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Case Study 1

February 28, 2015

DCIS Treatment with Conformal Breast Tangents and Field in Field Dose Shaping

History of Present Illness: Patient is a 72 year old female who underwent a bilateral digital screening mammography that revealed a mass in the right breast at middle depth. Multiple grouped calcifications in the right breast central to the nipple were also found at middle depth. A stereotactic core needle biopsy was performed and demonstrated solid type, nuclear grade 3, cTisN0M0 DCIS. Focal comedo type necrosis and pagetoid spread into the duct epithelium were found. Focal fibrocystic changes and associated benign calcifications were also noted. DCIS is a non-invasive disease characterized by cancer cells confined to the lumen of the mammary gland ducts.[1] The staging of cTisN0M0 indicated a clinical judgment that the disease was confined in place, had not spread to regional lymph nodes, and had no metastatic component. The nuclear grade 3 indicates high cell division rates and the presence of comedo-type necrosis also points towards a possibility of future invasiveness. The patient's case was discussed at a multidisciplinary conference which recommended breast conserving lumpectomy followed by radiotherapy.

Past Medical History: Patient was diagnosed with osteopenia in 2001 and was on Fosamax from 2005 to 2010. In 2009, she was diagnosed with senile nuclear sclerosis in both eyes and underwent cataract removal and lens insertion surgeries for the right eye and then left eye the same year. In 2010, she developed blepharitis in both eyes. She started to experience low grade vitreous degeneration in 2012 and an after-cataract which started to obscure her vision starting in 2013. Patient also reports an unspecified past foot surgery. She denies medication allergies and has no history of blood transfusions.

Social History: Patient is retired from a secretarial career with no military service history or other hazards of occupational exposure. She is married with 1 daughter. Patient has never smoked or used smokeless tobacco. She reports caffeine consumption of 5 cups per week and alcohol consumption of 5 glasses of wine (2.5 oz alcohol) per week. Patient denies recreational drug use. Patient is not sexually active. Her exercise included walking and bicycle riding. Patient does not report any concerns about stress or weight and follows no special diet. Patient's father had pancreatic cancer in his 60s. Patient's mother is alive but suffering from dementia. Her brother has no significant health concerns but her sister has been recently diagnosed with breast cancer and is also under treatment. Patient's daughter was treated for uterine cancer in her 40s and has undergone hysterectomy.

Medications: Patient takes Atorvastatin (Lipitor) and a multivitamin every day, and Lorazepam (Ativan) as needed for anxiety.

Diagnostic Imaging: Digital mammograms of both breasts were acquired in 2014 as part of a routine screening. A suspicious mass was observed in the right breast. X-ray guided stereotactic core needle biopsy was performed, which resulted in a diagnosis of cTisN0M0 DCIS with comedo type necrosis and pagetoid spread into the duct epithelium. The mammogram also showed multiple grouped calcifications central to the nipple at middle depth which were noted in a previous screening mammogram in 2013. A post lumpectomy simulation CT was acquired in 2015 on a Philips Brilliance 16 slice CT at 120 keV and 3 mm slice thickness.

Radiation Oncologist Recommendations: The radiation oncologist recommended that the patient undergo photon radiotherapy to the whole right breast with an electron boost to the lumpectomy site and surgical scar once the lumpectomy surgery was complete. The photon plan consisted of isocentric medial and lateral tangent conformal x-ray beams utilizing a field in field (FIF) technique to reduce the incidence of dose hot spots. The physician requested that no wedges be used on the medial tangent beam in order to reduce scattered dose to the contralateral breast and heart. Wedges on the lateral tangent beam could be used or not used at the discretion of physics and dosimetry. A electron boost was to be delivered en face using cerrobend beam blocks conforming to the lumpectomy site and scar as soon as photon therapy was complete.

The Plan (Prescription): In order to begin treatment quickly, the patient was initially planned with standard photon fractionation of 5040 cGy in 28 fractions of 180 cGy per fraction, followed by a 1000 cGy electron boost delivered in 5 fractions of 200 cGy. The radiation oncologist specified that the maximum dose to the breast tissue and lumpectomy site should be 107% of the prescription dose. The lumpectomy site should be fully covered by the 100% of prescription isodose line, and the breast tissue should be covered by the 95% of prescription line. The portion of the right lung receiving 20 Gy should be kept below 20%. After review of the patient's plan and anatomy, the radiation oncologist felt that the patient would be a good candidate for a hypofractionated accelerated whole breast therapy regime delivering 266 cGy per day, resulting in fewer treatment sessions, lower total dose, and no significant difference in tumor control or cosmetic outcome.[1,2,3] One of the main deciding factors in the suitability of a patient for accelerated whole breast therapy is the size of the breast. Large breasts that require high incident doses to achieve adequate coverage to deep tissues are not suitable because the higher daily dose will be too high in some parts of the breast. The patient has small breasts that are suitable for the accelerated protocol. The physician met with the patient and explained the hypofractionation option and the possible outcomes. The patient opted to pursue hypofractionation. The photon treatment schedule was adjusted after 4 fractions of 180 cGy (720 cGy) to finish with 14 fractions of 266 cGy (3724 cGy) for a total of 4444 cGy. The electron plan was left unchanged with 5 fractions of 200 cGy.

Patient Setup/Immobilization: The patient's simulation CT was acquired in the supine position on a custom-built inclined breast board set at 10 degrees. Both arms were raised and an Alpha Cradle form was made to support and immobilize her arms, shoulders, and head. The patient's position was checked during the creation of the Alpha Cradle form to make sure that she was rolled to a level position. A foam knee wedge was placed beneath her knees to improve the comfort of the simulation position (Figure 1).

The treatment isocenter could not be determined at the time of scanning, so an anatomic reference point was established to allow couch shifts to isocenter during treatment.[4] Leveling skin marks were made by the radiation therapists bilaterally on the skin lateral to the ribcage at a level below the breasts to improve reproducibility. An anatomic reference point was marked on the patient's mid-sagittal line around the midpoint of the sternum. A radiopaque marker was placed over the anatomic reference point. The radiation oncologist applied Beekley Medical CT-SPOT radiopaque marker lines to the patient's mid-sagittal line, the desired lateral field border, the superior and inferior field borders, the outline of the breast tissue based on palpation, the nipple, and the scar line. The marker lines highlighted the location of these physical landmarks on the CT scan but were not present during treatment (Figure 2).

Anatomical Contouring: Simulation CT images were transferred to a Varian Eclipse 10.0.42 treatment planning system (TPS). The radiation oncologist contoured the boundaries of the breast tissue and the lumpectomy site seroma. The dosimetrist then contoured organs at risk (OR) including right lung, left lung, heart, and the superior portion of the liver. The carina was contoured as an image guidance aid for the radiation therapists. The border wires, nipple wire, and scar wire were all contoured to assist in their visualization in digitally reconstructed radiographs (DRRs). The wire structures were overridden to air density. The radiation oncologist verified the accuracy of the ORs and made final adjustments to the breast contour.

Beam Isocenter/Arrangement: The plan isocenter location was set near the midpoint of the tangent line connecting the reference point location on the sternum and the lateral field border (Figure 3). The isocenter was kept in the same plane as the anatomic reference point to eliminate one couch shift dimension and the isocenter location was adjusted such that the couch shifts from the reference location were rounded to the nearest centimeter to facilitate rapid patient setup. The photon tangent beams were planned for a Varian Clinac 21 EX. The medial tangent beam, a left anterior oblique (LAO), was set at a gantry angle of 60 degrees, and the opposing lateral tangent beam, a right posterior oblique (RPO), was set at a gantry angle of 240 degrees (Figure 4). The couch rotation and collimator rotation were both set to 0 degrees for all beams. All photon beams were planned at 6 MV. Field sizes were chosen for each beam to encompass the breast tissue plus surrounding tissue superiorly and inferiorly to the border markers, and medially to the mid-sagittal line, being careful not to include any portion of the contralateral breast in the field. The field edge opposite of the midline marker was set to include at least 1.5 cm of flash in the air. A multileaf collimator (MLC) was used on both beams to block as much of the right lung and liver as possible without compromising coverage of the breast tissue (Figures 5, 6, 7).

Treatment Planning: Planning for delivery on the Varian Clinac 21 EX was performed on a Varian Eclipse 10.0.42 TPS. A dose calculation point was created in the same plane as the isocenter point at a location inside the breast tissue, and near the midpoint of curvature of the ribcage between the medial and lateral field borders. The dose calculation point was kept at least 5 mm from the ribs in order to avoid inhomogeneity calculation problems caused by changes in scattered dose. Initial dose weighting between the medial and lateral tangent beams was chosen to make the isodose distribution in the breast tissue approximately symmetrical. The dosimetrist evaluated the initial dose distribution to determine whether a wedge on the RPO beam could help distribute dose favorably. Wedges are beam modifying devices that create an attenuation gradient across a beam profile as the beam leaves the treatment head, which in turn creates a dose gradient in the incident beam.[5] This type of gradient can be useful in cases where dose needs to be uniformly shifted in one direction such as from the apex of the breast towards the chest wall, but wedges cannot simultaneously account for multiple curvatures such as the decreasing thickness inferiorly and superiorly from the breast's fullest point.[6] In these cases, dose shaping with MLCs can be a good alternative. It is even possible to use both a wedge and MLC shaping. The wedge can provide a global shift in dose distribution, and MLCs can fine-tune the local distribution.

Upon evaluation of the initial dose distribution, it was determined that no wedges would be necessary for the patient's plan. The dose measured at the calculation point was normalized to place the 100% isodose line near the boundary between breast tissue and the chest wall, such that most of the breast tissue was encompassed within the 100% isodose line. This normalization emphasized several dose hot spots that already existed in the initial dose distribution.

Dose shaping with MLCs was achieved by selectively blocking out dose to hot spots using FIF planning. Starting with the normalized dose distribution, a new isodose line was created and set up to show is isodose line a few percent below the current maximum dose value, revealing the location of the hottest spots in the plan. Starting with the medial tangent beam, a FIF beam was created with MLC leaves blocking out the observed hot spots. A few percent of the parent beam's energy were then shifted to the FIF beam and the plan was recalculated. The dose level of the hotspot locating isodose line was adjusted up or down as necessary and the process was repeated on the opposing beam. This alternating process was repeated iteratively until the dose objective of 107% maximum was met. Dose weighting between the parent fields and FIF beams were also tuned as necessary to shift some beam weight to an opposing field when a hot spot was unilateral. The goal of 107% maximum dose was achievable with 2 FIF beams for each tangent beam (Figure 8). The physicist verified that the calculated dose distribution met all of the stated constraints for target coverage and OR avoidance. The lumpectomy site was fully covered by the prescription dose, and the breast was adequately covered by the 95% isodose line. The volume of lung receiving 20 Gy was well below the constraint value (Figure 9).

Quality Assurance/Physics Check: The monitor units (MUs) calculated for each beam were evaluated by running a computerized second check with RadCalc 6.2 Build 5.3 and looking for agreement. A maximum deviation of 3.0% between Eclipse's MU value and RadCalc's MU value is tolerated. The maximum deviation for any beam in this plan was 2.1%, with a 1.5% overall deviation. Treatment parameters, treatment schedules, plan documentation, setup imaging, and billing codes were loaded and/or set up in Mosaiq 2.30.04D4 by the dosimetrist and verified by the physicist. Ion chamber QA measurement is not routinely performed for conformal plans and was not performed on this plan.

Conclusion: Dose sculpting with FIF planning is a useful technique for reducing hot spots in 3D conformal plans. On irregular anatomies such as breast tangent sections, wedges may help distribute dose appropriately in one area of the anatomy while simultaneously degrading favorable dose distributions in other areas. While wedges and FIF techniques are not mutually exclusive, FIF may offer more flexibility in locally reducing dose. The dosimetrist found that the placement of the isocenter point should be chosen carefully for breast tangent plans. A more suitable technique than what was used would be to place the isocenter directly on the tangent line connecting the midsagittal reference point and the lateral field borders, and not simply near it. This would enable the use of a half beam block, which would eliminate problems with cold triangles due to beam divergence differences between the opposing beams. The technique of building one FIF block at a time was chosen in an attempt to feather the dose gradient into smaller steps than would be achieved by mirrored FIF blocks in opposing beams. This process was time consuming due to the number of MLCs and field weighting adjustments. A more algorithmic approach may be helpful in the future. The dosimetrist also noted the importance of color choice in both isodose lines and contours. One is easily mistaken for the other without clear labeling or other form of differentiation. The next logical step from manually shaping dose with MLCs is the automated computer-optimized technique found in intensity modulated radiation therapy (IMRT). In cases where there is no justification for IMRT, conformal planning with FIF dose shaping is a valuable technique.

References

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Figures

Figure 1. Patient setup on CT simulation table with 10 degree breast board and Alpha Cradle immobilization.

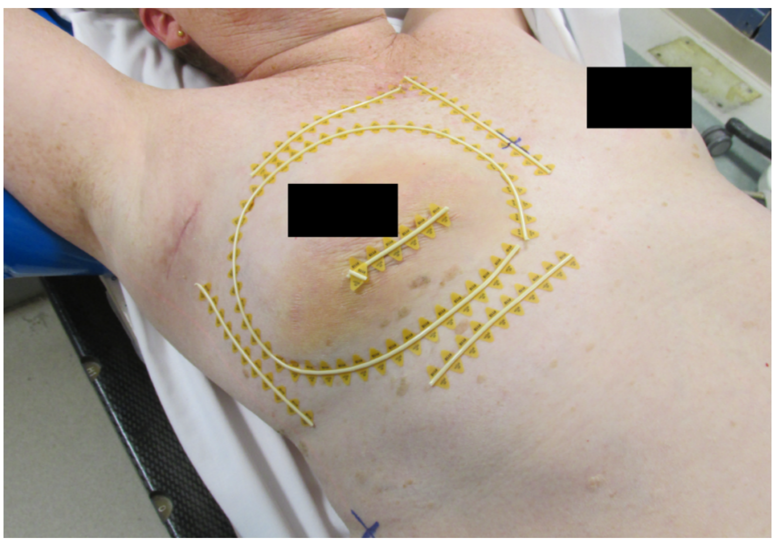

Figure 2. Beekley Medical CT-SPOT line applied to the skin to mark field borders, breast tissue, scar, and nipple.

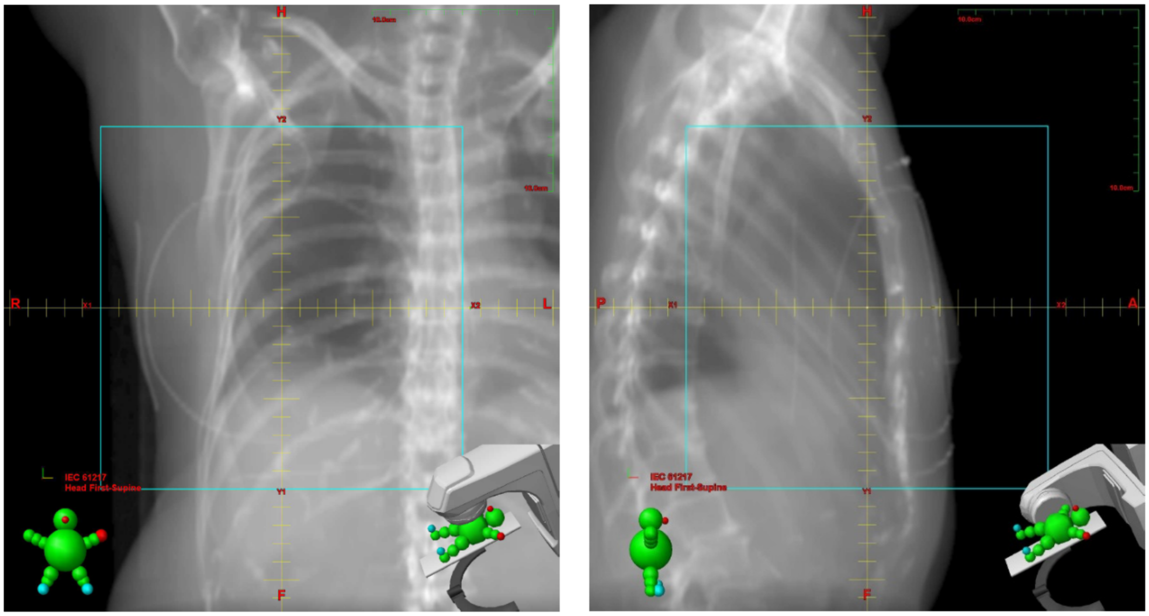

Figure 3. Anterior/posterior setup DRR (left) and right lateral setup DRR (right) showing isocenter location

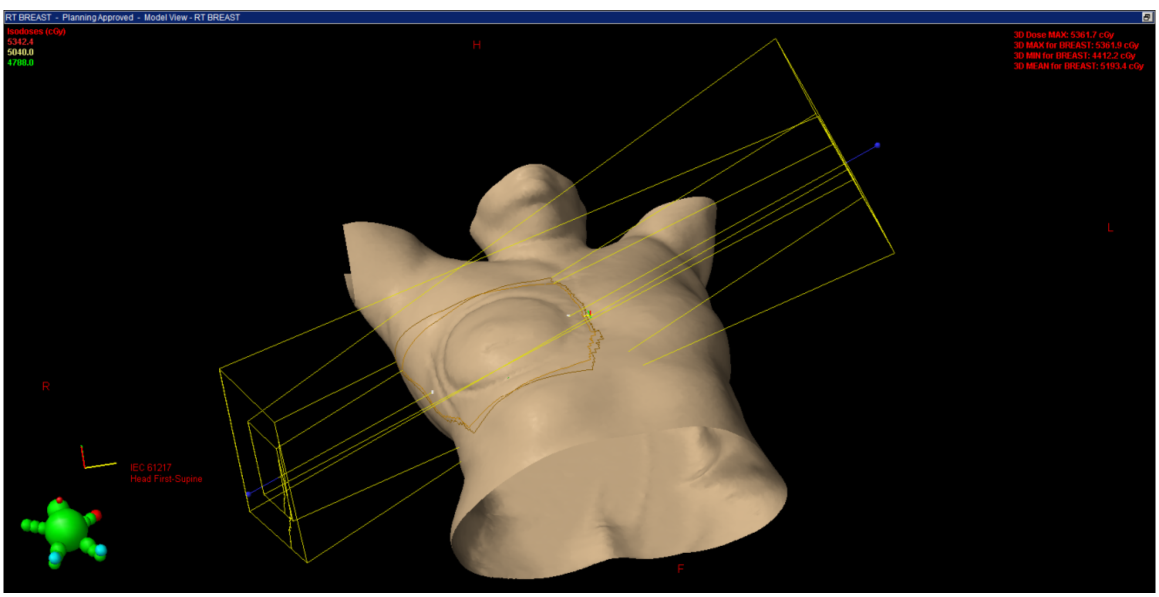

Figure 4. 3D rendering of the patient’s skin surface showing beam angles and the skin intersection of the initial beam blockings.

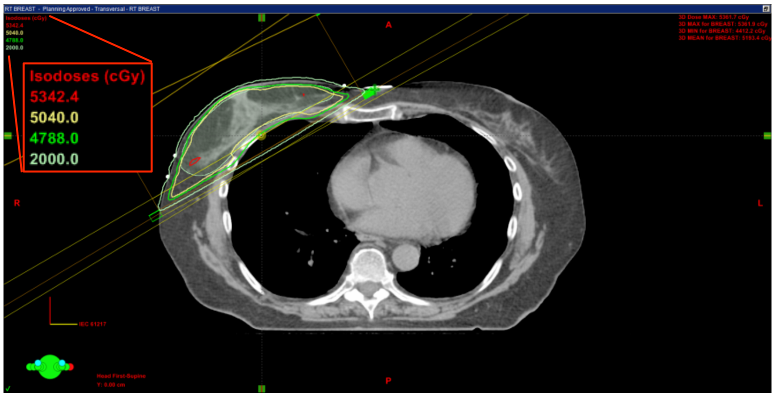

Figure 5. Axial view of isocenter showing breast tissue as the pale green inner shape, and isodose distribution of the final plan.

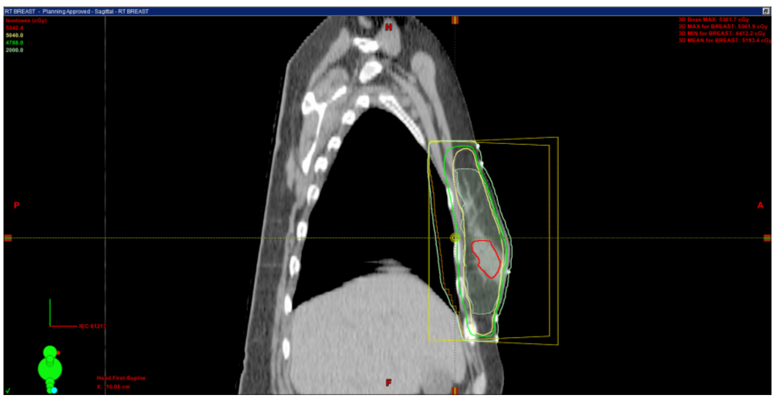

Figure 6. Sagittal view of same, with lumpectomy seroma outlined in red.

Figure 7. Coronal view of same.

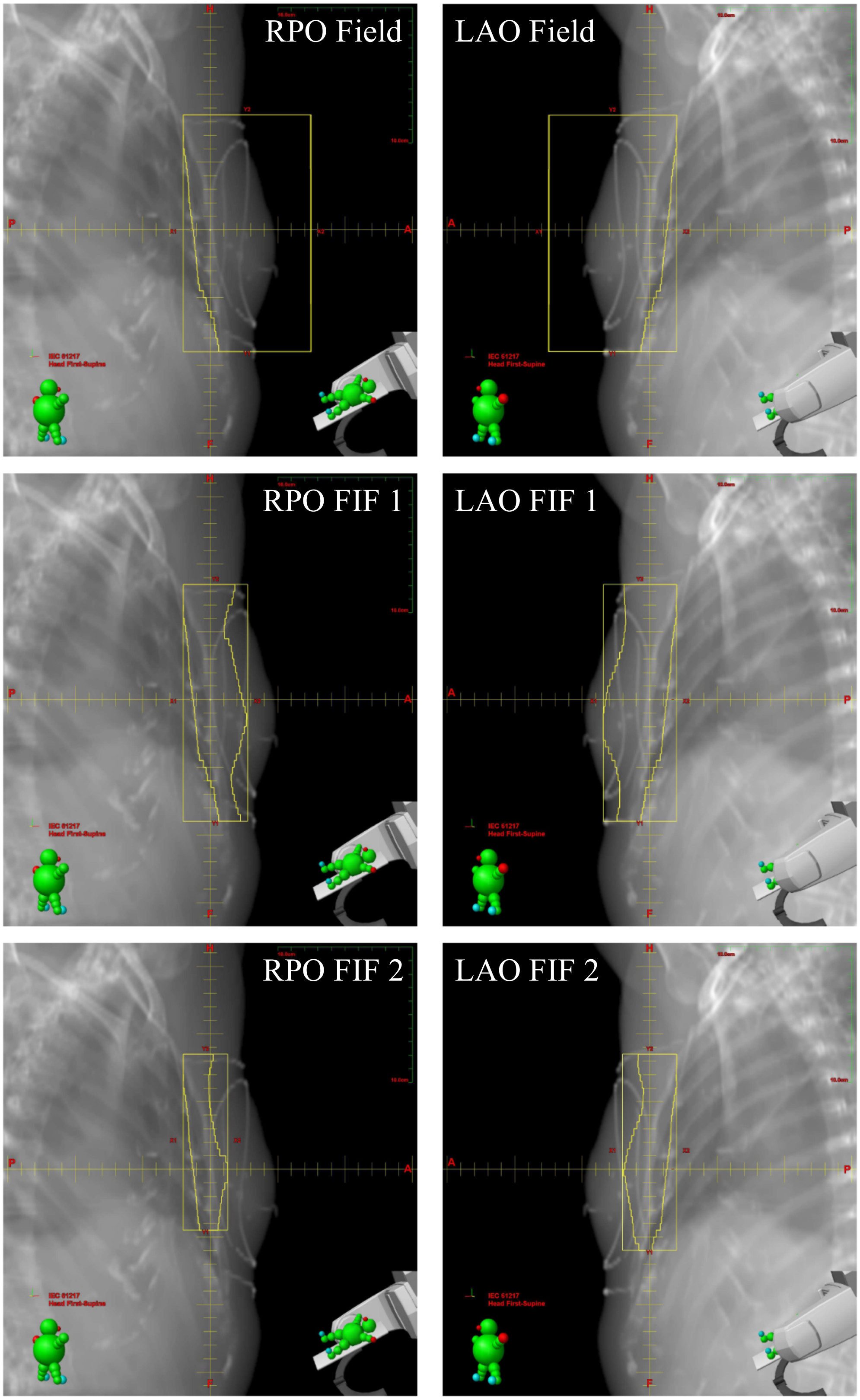

Figure 8. RPO and LAO beams and their associated field in field beams.

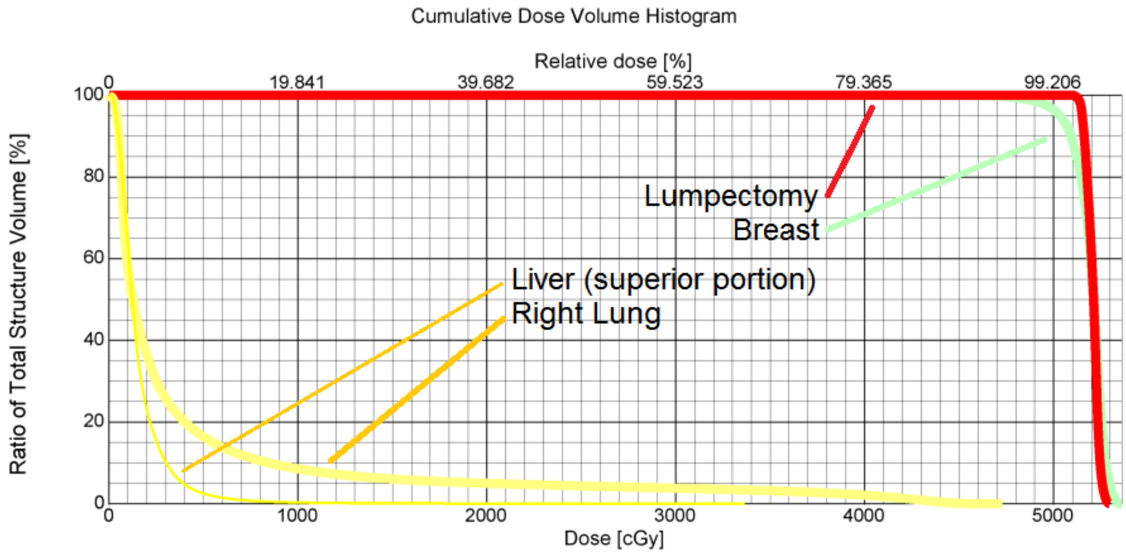

Figure 9. Dose volume histogram (DVH) showing target and avoidance doses.