# Transrectal Prostate Biopsy and Fiducial Marker Placement in a Standard 1.5T MRI Scanner

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**Introduction:** With an estimated annual incidence of 220,900 cases for 2003, prostate cancer is the most common non-cutaneous cancer in men in the United States (1). While transrectal ultrasound-guided prostate-biopsy is a specific test for prostate cancer, it has a low sensitivity (~80%)(2). In light of this, MR imaging has a potentially valuable role in the diagnosis of prostate cancer. MRI has a high sensitivity for detecting prostate tumors (3); however, due to its low specificity, the role of MRI in prostate cancer screening and staging has been limited (4). One potential solution is to combine tissue biopsy with MR imaging, thereby maintaining the sensitivity of MRI while gaining the specificity of tissue biopsy. To this end, prior work has been performed using low field-strength (e.g. 0.2 or 0.5T) open scanner architectures (5,6) or ultrasound registered with priorly-acquired MR data (7,8). The purpose of this study is to investigate the safety and accuracy of a novel 'APT-MRI' system (Access to Prostate Tissue under MRI-guidance) that provides transrectal needle access to the prostate while a patient is imaged inside of a 'closed' 1.5T scanner, which previously has not been possible.

**Methods:** Using a custom designed system (Figure 1)(9) and a GE Signa Excite 1.5T MR scanner (GE Medical Systems), four gold fiducial markers were placed within the prostate gland in each of four patients with localized prostate cancer. The design principle and mechanics of the interventional device employed in this study are similar to those of our previous non-clinical device (10). By depositing fiducial markers within the gland, we were able to assess not only needle placement accuracy, but also the accuracy with which the tissue itself was targeted (i.e. leaving a permanent marker allows for measurement of the impact of tissue deformation, produced during needle insertion, on targeting accuracy). Subsequently, the system was also used for three 1.5T MRI-guided prostate biopsy procedures in two patients (Figure 2).

**Results:** The mean MR procedure duration was 72 minutes; all patients tolerated the intervention well and no unexpected toxicities occurred. Using axial MR images (Figure 3), needle and marker placement errors were assessed. The mean needle placement accuracy was 1.9 mm for the fiducial marker placement studies and 1.8 mm for the biopsy procedures. The mean fiducial marker placement accuracy was 4.8 mm and the mean transverse fiducial marker placement accuracy was 2.6 mm (which is the predicted accuracy of the system for collecting tissue core biopsies). The gold fiducial markers were subsequently used to assess daily setup errors and off-line organ motion during a standard course of external beam radiation therapy for prostate cancer.

**Discussion:** In evaluating the needle and fiducial marker placement errors, it is evident that needle placement is more accurate than fiducial marker placement. This is largely the result of tissue deformation which occurs upon insertion of the needle. While needle placement accuracy is a fair assessment of the kinematic accuracy of the system, it is not the final measure of tissue targeting accuracy. Tissue targeting accuracy was assessed by comparing the location of the gold fiducial markers, deposited in the tissue, after the needle had been removed. As we are ultimately interested in the accuracy with which tissue samples can be acquired from the prostate, the transverse component of fiducial marker placement error was also examined (i.e. perpendicular to the needle insertion axis). Commonly, core tissue biopsies are 15 mm long and approximately 1.5 mm in diameter. Therefore, because the tissue core is so long, small errors in the insertion depth of the biopsy needle are not of great consequence. The transverse tissue targeting accuracy obtained with this system, 2.6 mm, is adequate for MR-guided biopsy (as images pixels are rarely smaller than 0.5mm, lesions which are less than 2-3 mm in size are unlikely to be MR visible).

We emphasize four key features of the APT-MRI system. First, the entire device is very compact and therefore, can be used in a standard, 1.5 T cylindrical scanner architecture, even with larger patients (the largest patient treated was 132 kg, 4 kg less the manufacturer limit for the scanner table). As standard scanner architectures are much more widely available than open models, this system will be applicable at many centers and moreover, can immediately take advantage of mainstream MRI hardware and pulse-sequence development (such as the introduction of 3.0T whole body scanners). Second, the needle placement procedure is uncomplicated; 4 targeted needle placements can be performed with an overall MR procedure time of approximately one hour (including time for confirmatory imaging after every needle and fiducial marker placement). Third, the endorectal sheath, which includes the local imaging coil and entirely contains the needle guide, remains stationary throughout the procedure. This helps to prevent deformation of the prostate and surrounding tissues during the procedure, maintaining accurate registration of all image data sets. Finally, we do not rely upon 'realtime' imaging techniques. Other than the device-tracking pulse sequence, no specialized pulse sequences are required when using this device. Therefore, we maintain the flexibility to use virtually any imaging technique, including MR spectroscopy and dynamic contrast enhancement, both of which have shown promise in the diagnosis and delineation of tumors within the prostate. While currently, we have only focused on anatomic imaging techniques, subsequent work will investigate the application of the device with pulse sequences that provide information on the functional and metabolic state of the tissue.

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**References**: (1) Jemal A. CA Cancer J Clin 2003;53:5. (2) Rabbani F. J Urol 1998;159:1247. (3) Yu KK. Radiol Clin North Am 2000;38:59. (4) Wefer AE. J Urol 2000;164:400. (5) Cormack RA. Int J Radiat Oncol Biol Phys 2000;46:207. (6) D'Amico AV. J Urol 2000;164:385. (7) DiBiase SJ. Int J Radiat Oncol Biol Phys 2002;52:429. (8) Kaplan I. Magn Reson Imaging 2002;20:295. (9) Krieger A. ISMRM 2004. (10) Susil RC. Radiology 2003;228:886.

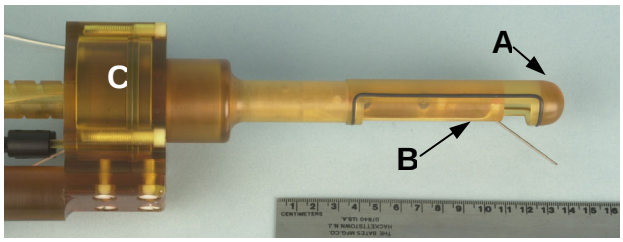


**Figure 1:** Interventional Device. A stationary endorectal sheath (**A**), with an integrated 20 mm diameter imaging coil, minimizes tissue deformation during the procedure. A cylindrical needle guide (**B**), which fits inside of the endorectal sheath, contains MR-tracking microcoils and a curved needle channel. The positioning stage (**C**) houses the mechanism that allow for remote actuation of the needle guide.

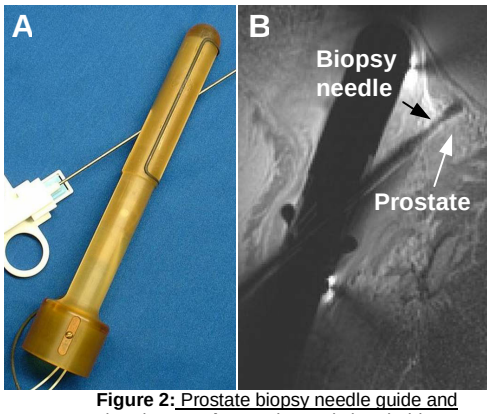


**Figure 2:** Prostate biopsy needle guide and sheath. **Panel A**: Endorectal sheath, biopsy needle guide (with angled needle channels), and biopsy gun. **Panel B**: Sagittal T1-wt FSE image acquired with the biopsy gun in place.

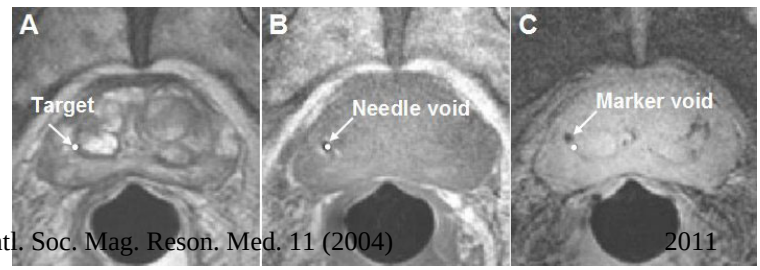


**Figure 3**: Targeting, needle, and fiducial marker visualization images. **Panel A**: Targets are selected on axial T2-wt FSE images. **Panel B**: The needle tip void is visualized in axial T1-wt FSE images. **Panel C**: The marker void is visualized on axial, T2*-wt gradient-echo images. Note that there is minimal tissue motion throughout the procedure.