ELSEVIER

CrossMark

BRACHYTHERAPY

Brachytherapy 14 (2015) 979–985

Dosimetric variations in permanent breast seed implant due to patient arm position

Elizabeth Watt[1,2,*], Siraj Husain[3,4], Michael Sia[3,4], Derek Brown[5], Karen Long[6], Tyler Meyer[1,2,3]

[1]*Department of Physics and Astronomy, University of Calgary, Calgary, Alberta, Canada*
[2]*Department of Medical Physics, Tom Baker Cancer Centre, Calgary, Alberta, Canada*
[3]*Department of Oncology, University of Calgary, Calgary, Alberta, Canada*
[4]*Department of Radiation Oncology, Tom Baker Cancer Centre, Calgary, Alberta, Canada*
[5]*Department of Radiation Medicine and Applied Sciences, University of California–San Diego, La Jolla, CA*
[6]*Department of Radiation Therapy, Tom Baker Cancer Centre, Calgary, Alberta, Canada*

ABSTRACT

PURPOSE: Planning and delivery for permanent breast seed implant (PBSI) are performed with the ipsilateral arm raised; however, changes in implant geometry can be expected because of healing and anatomical motion as the patient resumes her daily activities. The purpose of this study is to quantify the effect of ipsilateral arm position on postplan dosimetry.

METHODS AND MATERIALS: Twelve patients treated at the Tom Baker Cancer Centre were included in this study. Patients underwent two postimplant CT scans on the day of implant (Day 0) and two scans approximately 8 weeks later (Day 60). One scan at each time was taken with the ipsilateral arm raised, recreating the planning scan position, and the other with both arms down in a relaxed position beside the body, recreating a more realistic postimplant arm position. Postplans were completed on all four scans using deformable image registration (MIM Maestro).

RESULTS: On the Day 0 scan, the V_{200} for the evaluation planning target volume was significantly increased in the arm-down position compared with the arm-up position. Lung, rib, and chest wall dose were significantly reduced at both time points. Left anterior descending coronary artery, heart, and skin dose showed no significant differences at either time point.

CONCLUSIONS: Although some dosimetric indices show significant differences between the arm-up and arm-down positions, the magnitude of these differences is small and the values remain indicative of implant quality. Despite the delivery of the majority of dose with the arm down, it is reasonable to use CT scans taken in the arm-up position for postplanning.

Keywords: Brachytherapy; Dosimetry; Permanent breast seed implant; Deformable image registration

Introduction

Recent decades have seen the emergence of partial breast irradiation for the treatment of early-stage breast cancer, after lumpectomy, because of research showing that most recurrences occur near the excision site (1). Many radiotherapy techniques have been applied to partial breast irradiation (2), including multicatheter interstitial brachytherapy (3), intracavitary brachytherapy with the MammoSite (4), Contura (5), or Strut-Adjusted Volume Implant (6) devices, permanent breast seed implant (PBSI) (7, 8), and various external beam techniques, many of which are currently in clinical trials (9–12).

A method of PBSI as a 1-day procedure has been pioneered by Pignol *et al.* (7) at the Odette Cancer Centre (Toronto, Ontario, Canada) using stranded ^{103}Pd seeds placed in and around the postsurgical seroma. This is an appealing treatment alternative for patients compared with external beam radiation because of the reduced number of visits to the cancer center. Results from the Phase I/II study of PBSI have been promising, with no recurrences after a

Received 20 July 2015; received in revised form 17 September 2015; accepted 17 September 2015.

Conflict of interest: None declared.

* Corresponding author. Department of Medical Physics, Tom Baker Cancer Centre, 1331–29 Street NW, Calgary AB, T2N 4N2, Canada. Tel.: +1-403-521-3085; fax: +1-403-521-3327.

E-mail address: elizabeth.watt@albertahealthservices.ca (E. Watt).

1538-4721/$ - see front matter
http://dx.doi.org/10.1016/j.brachy.2015.09.008

median follow-up of 32 months and good tolerance and patient satisfaction reported. Additionally, acute skin reactions appear to be reduced in PBSI compared with external beam treatment (8, 13).

The planning CT scan for PBSI is taken with the patient's ipsilateral arm raised and placed in a fixed armrest. Patient setup in the operating room at the time of implant attempts to reproduce this position as accurately as possible. Postimplant CT scans are taken in the same position as the planning scan and the implant; these are used for dosimetry and quality assurance. In the months after the implant as the patient resumes her daily activities, however, anatomical changes and variations are unavoidable. Permanent ^{103}Pd seeds (half-life = 17 days) deliver radiation over an extended time period; because of the mobility of breast tissue, the dosimetric impact of seed movement over this time may be more significant than in other sites in which permanent seed implants are performed, such as the prostate. This study aims to quantify the impact of ipsilateral arm position on the dosimetry of the implant and nearby organs.

Methods and materials

Patient selection and characteristics

Seventeen consecutive patients treated with PBSI at the Tom Baker Cancer Centre (Calgary, Alberta, Canada) from November 2013 to December 2014 were considered for inclusion in this study. A multicenter registry trial for PBSI was approved by the institutional ethics review board, and all patients provided written informed consent. Patients first underwent breast-conserving surgery and were considered for PBSI according to the inclusion and exclusion criteria. Inclusion criteria required that patients be ≥50 years, tumor size ≤3 cm, and clear margins of at least 2 mm; these criteria are all recommended by *GEC-ESTRO* (14). Exclusion criteria included lobular component, extensive *in situ* or multifocal carcinoma, and node-positive disease. Eligible patients were offered PBSI, and those opting for this technique were further screened with CT and ultrasound volume studies to ensure the seroma was of implantable size and position. Eligibility required that the seroma was visible under both ultrasound and CT imaging and that the position of the seroma relative to the lateral breast edge allowed the fiducial needle to reach it. Consideration was also given to the proximity of the seroma to the skin and chest wall, and volume of breast tissue around the seroma, in an effort to limit dose to these structures and ensure an adequate planning target volume (PTV). Three patients treated with PBSI were excluded from this study because they did not undergo all the requisite scans for analysis. Two additional patients were excluded: one because her arm-up scans were taken in a different position than all other patients, before a protocol change at the center (two arms up compared with only ipsilateral arm up) and the other because of scan boundary limitations on her planning scan rendering dosimetric parameters for nearby organs indeterminable. Planning characteristics for the 12 patients included in the study are summarized in Table 1. For each patient, the breast quadrant of the seroma was defined as upper-inner, upper-outer, lower-inner, or lower-outer. This was determined using the position of the center of the seroma relative to the nipple.

Table 1
Patient characteristics at planning

Patients (left sided)	12 (8)
Quadrant (left sided)	
Upper outer	3 (1)
Upper inner	3 (3)
Lower outer	6 (4)
Lower inner	0
Seroma volume (cm^3)	16.8 (3.1–32.6)
Number of needles	18 (11–26)
Number of seeds	88 (42–116)
Time from surgery to implant (d)	107 (57–126)

Note. Values are median (range) unless otherwise indicated.

Treatment planning and delivery

Patients were simulated on a slant board in the supine position with the ipsilateral arm raised. The radiation oncologist contoured the clinical target volume (CTV; seroma and surrounding fibrosis) and chest wall muscle on the planning CT in Eclipse (Varian Medical Systems, Palo Alto, CA). The PTV was created as a 1- to 1.5-cm expansion of the CTV, trimmed to the skin and chest wall muscle. PTV modifications (because of proximity to the chest wall or skin) were performed as required according to specific patient anatomy. The body, planning skin contour (a 5-mm inner ring of the body contour, referred to as "skin$_{5\ mm}$"), and ipsilateral lung were automatically generated. For the purposes of this study, cardiac structures were contoured retrospectively on the planning scan for left-sided patients and reviewed by the radiation oncologist. The whole heart was delineated using guidance from the University of Michigan cardiac atlas (15). Because of challenging visualization of the left anterior descending coronary artery (LAD), an LAD region was delineated. This was a conservative contour containing a region where the LAD would reasonably be expected to exist, although it was not possible to see it on every CT slice for all patients. Retrospectively, an additional skin contour, a 2-mm contraction of the body contour (referred to as "skin$_{2\ mm}$"), was also created for further analysis. This was chosen because of a recent study by Hilts *et al.* (16), which found that $D_{0.2\ cm^3}$ (dose to the most irradiated 0.2 cm^3) for a 2-mm-thick skin rind is a meaningful skin dose metric for breast brachytherapy techniques.

A dose of 90 Gy using stranded "Advantage" ^{103}Pd seeds (IsoAid, Port Richey, FL) with 2.5 U activity at the time of implant was prescribed. The implant was forward planned according to recommended seed spacing guidelines (7) using MIM Symphony, version 6.1.7 (MIM Software, Inc., Cleveland, OH). Planning goals included a