

Prostate MRE at 3T: Trans-perineal wave propagation

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Introduction

There has been a great interest in applying Magnetic Resonance Elastography (MRE) to quantify the visco-elastic properties of the prostate in-vivo, with the goal of imaging prostate cancer. Current MRE methods [1-3] have limitations with acquiring high-SNR motion encoded MR-signals at 1.5T, and inducing shear waves of sufficient amplitude into the prostate reliably and in a patient-friendly manner. The aim of this study is to assess the feasibility of MRE of the prostate with trans-perineal excitation at 3T.

Methods

A second harmonic pulse sequence [4] was implemented on a 3T scanner to acquire high quality wave images. A harmonic vibration (45Hz) was generated by a commercial electromagnetic exciter placed in the console room. The vibrations were transferred to the subject in the scanner using a MR safe novel hydraulic transmission system designed by the authors. To reliably induce vibrations of sufficient amplitude in the prostate, the distal end of the transducer was applied to the perineal region of the subject in supine position, as shown in Figure 1a. This allows for efficient transfer of compressional waves to the prostate that are mode-converted to shear waves at tissue interfaces. MRE was performed in five healthy subjects.

Wave images were acquired for a 64x64 matrix and 7 slices with isotropic voxels of size 1.5mm³. The signal was averaged twice with an EPI factor of 5 where the total imaging time was ~15min. A cardiac coil was used. Images were processed offline similar to the approach described in [4]. Viscoelastic values were extracted using a new reconstruction algorithm that uses data fitting to a travelling wave expansion [5]. A region of interest (Figure 2a) surrounding the prostate was manually selected for estimation of wave amplitudes and viscoelastic properties. The approach was validated using a commercial elasticity controlled phantom.

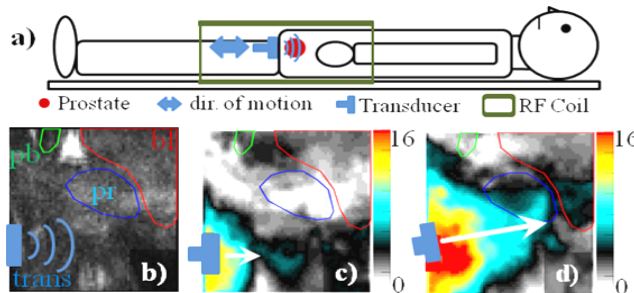


Figure 1. a) Setup for trans-perineal excitation. b) Sagittal T₂W image showing prostate (pr), bladder (bl), pubic bone (pb) and the location of the transducer (trans). The wave penetration depends on the position of the transducer. Note the wave amplitude images in c) and d) [μm], showing significantly higher wave penetration when the transducer is placed as in d).

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Results

Phantom validation was successful and no image artifacts were noted due to the hydraulic transducer. Preliminary results for two of the subjects are shown in Figures 1 and 2. Mechanical waves are transmitted effectively into the prostate via the perineum and produce sufficient shear waves so that the viscoelastic parameters can be reconstructed. The peak amplitude of the mechanical wave was 7μm as seen in Fig 2b. The best results are achieved when the transducer head is positioned right below the pubic bone and angled upwards (~25°) as seen in Fig 1a and d. The map of the elasticity and damping are shown in Fig 2c-d, where we observe a close correspondence between the elasticity and T₂ weighted images. For example, regions such as the urethra and the stiffer and more viscous zones surrounding it can be visually identified in Fig 2c and d. Furthermore, the prostate gland stands out in all the elasticity images and is nearly independent of the reconstruction settings.

Discussion

MR Elastography of the prostate at 3T with the 2nd harmonic approach using a hydraulic transducer applied to the perineum is feasible. Unlike pelvic excitation, trans-perineal excitation does not cause any discomfort to subjects and would be suitable even for long patient examinations. The prostatic gland consistently stands out in maps of viscoelastic properties. A close correspondence has been observed between the mechanical properties and the anatomical images inside the prostate gland. Further work will validate the elasticity measurements and their repeatability and dependence on subject state (bladder filling, colon filling, and leg position). Patient studies prior to radical prostatectomy will follow.

References

- [1] Sinkus et al, Proc. 7th ISMRM, 586, 2003.
- [2] Kemper et al, Fortschr Röntgenstr. 176, p. 1094-1099, 2004.
- [3] Dresner et al, Proc. 10th ISMRM, 526, 1999.
- [4] Herzka et al, MRM, 62(2), p. 284-291, 2009.
- [5] Baghani et al, TMI, 2010 (submitted).

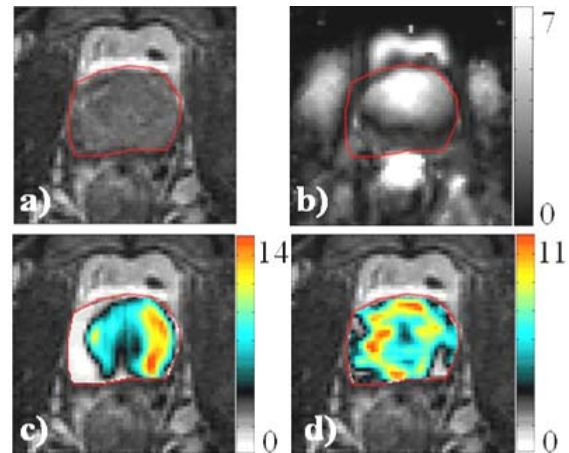


Figure 2. a) Transverse prostate T₂W image of a healthy volunteer. b) Measured total wave amplitude [μm]. c) Map of elasticity [kPa] and d) damping [dB/cm] of the prostate.