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Immediate breast reconstruction with anatomical implants following mastectomy: The radiation perspective

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ABSTRACT

Immediate implant-based breast reconstruction followed by postmastectomy radiation therapy (PMRT) is controversial because of the risk of compromised treatment plans and concerns regarding cosmetic outcomes. We evaluated the effects of immediate direct-to-implant breast reconstruction with anatomical implants on the quality of PMRT delivered by 3-dimensional conformal radiotherapy (3D-CRT). In this retrospective, single-institution study, patients who had undergone reconstruction with direct anatomic implant, performed by a single surgeon, received 3D-CRT between 2008 and 2013. For each patient, 2 plans (including or excluding internal mammary nodes [IMN]) were created and calculated. The primary end point was the dose distribution among reconstructed breasts, heart, lungs, and IMNs, and between right and left breasts. Of 29 consecutive patients, 11 received right-sided and 18 received left-sided PMRT to a total dose of 50 Gy. For plans excluding IMN coverage, mean D_{mean} for right and left reconstructed breasts was 49.09 Gy (98.2% of the prescribed dose) and 48.51 Gy (97.0%), respectively. For plans including IMNs, mean D_{mean} was 49.15 Gy (98.3%) for right and 48.46 Gy (96.9%) for left reconstructed breasts; the mean IMN D_{mean} was 47.27 Gy (right) and 47.89 Gy (left). Heart D_{mean} was below 1.56 Gy for all plans. Mean total lung volume receiving a dose of $\geq$ 20 Gy was 13.80% to 19.47%. PMRT can be delivered effectively and safely by 3D-CRT after direct-to-implant breast reconstruction with anatomical implants, even if patients require IMN treatment.

Introduction

For women with locally advanced breast cancer, adjuvant postmastectomy radiation therapy (PMRT) is an important treatment strategy that has been shown to prolong disease-free and overall survival.[1,2] Given the high risk of locoregional recurrence associated with lymph node–positive breast cancer, PMRT is recommended for patients with positive axillary lymph nodes.[3-5]

Immediate implant-based reconstruction after mastectomy can deliver excellent esthetic outcomes because of the availability of skin-sparing and nipple/areola-sparing mastectomy and the use of acellular dermal matrices (ADM) to expand and shape the implant pocket without serratus anterior muscle elevation.[6,7] Furthermore, the presence of a breast prosthesis during PMRT with photon beam is not associated with significant changes in dose distribution.[8,9] However, immediate implant-based breast reconstruction in patients requiring PMRT remains controversial because of concerns for higher risk of unfavorable reconstructive outcomes,[10-12] although some found that the risk of reconstructive failure after PMRT was acceptable.[13]

For radiation oncologists delivering PMRT, a key question is whether specific approaches of immediate reconstruction, including implant-based reconstruction, allow for optimal coverage of the chest wall and internal mammary nodes (IMN) with acceptable doses to the heart and lungs. A potential determinant for the quality of PMRT treatment plans after direct-to-implant reconstruction is the shape of the implant, as it may limit the options for field arrangements. Round and teardrop-shaped cohesive gel implants have been shown to yield similar esthetic results in

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breast augmentation.[14] However, in patients requiring PMRT, the use of anatomical implants with their gradually tapered slope above the medial part of the chest wall has the potential to obviate the need for a medial electron field[15] and allow for partially wide tangential field plan, hence, avoiding matching electron-photon fields, high skin doses with electrons, and reducing on-treatment time. In the present radiation planning study, we sought to determine whether the use of anatomical implants in combination with modern radiation techniques would enable us to improve the quality of treatment after ADM-assisted direct-to-implant reconstruction with anatomical implants compared with the reported series of nonanatomic (mostly round/tissue expanders) implants. We compared the doses with the reconstructed breast (RB), IMNs, heart, and lungs between treatment plans with and without intended IMN coverage in patients with left- or right-sided reconstruction.

Patients and Methods

Study design and patients

This retrospective study was approved by the responsible institutional review board and included 29 patients who received PMRT from 2008 to 2013 at our institution. All patients with Stage 0 to III breast cancer who underwent skin-sparing mastectomy followed by immediate direct-to-implant breast reconstruction with anatomically shaped silicon-filled implants (Natrelle 410, Allergan, Inc., Irvine, CA) were included. A fenestrated ADM derived from fetal bovine dermis (SurgiMend, TEI Biosciences Inc., Boston, MA) was used in shaping the implant pocket. All breast reconstructions were performed by a single plastic surgeon (M. S.). The primary end point was the dose distribution among RB, IMNs, heart, and lungs, with 3-dimensional conformal radiotherapy (3D-CRT) including or excluding IMN coverage.

Target and normal tissue delineation

The clinical borders of the treatment region, which were defined by the placement of catheters during computed tomography (CT) simulation, included the medial border at the patient midline, the lateral border situated approximately at the midaxillary line, the superior border at the inferior aspect of the clavicular head, and the inferior border 1.5 cm below the RB fold. The RB planning volume (target volume) was delineated on axial CT scans using the clinical borders as a guide. This target volume (including the implant and associated remnant breast tissue) was contoured and edited, with the anterior border placed 0.5 cm inside the external body contour. The posterior border was defined by connecting a point that is 5 mm lateral to the medial border with a point that is 5 mm medial to the lateral border and subsequently edited to be anterior to the intercostal muscles. The inferior border was placed 10 mm below the implant and the superior border extended up to the bottom of the clavicular head. This definition was based on an estimate of the 95% isodose surface derived from traditional tangential breast fields. The internal mammary chain was delineated lateral to the sternum at intercostal spaces 1 to 3, including the node, vein, and artery. The whole heart was contoured based on a heart atlas.[16] Bilateral lungs were contoured using automated density gradient tracking with subsequent review and editing as necessary. All contours were done by a single radiation oncologist (M.B.-D.).

Radiation treatment planning

In total, 2 treatment plans were generated for each patient, 1 with coverage of the RB alone and the other with both the RB and the internal mammary chain. CT simulation was performed with 3- to 5-mm cuts on a breast board with both arms above the head. Standard treatment planning using partially wide tangential fields with 6-MV photons or a combination of 6 and 15-MV photons were used. No bolus was used during planning or treatment. In accordance with the International Commission on Radiation Units and Measurements guidelines, the RB (target volume) was to be covered with 95% to 107% of the planned dose of 50 Gy (2.0 Gy per fraction). The implant was not defined as a separate target. IMNs were to be covered with 90% of the planned dose. Dynamic wedges and segments were used as needed to improve dose homogeneity and a multileaf collimator of 0.5 cm width was used as needed. For left-sided treatment, the heart was excluded from the fields; in case of anterior heart position, radiation was delivered with the Varian Real-time Position Management (RPM) system (Varian Medical Systems, Inc., Palo Alto, CA) and treatment plans were calculated on the RPM scan.[17] A supraclavicular field was added to all plans for conformality. No electron fields were added for IMN coverage and no field (exit/entry) was allowed through the contralateral breast.

Plan evaluation and statistical analysis

Dose-volume histograms were generated for the RB and IMNs and for normal organs, including the heart and lungs. Dose distributions were compared between the 2 plans for each patient or between right- and left-sided treatment plans using paired t-tests. Statistical comparisons were made for D_{mean} and doses to 95% (D_{95}) or 90% (D_{90}) of the volume of the RB, IMNs, and heart, and for the percentage of total lung volume receiving a dose of $\geq$ 20 Gy (V_{20}). Pearson correlation analysis was used to evaluate the effects of variants on dosimetric results, and nonpaired t-tests were used for independent group outcomes. A 5% significance level was used for all tests.

Results

Patients

Of 29 patients included in this analysis, 18 had undergone reconstruction of the left breast and 11 had undergone reconstruction of the right breast. A total of 2 patients had bilateral reconstruction. The mean implant volume was 392 mL (range: 225 to 615 mL), with no significant difference between implant volumes for left- and right-sided reconstruction (389 *vs* 396 mL, respectively, $p = 0.856$). The mean planned treatment volume based on RB contoured areas for treatment planning was 603 mL overall (range: 245 to 1209 mL) and similar for left and right RBs (564 *vs* 604 mL, respectively, $p = 0.683$). The mean medial distance (*i.e.*, the distance from the medial edge of the implant to the body midline) was 3.24 cm (range: 1.44 to 5.72 cm). Medial distances were similar on both sides and were not affected by implant volume.

Dosimetric findings

Implant volume and medial distance did not affect breast D_{mean} or D_{95}, heart D_{mean}, lung V_{20}, or IMN coverage across treatment plans. For plans with RB coverage only, mean D_{mean} for right and left RBs was 49.09 Gy (98.2% of the prescribed dose) and 48.51 Gy (97.0%), respectively (Fig. 1); the corresponding values for plans including IMN coverage were very similar (*i.e.*, 49.15 Gy [98.3%] for right RBs and 48.46 Gy [96.9%] for left RBs) (Table). Although the D_{mean} values showed statistically significant differences in favor of right- *vs* left-side coverage, the difference between mean values was $<$ 0.70 Gy for both plans and therefore is probably not clinically meaningful (Table and Fig. 2). RB D_{95} values were significantly smaller with left- *vs* right-sided treatment in plans that included IMN coverage. Statistically significant differences in D_{95} for left *vs* right RBs also were seen with plans that excluded IMN coverage, but the difference between mean values was small (Table and Fig. 2). For treatment plans including IMN coverage, the mean IMN D_{mean} values for left- and right-sided treatment were very similar, and there was no significant difference between left- and right-sided IMN coverage based on D_{90} (Table and Fig. 3). D_{mean} evaluated for the RB excluding the anatomical implant was 93.12% and 92.80% of the prescribed dose for plans with and without IMN, respectively ($p = 0.12$).

Doses to the heart in patients who received radiation treatment of the left RB were very low, even when IMNs were included in the treatment plan. The mean heart D_{mean} was 1.25 Gy (range: 0.83 to 1.46 Gy) for treatment plans with no IMN coverage and 1.56 Gy (range: 1.23 to 2.10 Gy) for plans including IMN coverage ($p <$ 0.001) (Table and Fig. 4).

The overall mean lung V_{20} was 16.45%. Mean lung V_{20} was generally higher for right- *vs* left-sided treatment and for plans including IMN coverage *vs* those excluding it (Table and Fig. 5). Plans including IMN coverage had a mean lung V_{20} of 17.95% (range: 8.10% to 21.32%) compared with 15.45% (range: 7.51% to 20.30%) for plans with no IMN coverage ($p = 0.040$). The highest