Bed-type oscillator for MR Elastography

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Introduction

In most magnetic resonance elastography (MRE) studies in vivo or ex vivo, a probe that contacted the target object was used to provide oscillation [1]. Another approach to applying oscillation in vivo was a bite-block driver for MRE measurement of brain [2]. Since those oscillators contacted the target objects with small area, the oscillation wave propagated from the attachment region. An oscillator designed to have large area of attachment would generate a flat wave that facilitates the analysis of wavelength from MRE images. An effective energy supply from the oscillator can also be expected with a large contact area. To realize such oscillator with a large area of attachment, we propose a bed-type oscillator for MRE studies in this paper. Phantom and human studies were performed to show the effectiveness of the new oscillator.

Methods

To yield a large contact area between the oscillator and the object, we designed a bed-type oscillator. The system has a moving plate under the measuring object (Fig.1). In comparison to standard probe-type oscillator, this system has a large contact area which provides sufficient vibration to the object for acquiring MRE image at the deeper part of the body. Note that, we used a coil whose alternating current is synchronized with motion sensitizing gradient (MSG) of MRE to actuate moving plate.

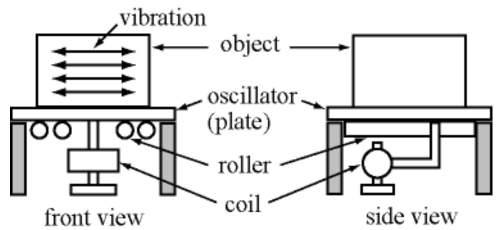

Fig.1 : Bed-type oscillator

Two experiments were performed to confirm the effectiveness of the system. In the first experiment, a silicon phantom (KE1052 : Shin-Etsu Chemical Co., Ltd, Tokyo, Japan) was imaged by the probe-type oscillator and the bed-type one to show the difference of the propagating wave pattern caused by each oscillator. Each MRE image was acquired with Magnetom Sonata (Siemens AG, Erlangen, Germany) with 100Hz oscillation. To acquire MRE images, a modified gradient echo sequence was applied including a sinusoidal MSG of 25mT/m whose direction and frequency are identical to those of vibration. In the second experiment, right calf of a healthy volunteer was examined in vivo. Oscillation conditions and MRE sequences were identical to the phantom experiment.

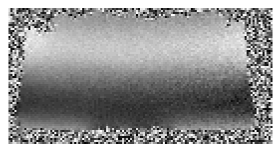

Fig.2 : MRE image obtained with the bed-type oscillator (silicon phantom)

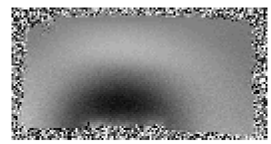

Fig.3 : MRE image obtained with the probe-type oscillator (silicon phantom)

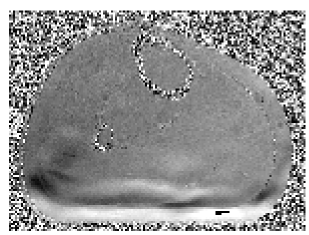

Fig.4 : In vivo measurement of a calf with the bed-type oscillator

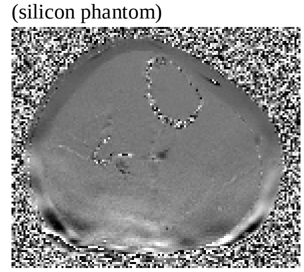

Fig.5 : In vivo measurement of a calf with the probe-type oscillator

Results and Discussion

Figs. 2,3 show the results of the phantom study. Fig. 2 and 3 are MRE images obtained with the bed-type oscillator and the probe-type oscillator, respectively. The shear wave produced by the probe-type oscillator becomes spherical wave, while that by the bed-type oscillator becomes flat wave. It is easy to analyze MRE images and convert them to viscoelastic properties from the flat wave.

Fig.4 shows an MRE image of human calf obtained with the bed-type oscillator, and Fig.5 shows that with the probe-type oscillator. By comparing these images, the area of propagating shear wave by the bed-type oscillator is larger than that by probe-type oscillator. Since the propagating wave appears flat, the wave is easier to recognize in the MRE image with the bed-type oscillator than that with the probe-type oscillator.

Conclusion

In this paper, we proposed a bed-type oscillator to provide vibration for MRE experiments. The experimental results of the phantom showed that the bed-type oscillator produced flat wave in the object, and propagating shear wave is easy to observe in the MRE image of human calf obtained with the bed-type oscillator.

Reference

1. Muthupillai R et al, ``Magnetic resonance elastography by direct visualization of propagating acoustic strain waves," SCIENCE, vol.269, pp.1854-1857, 1995.
2. A. Manduca et al, ``Spatio-temporal directional filtering for improved inversion of MR Elastography images, " Medical Image Analysis, 7, pp.465-473, 2003