MR elastography of the prostate using an endorectal coil for actuation: feasibility in a phantom and porcine prostate
Gregor Thörmer1, Martin Reiss-Zimmermann1, Josephin Otto1, Nikita Garnov1, Michael Moche1, Thomas Kahn1, and Harald Busse1
1Dept. of Diagnostic and Interventional Radiology, Leipzig University Hospital, Leipzig, Saxony, Germany

Introduction/Purpose
Functional information on water diffusion, tissue perfusion and metabolite concentrations may improve MR diagnostics of prostate cancer (PCa). MR elastography (MRE) is an emerging modality that measures the propagation of mechanical waves in the tissue to noninvasively determine its viscoelastic properties. While previous work was devoted to other regions of the body [1], in particular breast and liver, MRE also holds promise to improve PCa diagnostics. However, it is difficult to generate shear waves inside the prostate gland that are appropriate for MRE [2]. This work describes a potential concept for prostate MRE and presents preliminary results using the endorectal coil for both MR imaging and elastography.

Materials and Methods
The basic setup for MRE was adapted from a previous implementation at a different institution [3] and is shown in Fig. 1. A commercial endorectal coil (ERC, Medrad) was modified to dynamically generate mechanical stress in terms of expansion and contraction (Fig. 2) in a multimodality prostate phantom (model 053-MM, CIRS, Norfolk, VA) and in a porcine model. The endorectal actuator will induce shear waves in the object under examination that propagate orthogonal to the compression direction. The resulting tissue displacements were measured in a 3.0-T scanner (Magnetom Trio, Siemens Healthcare) with a motion-sensitive EPI sequence (FOV 181 × 181 mm², TR/TE=3,000/150 ms, slice thickness 5.0 mm, spatial resolution 1.5 × 1.5 mm², acquisition time 2 min) at actuation frequencies of 50–200 Hz. Viscoelastic parameters were calculated from the obtained phase differences of the shear-wave patterns.

Results and Discussion
Map of shear modulus G (Fig. 3c) clearly allows identification of embedded 6-mm large “phantom lesions” against the background (bkg). Measured absolute values of \( G_{\text{bac}} \) (8.2±1.9 kPa) and \( G_{\text{bac}} \) (3.6±1.4 kPa) were substantially different. Both G values were systematically lower than those reported by the vendor (13.0±1.0 and 6.7±0.7 kPa, respectively). In the porcine model, shear waves could be generated and anatomical structures like prostate, bladder, bulbourethral gland and surrounding (muscle) tissues could be clearly identified on the shear modulus map (Fig. 4).

Conclusion
The close proximity of the actuator to the prostate permits the application of high mechanical excitation frequencies, which are required to achieve high spatial resolution. A main advantage of this design is the simultaneous use of the modified ERC for MR imaging and elastography. The presented approach for endorectal MRE is technically feasible. Clinical application, however, requires further optimization and validation.

Acknowledgements
We would like to thank I. Sack, J. Braun and their group in Berlin for providing the modified pulse sequences and assisting with the basic implementation. Grant support under BMBF 13N10360 is also greatly acknowledged.

References