

AbstractID: 2763 Title: Transrectal fiducial carrier for radiographic image registration in prostate brachytherapy

MOTIVATION: Intraoperative dosimetric optimization of TRUS-guided prostate brachytherapy implants requires localization of seeds relative to prostate[1], for which radiographic fiducial-based registration of fluoroscopy and TRUS seems appropriate[2,3]. It is critical to mount the fiducials rigidly and stabilize the prostate, because TRUS and fluoroscopy are sequential and the moving TRUS probe may dislocate the prostate. Transrectal approach provides the shortest distance to the implanted seeds and prostate, thereby maximizing registration accuracy.

METHODS: A precision-machined transrectal sheath containing fiducials is mounted rigidly on the stepper and wraps around the TRUS probe. It mechanically decouples the prostate from the TRUS probe and thus stabilizes the prostate. Acoustic impedance, wall thickness, and diameter were optimized. Acoustic coupling is maintained by circulating liquid gel. The system is depressurized during probe motion. Two embodiments accommodate various types of radiographic fiducial markers. A closed 360-degree sheath of 30mm diameter was developed for conics that are extremely robust to segmentation and image distortion, being mathematically invariant to projective transformation. A partial 180-degree sheath was developed for straight lines and point fiducials that are computationally simpler to localize but inherently less accurate. The sheath connects to a commercially available TRUS stepper.

RESULTS: Phantom and in-vivo canine tests were performed. Prostate motion and sheath stability were quantitatively analyzed with volume CT by tracking both structures and implanted markers while the TRUS probe was retracted by 5mm increments. With the sheath in place, prostate and sheath both were stationary in CT imaging and the fiducials did not interfere with the TRUS image. Excellent acoustic coupling was achieved during probe motion with acceptable degradation of ultrasound image quality.

References:

- [1] Nag *et al.*, Int J Radiat Oncol Biol Phys 51(5):1422-30
- [2] Zhang *et al.*, Phys. Med. Biol. 49:N333-N345
- [3] Jain *et al.*, SPIE Medical Imaging 2005 (in proceedings)

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