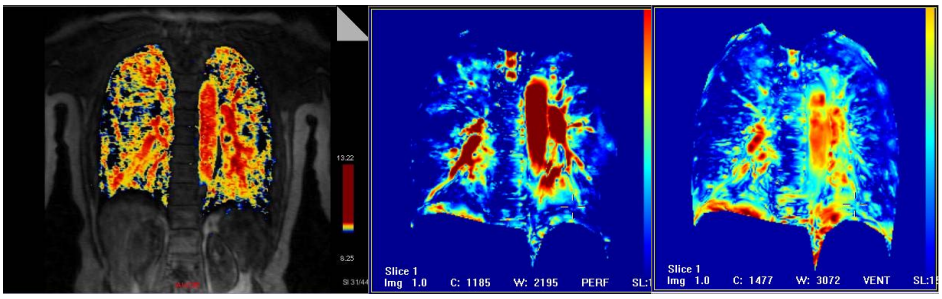

Fig 2. Perfusion images from DCE (left), non-contrast FD (middle) and ventilation (right) from the same patient as Fig 1.

References –

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