Multi-Purpose Prostate Phantom

B. Zhang[1], R. P. Gullapalli[1]
[1]Diagnostic Radiology Department, University of Maryland, Baltimore, Baltimore, MD, United States

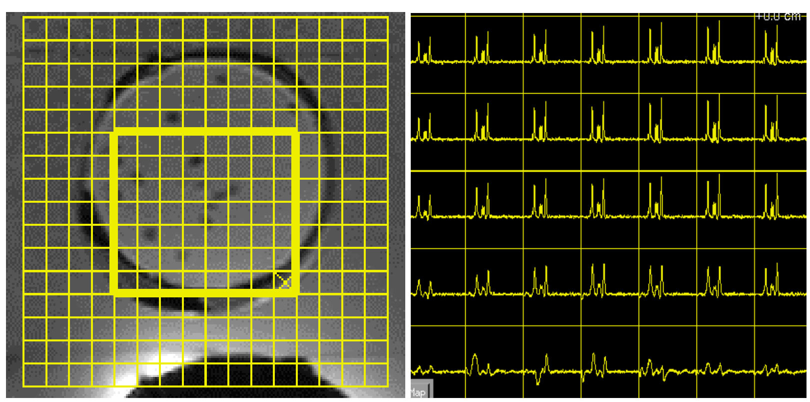
Introduction
Endorectal coil MR imaging of the prostate has become a standard methodology for diagnosis of prostate cancer. MRI of the prostate using the endorectal coil along with spectroscopic imaging have shown to improve the sensitivity and specificity of cancer detection [Kurhanewicz 2000]. However techniques such as MRSI still pose a major challenge in the successful execution of the exam. Given the nature of the exam and the unavailability of a suitable test bed before using the technique on humans exacerbates the problem. Further any information obtained from MRI regarding the prostate is in its deformed state since the endorectal coil deforms the prostate. For proper treatment planning such as brachytherapy, it becomes essential that this deformation is corrected before the information is used for either TRUS biopsy or ultrasound guided brachytherapy. Several deformation correction algorithms [Mizowaki T, 2002] exist, but lack a suitable phantom to check for the accuracy of the correction provided by these algorithms. We have constructed a first proto-type of such a phantom mainly for MRI use although it could be used by other modalities and here we provide some preliminary results from this work.

Materials and Methods
In constructing the prostate phantom the T1 and T2 values of the prostate was given primary consideration followed by the Young's modulus of the prostate tissue from previously reported studies [Kemper J, 2004, Hamhaber U, 2003]. The size of the prostate was an elliptical sphere of dimensions 52x41x35 mm^3 and was constructed using 0.5% agarose gels doped with 0.1mM Gd-DTPA. The biochemicals choline (10mM), creatine (30mM), citrate (100mM) and Lactate (35 mM) that are predominantly seen in prostate MRSI were also added. To mimic implanted seeds, we used sesame seeds that were randomly distributed within the prostate. Lard was used to mimic the periprostatic fat and formed the outer layer of the entire prostate. The phantom as shown in fig 1 allows for insertion of the endorectal coil or an ultrasound transducer through a 1.25 inch diameter hole and allows for the inflation of the balloon of the endorectal coil. The phantom was imaged on Philips Eclipse 1.5T system and spectra were obtained using a PRESS CSI sequence (TE/TR=130/1500ms) with frequency selective fat and water suppression.

Results
The T1 for the prostate, fat, and background material were 589, 148 and 1880ms respectively. The T2 values were 73, 53, and 90ms respectively. The Young's modulus of the prostate was about 3kPa and these values are consistent with the values previously published. Figure 2 shows spectra from the prostate phantom using the endorectal probe. The spectra are from a voxel size of 0.25 cc and show an even distribution of the metabolites (Cho 3.03ppm, Cr 3.93 & 3.22ppn, Cit 2.58pm) with some lipid contamination in the bottom row.

Conclusion:
A test-bed for the validation of prostate imaging and spectroscopic acquisition techniques is highly desirable. Such a test-bed can also be used for training purposes by either radiologists or radiation oncologists. The phantom is amenable to imaging by multiple modalities including ultrasound. It allows for testing deformation algorithms and also allows clinicians to practice image guided biopsy or brachytherapy procedures. While we have successfully tested this first prototype, additional work is necessary to further improve the stability of the phantom which would also include other anatomical structures.

Figure 1: Prostate phantom.



(a) (b)

Figure 2: (a) The MRS image and (b) the spectra of the prostate phantom.

References
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