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# Stranded seed displacement, migration, and loss after permanent prostate brachytherapy as estimated by Day 0 fluoroscopy and 4-month postimplant pelvic x-ray

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**ABSTRACT**

**PURPOSE:** The aim of the study was to determine the incidence of local displacement, distant seed migration to the chest, and seed loss after permanent prostate brachytherapy (PPB) with stranded seeds (SSs) using sequential two-dimensional fluoroscopic pelvic and chest x-rays.

**METHODS AND MATERIALS:** Between October 2010 and April 2014, a total of 137 patients underwent PPB and 4-month followup pelvic and chest x-ray imaging. All patients had exclusively SSs placed and an immediate postimplant fluoroscopic image of the seed cluster. Followup x-ray images were evaluated for the number, location, and displacement of seeds in comparison to Day 0 fluoroscopic images. Significant seed displacement was defined as seed displacement >1 cm from the seed cluster. Followup chest x-rays were evaluated for seed migration to the chest.

**RESULTS:** Seed migration to the chest occurred in 3 of the 137 patients (2%). Seed loss occurred in 38 of the 137 patients (28%), with median loss of one seed (range, 1−16), and total seeds loss of 104 of 10,088 (1.0%) implanted. Local seed displacement was seen in 12 of the 137 patients (8.8%), and total seeds displaced were 0.15% (15/10,088).

**CONCLUSIONS:** SS placement in PPB is associated with low rates of substantial seed loss, local displacement, or migration to the chest. Comparing immediate postimplant fluoroscopic images to followup plain x-ray images is a straightforward method to supplement quality assurance in PPB and was found to be useful in identifying cases where seed loss was potentially of clinical significance. © 2016 American Brachytherapy Society. Published by Elsevier Inc. All rights reserved.

*Keywords:* Brachytherapy; Prostate; X-ray; Radiotherapy; Seed migration

## Introduction

Loose seed (LS) placement in permanent prostate brachytherapy (PPB) is associated with seed migration to the lung or other locations in the body, whereas seed placement with stranded seeds (SS) results in a lower incidence of seed migration (1, 2). Seed migration is a well-documented occurrence (3−6). Although seed migration has not routinely resulted in adverse clinical manifestations, there are isolated reports where angina (7), acute myocardial infarction (8), and lung cancer (9) were coincident with seed migration to the affected organs. Though the frequency of clinical complications is low, this remains an important topic because PPB continues to be used as an effective and convenient treatment option for a large number of men with localized prostate cancer worldwide (10).

There are significantly fewer published data evaluating local seed displacement away from the seed implant cluster as compared to distant seed migration (11, 12). Despite having a lower incidence of seed migration, some reports indicate that seed displacement of SS trains in and around the prostate may occur and adversely affect prostate

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Conflict of interest: None.

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dosimetry (13−16). Data pertaining to seed loss and seed displacement with exclusively SS is limited; the majority of reports address implants that include a mixture of SS and LS (MS) (11, 12, 17, 18). The purpose of this study was to use plain film radiography of both the pelvis and chest at the initial followup to determine whether systematic seed displacement around the prostate, overall seed loss, or migration to the chest occurred when employing exclusively SSs in PPB.

## Methods and materials

Between October 2010 and April of 2014, a total of 137 patients underwent PPB with SS at our institution followed by serial plain film pelvic and chest imaging. In this study, seed migration was defined as movement of seeds to distant organs, primarily the lungs. Seed displacement was defined as movement of seeds away from the prostate seed cluster seen in pelvic x-ray. Seed loss was defined as any decrease in seed count determined by 4-month followup pelvic x-ray or chest x-ray. Imaging consisted of chest x-rays with both posterior-anterior (PA) and lateral views and upright pelvic anterior to posterior (AP) and 45° oblique views at the first followup visit after PPB. Institutional Review Board approval was obtained to conduct this study, and all patients provided consent to the use of their medical records for research purposes. PPB performed in this patient cohort was consistent with methods described in the 2012 American Brachytherapy Society Guidelines (19). Thirty-two patients had brachytherapy combined with external beam radiation therapy and 105 underwent monotherapy. Two patients had $^{103}$Pd implants, and the remainder had $^{125}$I. Needle and seed placement were guided by axial and sagittal transrectal ultrasonography (TRUS) in conjunction with intraoperative pelvic PA fluoroscopy. A Foley catheter was placed within the urinary bladder. Full-strength contrast was placed in the Foley balloon, and diluted contrast was injected into the bladder. Under sagittal ultrasound guidance, two inert gold marker seeds, 1 mm in diameter and 3 mm in length, were placed near the prostatic base and apex. The marker seeds were parallel and slightly lateral to the midurethra, in the approximate midprostate in the sagittal plane. After all needles were placed, SSs were deposited via an afterloading technique. Centrally located needles were frequently used to place two separate strands of two to three seeds each at the superior and inferior prostate. SS type included 117 patients with Rapid Strand ($^{125}$I) (Oncura Inc., GE healthcare Inc, Little Chalfont, United Kingdom), 18 patients with Strand Port ($^{125}$I) (Brachysciences, Oxford, CT), and 2 patients with Theraseed ($^{103}$Pd) (Theragenics Inc., Buford, GA). Immediate postimplant PA and oblique fluoroscopic images were recorded with patients in the dorsal lithotomy position, and a step-section planimetric TRUS study was conducted postprocedure to compute prostate volume. Postimplant CT scans were performed within 8 h of seed placement; Foley and rectal catheters were used for contrast placement.

C-arm fluoroscopic images were acquired with the use of a GE Lithotripter OEC 9800 C-Arm or a GE Lithotripter OEC 9800+ C-Arm (GE Healthcare, Little Chalfont, United Kingdom), and 4-month plain film x-rays were acquired with a wall mounted Phillips Optimus 80 Bucky TH (Philips, Andover, MA) or Philips PCR Eleva computed radiography image receptors (Philips, Andover, MA).

Seed migration to the chest was evaluated using the approach previously described (20). For local displacement, the method used was similar to that described by Fuller *et al.* (11), who defined local seed displacement as a seed that was displaced greater than or equal to 1 cm from the implant cluster. The implant cluster was defined as the ellipse that encompassed the most cranial and caudal seeds in the superior−inferior dimension and the most lateral seeds. Each patient was analyzed for incidental seed displacement as illustrated in Fig.1-3.

Automated seed counting was performed on the Day 0 CT images by Variseed (Varian Medical Systems, Palo Alto, CA) and was used to establish the baseline seed number, which was also confirmed by the number of seeds documented in dosimetry records, the number transcribed in the operative report, and manual seed count tabulated by a physicist during the implant procedure. Two observers (BJB and CCF) performed a manual count of all Day 0 fluoroscopic and 4-month followup x-ray images on all patients. In cases where the followup seed count differed from the automated seed count of the CT scan on Day 0, the observer performed a second count using the 4-month oblique pelvic radiograph. If there were fewer seeds identified on the AP and oblique x-ray images than on the CT count and the number implanted in the prostate as recorded by the procedure note, then it was established that the patient had lost seeds. The number of seeds recorded from the CT scan on Day 0 was also verified by the seed counts in the postimplant Day 0 fluoroscopy images. All seed counts were then recounted by a second observer (BJB) for further verification.

The dimensions of the implant cluster were measured to determine the movement of seeds in horizontal (x-axis) and vertical craniocaudal (y-axis) directions. The implanted gold fiducial markers were used as 3-mm reference lengths and points of measurement on the y-axis. This measurement was also verified with the known length of the seed radiopaque markers, using oblique and lateral images as necessary. The angle of the gold seed was measured from the lateral scout CT image on Day 0 to calculate the error associated with the foreshortening of the gold seed produced in AP views. The x-axis measurement of the seed cluster dimensions was based on the distance between the two seeds having greatest separation at the most lateral portions of the implant. The y-axis measurement was determined by measuring the distance between the Cranial and Caudal Gold Seeds (CCGS) and the distance from the most

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