PARAMETER OPTIMIZATION FOR LIVER MR ELASTOGRAPHY AT 3 T

Johannes Strasser[1], Jörg Roland[2], Gert Reiter[3], and Rudolf Stollberger[1]
[1]*Institute of Medical Engineering, Graz University of Technology, Graz, Austria,* [2]*Siemens Healthcare, Erlangen, Germany,* [3]*Siemens Healthcare, Graz, Austria*

Introduction

Magnetic Resonance Elastography (MRE) enables tissue stiffness estimates via MR phase images depicting mechanical shear waves induced by an external applicator. These quantitative stiffness values can be used as imaging biomarker for liver diseases, especially liver fibrosis [1]. Most applications of MRE have been performed at 1.5 T. As 3 T systems are now increasingly used for routine liver investigations, it is necessary to adapt MRE protocols to 3 T. The higher field strength offers certain challenges for MRE exams, in particular the faster T2* relaxation at that field strength. In rare previous studies at 3 T this challenge was tackled, either by using a spin echo sequence and encoding only half of the motion period [2] or by using a gradient echo sequence and encoding the full motion period [3] to achieve shorter echo times. In the present study a gradient echo sequence was used with motion encoding gradients which encode a full wave motion period. The influence of the encoding matrix, the SNR and the spatial resolution sizes were investigated in combination with parallel imaging for a short breath-hold. Of a cohort of healthy volunteers mean liver stiffness values at 3 T were analyzed.

Methods

All experiments were performed on a 3 T MR Scanner (MAGNETOM Tim Trio, Siemens Healthcare, Erlangen, Germany). For liver MRE a Work-In-Progress package (WIP 622, Siemens Healthcare, Erlangen, Germany) and the Resoundant acoustic mechanical driver system (Resoundant, Rochester, MN, USA) were used. The passive part of the driver was placed on the right chest wall over the liver. It was fixed by an elastic belt at slightly different positions and with varied tightness to investigate the impact of a specific applicator position on the spatial dependent shear wave formation in the investigated image slice. The MR signal was acquired by a gradient echo technique. Voluntary test persons were willing to undergo MRE exams with different parameter settings. Base resolutions from 128 to 256 as well as quadratic and rectangular pixels were tested. FOV was varied from 300 mm to 400 mm and slice thickness from 5 to 10 mm. TE was minimized to the shortest possible in-phase echo time. Four phase-offset images were obtained within one inhaled breath-hold. To keep the breath-hold duration as short as possible several fast imaging techniques were used: parallel imaging, Partial Fourier and rectangular FOV. Spatial effective shear stiffness maps were calculated by the WIP software. For analysis of the stiffness an elastogram with a superimposed 95 % confidence interval representing areas of reliable wave propagation was consulted. In the confidable areas of this image the mean liver shear stiffness within regions of interest was assessed.

Results

Adequate image results with respect to maximization of the confidence area in the elastogram accompanied by recognizable shear wave illustration were obtained by adapting the sequence parameters to the following settings: resolution 128, quadratic pixels, FOV 300 mm or 340 mm, TR 50 ms, TE 22.1 ms, flip angle 25°, mechanical frequency 60.1 Hz, motion encoding gradient frequency 60 Hz in slice direction, slice thickness 5 mm, parallel imaging GRAPPA factor 2, Partial Fourier 6/8, which resulted in typical acquisition times of around 20 seconds of breath-hold. With these acquisition parameter settings seven healthy volunteers (25 to 27 years old, 2 female, 5 male) underwent liver MRE tests so far. The vibrating applicator was placed and firmly attached against the right chest wall with its center on the middle of the rib. Clear wave propagation most often appeared in slices showing more cranial parts of the liver. Mean liver stiffness values of these volunteers were in the range of 1.44 kPa to 1.89 kPa. As an example Figure 1 shows MRE images of one volunteer investigated using the parameters mentioned afore. The use of parallel imaging techniques combined with Partial Fourier acquisition resulted in suitable MRE scans and reduced acquisition time drastically.

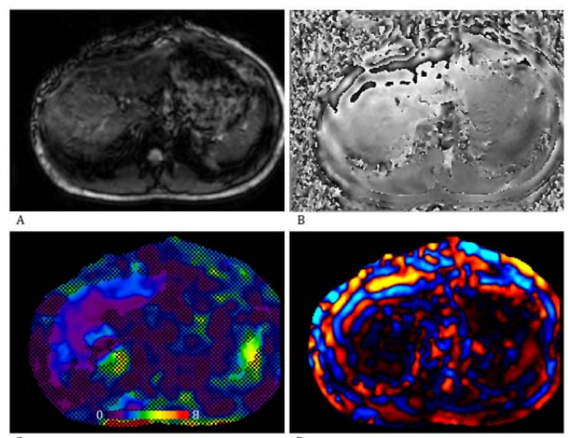

Figure 1: Example MRE images of a healthy volunteer using the specified acquisition parameters at 3 T. A: magnitude image, B: phase-difference image, C: elastogram overlapped by a 95 % CI of the wave propagation reliability, D: wave image

Discussion and Conclusion

The achieved results show the improved suitability of using liver MRE at 3 T when adapting certain imaging parameters. Primary these adjustments address the SNR challenge by handling the fast T2* signal decay of the liver tissue with a reduced base resolution and shortest feasible in-phase echo time. Compared to literature reports at 1.5 T [1] as well as at 3 T [3] the values for liver stiffness achieved in this study are slightly lower. It is suggested that these somewhat lower stiffness values obtained here are due to the fact that the volunteers were a cohort of young people. Further research is ongoing to establish and simplify liver MRE at 3 T and to make this test suitable in medical routine liver exams.

References

[1] Yin M et al., Clin Gastroenterol Hepatol 5:1207-1213 (2007)
[2] Herzka D A et al., MRM 62:284-291 (2009)
[3] Mannelli L et al., Clinical Radiology 67:258-262 (2012)