Virtual Phantom MRI: a novel quantitation method. Temporal stability and spatial linearity validation.

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Introduction

The ability of generating reference signals is of great benefit for quantitation of the MR signal. In the field of MR spectroscopy, the 'Electronic REference To access In vivo Concentrations' (ERETIC) approach has found numerous applications [1-3]. With ERETIC, a reference signal is generated by radiofrequency (RF) electronics and transmitted to the receiver coil of the MR scanner during the data acquisition. In a very recent study, the extension to MR Imaging of ERETIC has been proposed with the implementation of a dedicated experimental set-up that generates MR images of **Vi**rtual **P**hantoms (ViP MRI) [4].

The aim of the current study was to validate the temporal stability and spatial linearity of the ViP signal, in order to establish whether the ViP MRI method could be used for quantification of the MR signal.

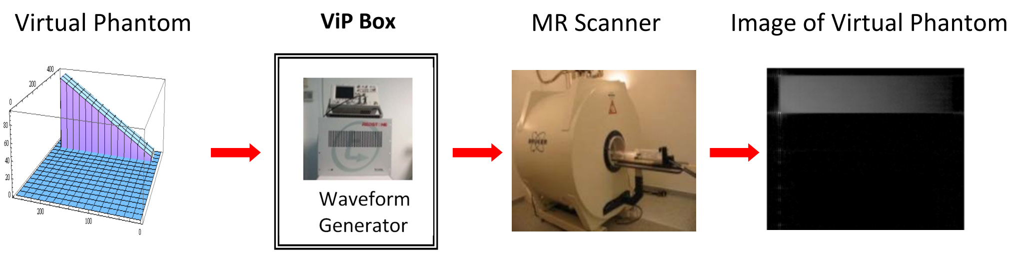

***Figure 1**. ViP MRI: a virtual phantom is designed and the ViP Box transmits the k-space lines to the scanner during a standard MR acquisition. An image of the virtual phantom is then generated by the scanner.*

Methods

A schematic representation of the ViP MRI approach and set-up is illustrated in **Figure 1**. The 'Vip Box' consists of a waveform generator and a home-made RF coil. The RF coil was fixed within the scanner bore and was used to transmit the ViP signal. Experiments were performed at 4.7 T (47/40 Biospec Scanner, Bruker) on physical phantoms (agar tubes) and different virtual phantoms. The k-space lines of the virtual phantom were played line-by-line in synchronization with the MRI data acquisition.

Results

Time-series measurements showed a coefficient of variation of 0.29% and 0.28% for the virtual and physical phantom, respectively (**Figure 2**). In the virtual phantom designed as a signal-ramp (**Figure 3**), an excellent linearity was observed with a coefficient of determination r^2 = 0.9971, as assessed by linear regression.

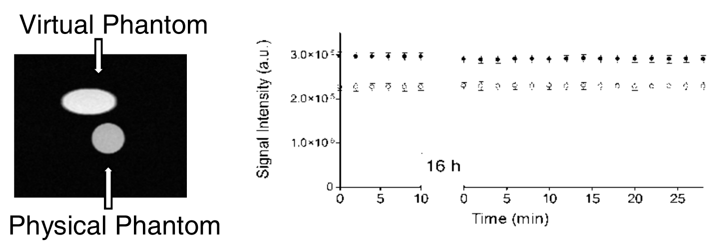

***Figure 2**. **Left panel**: a spin-echo MR image of an elliptically shaped virtual phantom and a tube with agar (physical phantom). **Right panel**: the signal intensity at different times of the virtual phantom (symbols '●') and physical phantom (symbols '○'). The coefficient of variation of the signal was below 1%. An interval of 16 hours was taken between the two time series.*

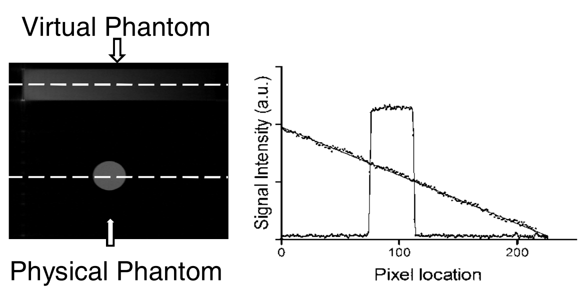

*Figure 3. **Left panel**: a spin-echo MR image of a virtual phantom ('signal ramp' shaped) and a tube with agar (physical phantom). **Right panel**: the signal intensity along the profiles indicated on the image.*

Discussion/Conclusions

Validation of the time stability and signal linearity indicates that the ViP method represents a promising approach to provide a reference signal for quantitation in MRI. In addition, as the VIP Box is a stand-alone and independent unit, ViP MRI can be performed on MR scanners from different vendors.

References. [1] Barantin L et al, Magn Reson Med 1997, 38:179-182. [2] Heinzer-Schweizer S et al, NMR Biomed 2010, 23:406-413 [3] Albers MJ et al, Magn Reson Med 2009, 61:525-532. [4] Gambarota G et al, 30th Annual Meeting ESMRMB 2013, 318-319.