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# Comparison of prostate distortion by inflatable and rigid endorectal MRI coils in permanent prostate brachytherapy imaging

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**ABSTRACT**

**PURPOSE:** To study the deformation of the prostate by a rigid reusable endorectal coil and a balloon-type endorectal coil (BTC) during MRI of the prostate in brachytherapy imaging.

**METHODS AND MATERIALS:** The prostate gland was contoured on 157 MRI scans from 52 prostate cancer patients undergoing brachytherapy. The curvature of the posterior prostate surface deformation was computed as a measure of prostate distortion and compared between scans with a BTC, rigid endorectal coil (REC), or no endorectal coil. For the nine patients who had MRIs with all three endorectal scenarios, a mean prostate deformation vector was also calculated between scenarios using deformable image registration. These measures of prostate distortion were compared with the prostate anterior-to-posterior to left-to-right ratio (AP/LR) on the largest prostate axial slice.

**RESULTS:** Significant differences in prostate curvature were found between scans without an endorectal coil versus a REC versus a BTC ($p < 0.001$). The mean prostate deformation was 3.9 mm due to the BTC and 2.0 mm for the REC ($p = 0.012$). The mean AP/LR ratio was 0.62 with a BTC versus 0.76 without a coil or 0.73 with a REC ($p < 0.001$), but no difference existed between scans with a REC versus no coil ($p = 0.7$). The AP/LR ratio showed moderate correlation with prostate curvature (r = 0.48), and with mean prostate deformation (r = −0.64 to 0.68).

**CONCLUSIONS:** The REC caused minimal deformation of the prostate compared with a BTC with adequate MR image quality, and calculation of the cross-sectional AP/LR ratio on the largest axial prostate slice can serve as a simple measure of prostate distortion. Published by Elsevier Inc. on behalf of American Brachytherapy Society.

*Keywords:* Prostate; Brachytherapy; MRI guidance; Endorectal coil

## Introduction

In low-dose-rate prostate brachytherapy, postimplant quality imaging assessment is important to ensure that adequate radiation dose from the radioactive seeds covers the prostate, whereas the dose to the surrounding critical structures (e.g., rectum, bladder, and urethra) remains below predefined levels. Any images used for this postimplant quality assessment must provide adequate spatial accuracy for target delineation and seed localization as well as visualizing the anatomy of surrounding structures. At present, CT is often used for this purpose, as it can easily visualize the metallic casing of the seeds. However, ‘‘blooming’’ artifacts of those metal casings reduce the spatial accuracy of the seed positions. More problematic is that the anatomic boundary of the prostate and some of the surrounding anatomic structures (e.g. the external sphincter) are difficult to visualize on CT, which can cause uncertainties and variations in target delineation, and this uncertainty in target accuracy can lead to postimplant prostate D90 variations up to 23% (1, 2). On the other hand, MRI can provide excellent contrast of the prostate and thus may have important roles in dosimetric assessments of brachytherapy both before and after seed implantation (3, 4). MR images of the prostate are typically acquired with endorectal coils (5, 6) or with a phased-array body coil wrapped around the pelvis (7−9). Images

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acquired with endorectal coils are routinely used for prostate cancer diagnosis and staging (10), and have been shown to improve image quality for these purposes in both 1.5T and 3T MRI machines (11−13). Endorectal coils are of two major types, either an inflatable balloon type or a rigid type (14−16). Current standards for postimplant assessment includes CT and MRI fusion to combine precise dosimetry obtained through seed localization on CT with optimal prostate anatomical information obtained on MRI (17, 18).

Another prerequisite for prostate brachytherapy imaging is the need for minimal geometric deformation of the prostate on both the preimplant images (which are typically obtained with transrectal ultrasound) and the postimplant images. The disposable, single-channel inflatable balloon-type endorectal coils (BTCs; eCoil, Bayer Medrad, Whippany, NJ) have been used routinely at many institutions, including ours, for both diagnostic imaging and recently for prostate brachytherapy treatment planning and evaluation. Although substantial improvements in image quality have facilitated accurate delineation of the prostate and surrounding structures, prostate MR images acquired with a fully inflated BTC in place have shown significant deformation of the prostate (19).

An alternative to balloon-style coils recently introduced by InVivo (Gainesville, FL) is a reusable rigid endorectal coil (REC). This REC is similar in size to the transrectal ultrasound probe used for preimplant image acquisition and guidance during the seed implantation; the expectation is that prostate MR images acquired with an REC will have less volumetric deformation of the prostate and that the dose distribution can thus be more accurately assessed. In this study, we studied and compared prostate deformation in brachytherapy MR images acquired with the REC with those obtained with the traditional BTC and report our initial clinical experience with using this REC for brachytherapy.

## Methods

Prostate MR images were obtained with the two types of coils (the BTC and the REC) from 52 consecutive patients with prostate cancer who underwent prostate brachytherapy at our institution. The two types of coils were used with different scanners: the BTC was used with a 3T GE Signa HDxT scanner, and the REC was used with a 1.5T Siemens MAGNETOM Aera wide-bore (70 cm, XQ gradient) scanner. A total of 157 MRI scans were acquired in these patients, including diagnostic MRI scans obtained before brachytherapy. These MRIs were acquired at three different time points: preimplant for prostate brachytherapy planning and/or prostate cancer diagnosis (pre-implant), immediately postbrachytheray implant (Day 0), and 1 month after brachytherapy implantation (Day 30). Although not the main goal of this study, MR image quality was evaluated for seed visibility and imaging artifacts.

Of the 52 patients, 49 patients had preimplant, Day 0, and Day 30 MRI studies, one patient had preimplant and Day 0 studies only, and two patients had Day 0 studies only. Of the 157 MRI scans, 50 were performed without an endorectal coil, 82 were performed with a REC, and 25 were performed with a BTC. A total of nine patients had images acquired with all three types of endorectal scenarios, and 20 patients had at least two different types of endorectal device scenarios. The coil types, MRI pulse sequences, and image acquisition parameters used are described below.

The inflatable BTC was used with a 3T GE Signa HDxT scanner; the imaging protocol consisted of a 3D T2-weighted fast spin echo scan (CUBE) sequence for better anatomical structure visualization and a 3D fast-spoiled gradient echo sequence for optimal seed localization. The specific imaging acquisition parameters for each sequence were as follows:

(1) 3D T2-weighted axial fast spin echo (3D CUBE), with the exactly matching slice location, orientation, and thickness; TR = 2000, TE = ~120, number of excitations = 1, field of view = 14 cm, imaging matrix = 224 × 224 (extrapolated to 512 × 512), frequency encoding direction = anterior-posterior (A-P), slice thickness = 2 mm with no gap, ETL = 74, and bandwidth = ±41.67 kHz.
(2) 3D axial fast-spoiled gradient echo, with TR = 6.18, TE = Min Full (~3.3 ms), flip angle = 20, number of excitations = 8, field of view = 14 cm, imaging matrix = 256 × 256, frequency encoding direction = A-P, slice thickness = 2 mm with no gap, bandwidth ±83.33 kHz. To reduce bowel motion artifact, glucagon was injected intravenously immediately after the insertion of the endorectal BTC coil, which was inflated with 30−60 $cm^3$ of air.

The REC was used with a 1.5T Siemens MAGNETOM Aera scanner, with the following imaging acquisition protocol:

(1) 3D axial FLASH, with TR = 6, TE = 2.38, flip angle = 25, average = 3, FOV read = 150 mm, FOV phase = 100%, imaging matrix = 256 × 256, phase-encoding direction right-left (R/L; i.e., frequency encoding direction A/P), phase oversampling = 100%, slice thickness = 1.00 to 2 mm, slice oversampling = 55.6%, bandwidth = 500 Hz/pixel. The coil was inserted while the patient was supine, and the coil was positioned against the anterior rectal wall by using a locking articulated arm attached to the tabletop support with the REC coil assembly. Glucagon was injected immediately after the coil was inserted to suppress bowel motility.
(2) 3D T2-weighted axial SPACE with the exactly matching slice location, orientation, and thickness,