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Original Report

Dosimetric impact of setup accuracy for an electron breast boost technique

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Abstract

Purpose: To determine the setup error on an electron breast boost technique using daily cone beam computed tomography (CBCT). Patient and setup attributes were studied as contributing factors to the accuracy.

Methods and materials: Reproducibility of a modified lateral decubitus position breast boost setup was verified for 33 patients using CBCT. Three-dimensional matching was performed between the CBCT and the initial planning CT for each boost fraction by matching the tumor bed and/or surgical clips. The dosimetric impact of the daily positioning error was achieved by rerunning the initial treatment plans incorporating the recorded shifts to study the dose differences. Breast compression, decubitus angle, tumor bed location and volume, and cup size were studied for their contribution to setup error.

Results: The range of setup errors was: 1.5 cm anterior to 9 mm posterior, 1.3 cm superior to 2.3 cm inferior, and 3.2 cm medial to 2.4 cm lateral. Seven patients had setup errors that were ≥2-cm margin placed on the tumor bed and scar. Four of those 7 patients had unacceptable coverage as defined by the volume of the tumor bed plus scar that is covered by the 90% isodose line (V90) compared with the original plan. All other patients had no discernible difference in the coverage (V90). The use of compression, tumor bed location, or volumes >20 mL showed no effect on coverage.

Conclusions: In general, this study supported that a 2-cm margin was adequate (29 of 33 patients) when patients are treated under typical conditions. Care should be taken when high electron energies are selected because the coverage at depth is more difficult to maintain in the clinical environment.

Introduction

Postoperative radiation therapy for patients with breast cancer is traditionally delivered via tangential whole breast photon beams followed by an electron boost directed to the surgical cavity. The dimensions of the surgical cavity, defined either by surgical clips or surgical seroma, evolve

Conflicts of interest: None.

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over a period of months following a lumpectomy.[1,2] These changes can continue through the 3- to 5-week course of tangential beam radiation and is inversely correlated with the length of time from lumpectomy. For this reason, many patients require replanning using computed tomography (CT) scanning for the electron boost. At our institution, we routinely use a modified lateral decubitus position for the breast boost in patients in which body habitus and tumor location precludes the use of the supine breast position.[3] This technique allows for freedom in patient rotation to optimize the patient anatomy for the boost delivery. In an effort to further reduce the electron energy (and thus the skin dose) and to improve the target volume coverage in larger patients, an in-house designed compression device is used.[4] This technique has also allowed a decreased distance between the skin and the target volume depth, improved electron coverage of the tumor bed, and reduced skin dose.

Although much effort had been made to develop the modified lateral decubitus position technique and to use a compression device, the efficacy in terms of dose coverage had not been studied. In this study, cone beam CT (CBCT) was used to evaluate setup reproducibility and its impact on the dosimetry of the electron breast boost. In addition, any correlation between the dosimetric coverage and patient/tumor bed characteristics was investigated.

Methods and materials

A total of 33 patients ranging from 33 to 77 years old were entered into an institutional protocol. Consenting postsegmental mastectomy patients diagnosed with invasive carcinoma of any type or ductal carcinoma in situ were selected. Patients having any contraindication for external beam radiation therapy, such as systemic lupus, scleroderma, or previous ipsilateral breast irradiation, or who had undergone modified radical or total mastectomy were excluded from the study. No other selection criteria were included.

Patients were simulated for their electron breast boost using a GE LightSpeed scanner (GE Healthcare, Little Chalfont, UK). Patients were immobilized using a Vac-Lok bag (Civco, Orange City, IA) in the lateral decubitus position so that the surface of the breast in the location of the scar and tumor bed was en face. Care was taken to ensure that the Vac-Lok bag was formed around the patient to maintain a reproducible position. Alignment marks were placed on the patient from the simulation room lasers. In 25 of the 33 patients studied, an in-house custom compression device was used to reduce the depth of the distal tumor bed relative to the skin, thus allowing for a lower electron energy level. The daily reproducibility of the compressed device was indexed to the breast by skin markings as well as index markings made to the Vac-Lok bag. The CT images were sent to the Pinnacle treatment planning system (Philips, Amsterdam, the Netherlands) for planning of the breast boost.

In the treatment planning process, the tumor bed, surgical scar, and surgical clips were contoured and then combined to create the clinical tumor volume. A 2-cm margin was added to the combined structure to create the planning tumor volume extension. A custom electron cutout was then fabricated to define the beam portal. The margin was used to account for positioning variability, breathing motion, breast shape changes, penumbra, and microscopic disease. The electron energy was chosen to achieve tumor bed coverage at a minimum of 90% of the total dose (V90). Typical fractionation schemes were 5 to 7, with 1 patient receiving only 2 fractions. All fractions were prescribed to deliver either 200 or 250 cGy.

For treatment, each patient was set to the marks established at simulation in her modified lateral decubitus position. A CBCT using the Varian linear accelerator's on-board imager (Varian Medical Systems, Palo Alto, CA) was performed for each fraction for every patient to quantify the setup accuracy and its dosimetric impact. At the treatment console, the radiation oncologist then performed a 3-dimensional–3-dimensional (3D-3D) match between the planning CT data set and the CBCT data set while the patient was on the treatment table. The radiation oncologist used soft-tissue registration and relied on seroma in the tumor bed and/or surgical clips as landmarks on which to match the contoured anatomy. The table shifts in the lateral, longitudinal, and vertical directions were recorded for subsequent data analysis. The table shifts were transformed into the patient's coordinate system by a shift of the isocenter for the dosimetric analysis.

For the 33 patients entered into the study, the total number of fractions, and thus the total number of table shift recordings, was 167. A descriptive analysis was performed on all table shifts. The average and range of the shifts in all 3 directions for each patient were determined. The radial displacement, defined as the vector that resulted from the combined linear table translations in the lateral, longitudinal, and vertical directions within a single fraction, was calculated and expressed as an average, range, and maximum for each patient. A dosimetric analysis was performed using the treatment planning system. A composite treatment plan was constructed using the shifts obtained from the 3D-3D matching. A separate electron beam was created for each fraction and the inverse of the obtained shifts was applied to each isocenter for each beam. The plan was then recalculated to achieve a composite plan that represented the setup inaccuracies from the 3D-3D matching. The dose received by 100%, 95%, and 90% of the breast volume, V100, V95, and V90 were recorded for both the original plan and the recalculated composite plans. In this report, only the V90 was reported because this was the minimum coverage deemed acceptable.