A retrofit technology for MR Elastography

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Introduction

In this work we developed a new retrofit MR Elastography (MRE) system consist of a gradient-echo type multiecho MR sequence and a wirelessly synchronized pneumatic vibration system. Our previous work (Magn. Reson. Imaging 2014) have shown that a conventional gradient-echo type multi-echo MR sequence without additional bipolar magnetic field gradients (motion encoding gradient: MEG), is sensitive to vibration if the vibration frequency is set to an integer multiple of 1/repetition time (TR). To synchronize the pneumatic vibration and TR, we used the first shot of the RF excitation pulse as a trigger to start the vibration. In the previous work (ISMRM2014, 1686), we introduced the wireless TR synchronization system with a dipole antenna tuned for the RF excitation frequency to make any electrical wiring from the MRI electronics unnecessary. The leak RF excitation signal received via the dipole antenna, in the magnet room, was used as the TR synchronization trigger. The fusion of gradient-echo type multi-echo MRE sequence and the wireless synchronization pneumatic vibration system was made the MRE system independent from the MRI system. However, the dipole antenna connected to the cable through a hole in the RF shield room, may introduce RF noise into the shield room and cause MR noises. In this study, we replaced the cable by an optical fiber, to prevent the external RF noise enter the magnet room. The purpose of this study was to test the retrofit MRE system by using clinical MR imager, and examine the potential of this method through gel phantom experiments and volunteer studies. The retrofit MRE system makes it possible to perform MRE in any MRI systems, and it has clinical application potential.

Materials and methods

Figure 1 shows retrofit MRE system with the wireless synchronization pneumatic vibration system. A dipole antenna, RF receiver and an optical signal generator were placed in the magnet room. The leak RF excitation pulse was converted to optical pulse, then it was transferred via the optical fiber, which blocked the external RF noise entering to the magnet room. Finally, the optical signal was converted to TTL-trigger signal. The sine wave generator system (LabVIEW, USB-6221) receives the TTL-trigger signal, so that the pneumatic vibration system synchronizes to the TR. Thus, the first shot of the leak RF excitation pulse triggered the vibration. All MRE data were acquired on a 3.0-T clinical imager (Achieva, Philips). The MRE sequence parameter were TR: 40ms, 1st TE: 2.3ms, TE-interval: 10.0ms, FA: 20degree, Matrix: 256×256, vibration frequency: 50Hz, vibration phase offset: 8, total acquisition time: 2m44s, vibration-type: continuous vibration (TR cycle shear motion). All elastograms were produced by Local Frequency Estimate (LFE) algorithm freeware (MRE/Wave, MAYO CLINIC).

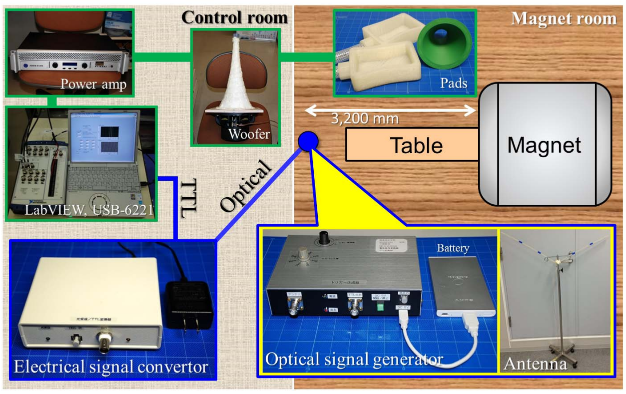

FIG. 1. Retrofit MRE system

Results and discussion

Figure 2 shows the waveform of leak RF pulse received via the dipole antenna, optical signal pulse and the TTL trigger pulses. We can see two types of RF pulse, the regional saturation technique (REST) pulse and the imaging excitation pulse. The REST pulse was used to avoid flow artifacts. The time interval between each RF pulse was 40ms, because we set the TR of the MRE sequence for 40ms. The leak RF excitation pulse provides enough intensity to generate the TTL-trigger signal. Figure 3 demonstrates the wave image (a,c), and elastogram (b,d) obtained from wireless synchronization MRE system at gel-phantom and volunteer psoas major muscle, respectively. These images were the magnitude image overlaid with the wave image or the elastogram. These phantom and volunteer studies demonstrated that MRE can be performed by using a common gradient echo type multi-echo sequence, and a dedicated MRE sequence (built-in MEG) is not always necessary for MRE. In addition, since the retrofit MRE system do not require any modification to the MRI, then it enables to perform the MRE on any existing MRI systems.

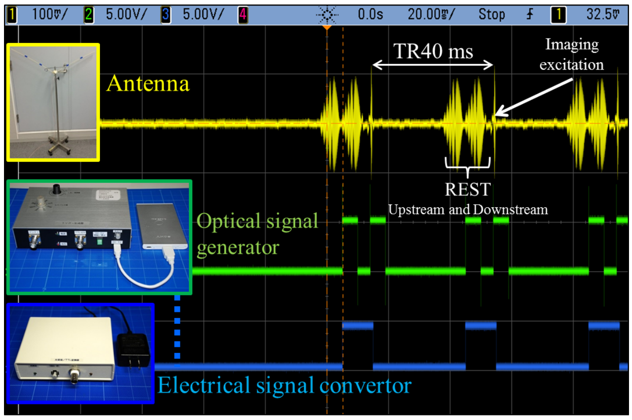

FIG. 2. Waveform of leak RF pulse, optical signal, and TTL

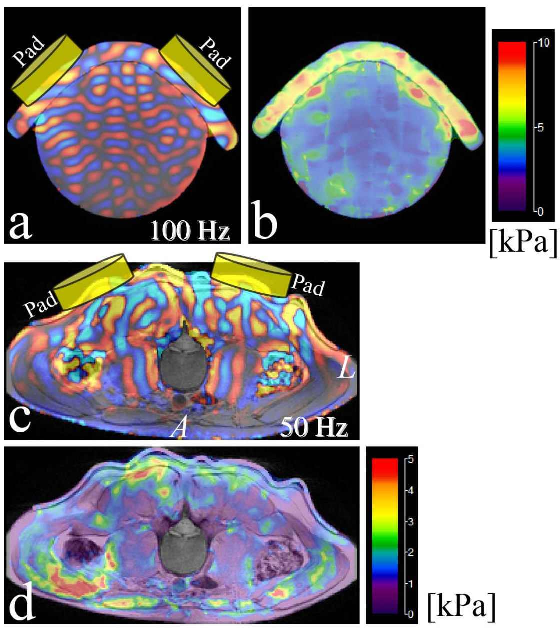

FIG. 3. Phantom and volunteer study of the retrofit MRE