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Original research article

Radiotherapy setup displacements in breast cancer patients: 3D surface imaging experience

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ABSTRACT

Aim: In this study, we intend to compare two different setup procedures for female breast cancer patients.

Background: Imaging in radiotherapy provides a precise localization of the tumour, increasing the accuracy of the treatment delivery in breast cancer.

Materials and methods: Twenty breast cancer patients who underwent whole breast radiotherapy (WBRT) were selected for this study. Patients were divided into two groups of ten. Group one (G1) was positioned by tattoos and then the patient positioning was adjusted with the aid of AlignRT (Vision RT, London, UK). In group two (G2), patients were positioned only by tattoos. For both groups, the first 15 fractions were analyzed, a daily kilovoltage (kV) cone beam computed tomography (CBCT) image was made and then the rotational and translational displacements and, posteriorly, the systematic (Σ) and random (σ) errors were analyzed.

Results: The comparison of CBCT displacements for the two groups showed a statistically significant difference in the translational left–right (LR) direction ($\rho = 0.03$), considering that the procedure with AlignRT system has smaller lateral displacements. The results of systematic (Σ) and random (σ) errors showed that for translational displacements the group positioned only by tattoos (G2) demonstrated higher values of errors when compared with the group positioned with the aid of AlignRT (G1).

Conclusions: AlignRT could help the positioning of breast cancer patients; however, it should be used with another imaging method.

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1. Background

Belgium has the highest incidence of breast cancer in the world and it is the third country in the world with the highest mortality rate.[1]

In early stages of breast cancer, adjuvant radiotherapy has shown great results reducing the risk of locoregional recurrence.[2,3] For adjuvant whole breast irradiation, the typical fractionation is 45–50 Gy delivered in 1.8–2 Gy per fraction.[4] The main disadvantage of this fractionation scheme is a longer treatment time increasing the health care costs.[5] Another study showed that hypofractionated schedules, 40–42.5 Gy, delivered in 15–16 daily fractions, did not show inferiority when compared with conventional schemes in tumour control and treatment toxicity.[6]

Nowadays, hypofractionated WBRT has been more used in radiotherapy treatments[7] and requires a precise patient immobilization and positioning.[8,9]

The errors during breast cancer radiotherapy treatments are caused by several variations, which can happen interfraction, like daily setup errors and intrafraction errors, such as respiratory motion.[10] The uncertainties can also be defined by systematic and random errors. Systematic errors represent displacements that can happen in the same direction and similar magnitude.[11] This type of errors describes a constant deviation of patient positioning during the entire treatment.[11,12]

A random error can be defined as a day-to-day variation in the patient positioning[12] and can occur in different directions and magnitudes for each fraction of the treatment.[11]

To assure a correct dose distribution, an image guided radiation therapy (IGRT) has been emphasized.[8,11,13] IGRT provides a precise localization of the volumes of interest by comparing verification images at the time of treatment with the reference image.[8,11,14,15] Thus, it is possible to detect patient displacements[13] and increase the accuracy of the treatment delivery in breast cancer.[8]

For years, in WBRT the common patient setup was the alignment with lasers, skin marks and megavoltage (MV) electronic portal image (EPI) verifications.[13] With the objective of guiding the setup by alignment of the chest wall, EPIs are taken before the treatment to evaluate the integrity of the patient setup and treatment isocenter.[15,16] With this system, it is possible to correct patient positioning in 3 to 6 degrees of freedom.[15] However, portal images provide an insufficient visible anatomy[9] and represent considerable additional dose over the course of the treatment.[9,15]

The CBCT represents a technological advance in IGRT.[14] The kilovoltage (kV)-CBCT system is a method of generating 3D images for computed tomography (CT) reconstruction using rotational large fields cone beams.[17] This system provides 3D information of the breast region and shows soft tissues images.[17] This technology allows a high definition of anatomic and geometric imaging with a good spatial resolution, essential to evaluate the patient position, target volume and increase the geometric accuracy of the treatment.[17] The disadvantages of this system are a more complex and time-consuming imaging modality and an additional radiation exposure.[17]

Recently, new surface-based monitoring systems have been introduced, with the advantage of monitoring patients in 3D, without the use of ionizing radiation.[9,18,19] With 3D surface systems, a surface model of the breast is acquired and used to align the patient for daily setup.[15] In each treatment fraction an image of patient breast surface is acquired to be then compared with a reference surface model.[15,16,18]

2. *Aim*

With this study we intend to evaluate the translational and rotational displacements – left–right (LR), craniocaudal (CC), anterior–posterior (AP), comparing two different setup procedures for two groups of patients. The systematic (Σ) and random (σ) errors in translational and rotational displacements will also be analyzed for both groups.

3. *Materials and methods*

3.1. *Patient data*

Twenty breast cancer patients from Cliniques Universitaires Saint Luc (CUSL) were selected for this study. These patients underwent WBRT and the displacements were analyzed in the first 15 fractions.

3.2. *Planning CT*

All patients were given CT scans in a supine position, with a breast board and were instructed to perform free breath. After the acquisition of the CT scan, six tattoos were made, two in the middle of the chest, two in the right side of the patient and two in the left side of the patient.

The CT data were imported to the AlignRT and treatment planning system – XIO (Elekta AB, Sweden).

3.3. *Dosimetric planning*

In the treatment planning system, the planning target volume (PTV) was defined as the mammary gland. The organs at risk contoured were the contralateral and ipsilateral lungs, contralateral breast, heart and spinal cord. A 3D-conformal radiotherapy (3D-CRT) plan was performed using two tangential fields, each one with 6 MV and field-in-field to improve dose homogeneity.

3.4. *AlignRT setup*

The images were imported by the CT to AlignRT software to generate a reference image. In this system, were defined the 3D body outline and the region of interest as the mammary gland.

AlignRT system consists of two (typical setup) or three camera units. Each camera unit has two data cameras, a texture camera, a speckle projector and a light flash.[20] In our study, three camera units were used, two laterals and one central.

The 3D surface model of the patient is daily computed by a pseudo random optical pattern projected into the patient via the speckle projector.[20,21]

3.5. *Patient setup*

Patients were divided into two groups of ten patients each, group one (G1) and group two (G2).

Fig. 1 summarizes setup procedures for both groups.