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Investigation of the dose profiles in the junction region between the supraclavicular and tangential fields

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ABSTRACT

Aim: To evaluate the homogeneity of the dose at the junction for fields used in breast radiotherapy using a different technique.

Methods: A total of 4 fields, including 2 tangential fields and AP-PA fields, were planned on the phantom on the RayStation treatment planning system. Gamma analysis was used to compare the results of the measurement and treatment planning system.

Results: When the graphs are analyzed, it is seen that the dose obtained in the junction region on the 2D measurement system as a result of the 1st tangential field and AP field irradiation is 8.3% less than the dose obtained in the treatment planning system. For the 2nd tangential field and PA field, this difference was obtained as 11.8%. When the horizontal profile in the junction region was analyzed as a result of irradiation of all areas, dose differences were measured between 12.5-8.2%. Due to the examination of a region with a high dose gradient, parameters such as the tongue-and-groove effect of MLCs, jaw calibration, parameters included in the treatment planning system's calculations, and measurement setup can directly impact the obtained data.

Conclusions: The results of our study indicate that doses in the connection area should be planned by treatment centers with different techniques, examined with different dosimetric devices, and the acceptability of the obtained doses should be verified.

Key words: Junction region, breast radiotherapy, supraclavicular field, 3-dimensional conformal radiotherapy.

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Introduction

Cancer is a global health problem characterized by its widespread occurrence and the prevalence of people affected by the disease is increasing worldwide. Recent studies have shown that survival rates increase in women after breast cancer diagnosis. Radiotherapy of breast cancer is used to reduce the risk of recurrence and improve overall survival in patients with breast cancer [1,2,3,4,5,6]. Generally, in classical 3-dimensional conformal radiotherapy (3D-CRT) applications, the breast area (or chest wall) is irradiated with 2 tangential fields and the supraclavicular and axial lymph nodes are irradiated with anterior-posterior fields (AP-PA). In order to avoid hot and cold doses that may occur in the junction region, the tangential fields and AP-PA fields must be precisely matched [7,8,9,10,11]. The field edges with a high dose gradient can have a significant effect on the dose distribution in the junction region [7,9,12]. Therefore, the use of different techniques at the junction may be considered to avoid the occurrence of hot and cold doses.

Single isocentric treatment techniques are used to reduce the uncertainties in the connection region. This treatment technique can be called the half-field technique (HF-T) and is applied with half-ray fields obtained by opening the beam fields asymmetrically from the isocenter [12,13,14,15]. However, the dose at these junctions remains unclear [12,16,17]. Advances in technology have enabled the use of intensity-modulated radiotherapy (IMRT) techniques in breast radiotherapy. Although treatment plans made with the IMRT technique achieve a better dose distribution and eliminate the junction problem, most centers continue to use 3-dimensional conformal radiation therapy (3D-CRT). Nowadays, the single isocenter half-field technique is widely used. Although this technique has advantages such as treatment time, easy installation, and organ protection, it has disadvantages such as obtaining insufficient dose or overdose at the junction of half radiation fields. Studies have shown that the dose in the connection areas can be reduced by up to 28% due to the tongue and groove effect [18,19,20,21].

In a study by Claridge-Mackonis et al., doses in the junction between deep inspiration breath hold (DIBH) and the free-breathing patient were examined. While mean dose at the junction was not found to be significantly different in free-breathing patients and patients using the DIBH technique, variability in junction dose was found to be significantly higher for DIBH patients compared to free-breathing patients [5].

In this study, we evaluated the homogeneity of the dose at the junction for fields used in breast radiotherapy using a different technique. In this evaluation, we compared the dose distribution obtained from the treatment planning system with the dose distribution measured in the 2D system.

Materials and metods

A total of 4 fields, including 2 tangential fields and AP-PA fields, were planned on the phantom on the RayStation treatment planning system (TPS) version 9B. The grid size in TPS is set to 0.3 cm. Dose calculation was made using the Collapse cone algorithm and 6 MV x-rays.

The field-in-field technique was used to ensure dose homogeneity. After creating treatment fields suitable for breast radiotherapy, the gantry was set to 0 degrees and source-skin distance (SSD)

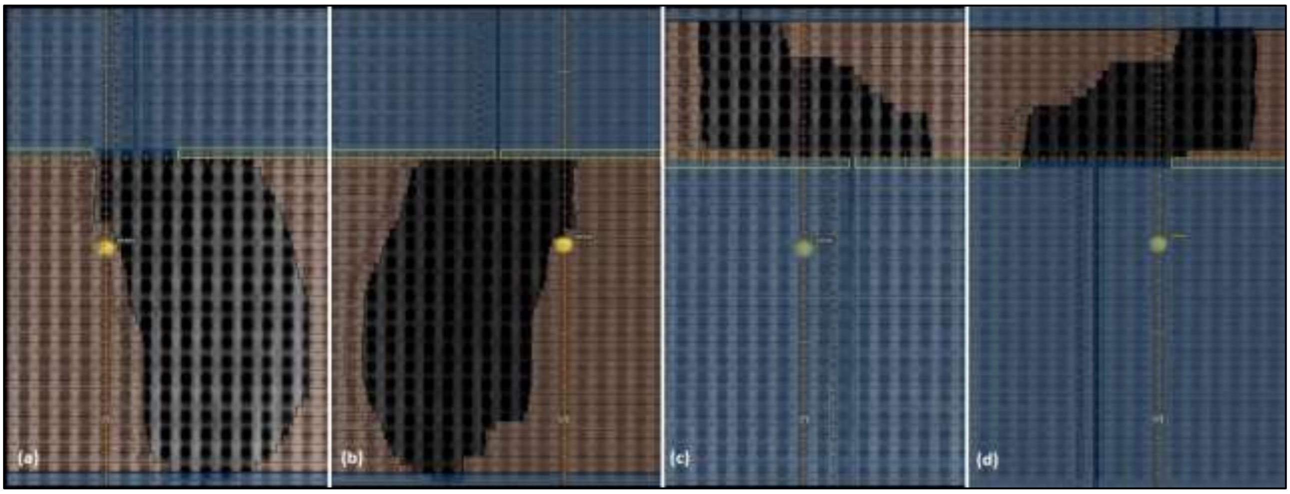

Figure 1. The beam fields created with MLCs in the TPS. (a): 1st tangential field (b): 2nd tangential field (c): AP field (d): PA field.

= 94 cm, and the treatment planning was transferred to the Siemens Artiste linear accelerator (LINAC) with 160 Multi-leaf collimators (MLC). The irradiation environment was created in accordance with the simulation in the treatment planning system. In our study, we positioned the MLCs at a distance of 0.5 mm from the central axis only for 1st tangential and posterior-anterior (PA) fields. The MLC positions and the beam fields created in the treatment planning system are shown in Figure 1.

PTW OCTAVIUS (PTW, Freiburg, Germany), a 2-dimensional detector system, was used to calculate the dose at the junction of the tangential and AP-PA fields [22]. The irradiation environment was prepared so that the junction areas were on the detector. The DICOM files within the RayStation TPS were exported to facilitate their utilization in the PTW VeriSoft system (PTW, Freiburg, Germany). We assessed the junction dose through a comparative analysis of dose profiles obtained from 2-dimensional dosimetry and those calculated by the TPS. Gamma analysis was used to compare the results of two measurements.

Results

The simulation environment in the treatment planning system was created in the LINAC device and irradiation result data were obtained from PTW Octavious, a 2D measurement system. All beams were delivered at gantry 0° and 132 MU, 113 MU, 141 MU and 105 MU doses were given for tangential fields and AP-PA fields, respectively. The results obtained by gamma analysis with 3 mm and 3% dose criteria show 98.3%, 98.1% and 98.3% similarity rates for all fields, 1st tangential-AP and 2nd tangential-PA irradiations, respectively. However, the gamma distribution map for the all fields irradiation sample clearly shows the dose differences in the junction region in Figure 2.

The dose profiles to be analysed for the junction region are shown in Figure 3.

The data obtained from the treatment planning system and the measurement were analysed as a percentage and the results are shown in Figure 4.

When the graphs are analysed, it is seen that the dose obtained in the junction region on the 2D measurement system as a result of the 1st

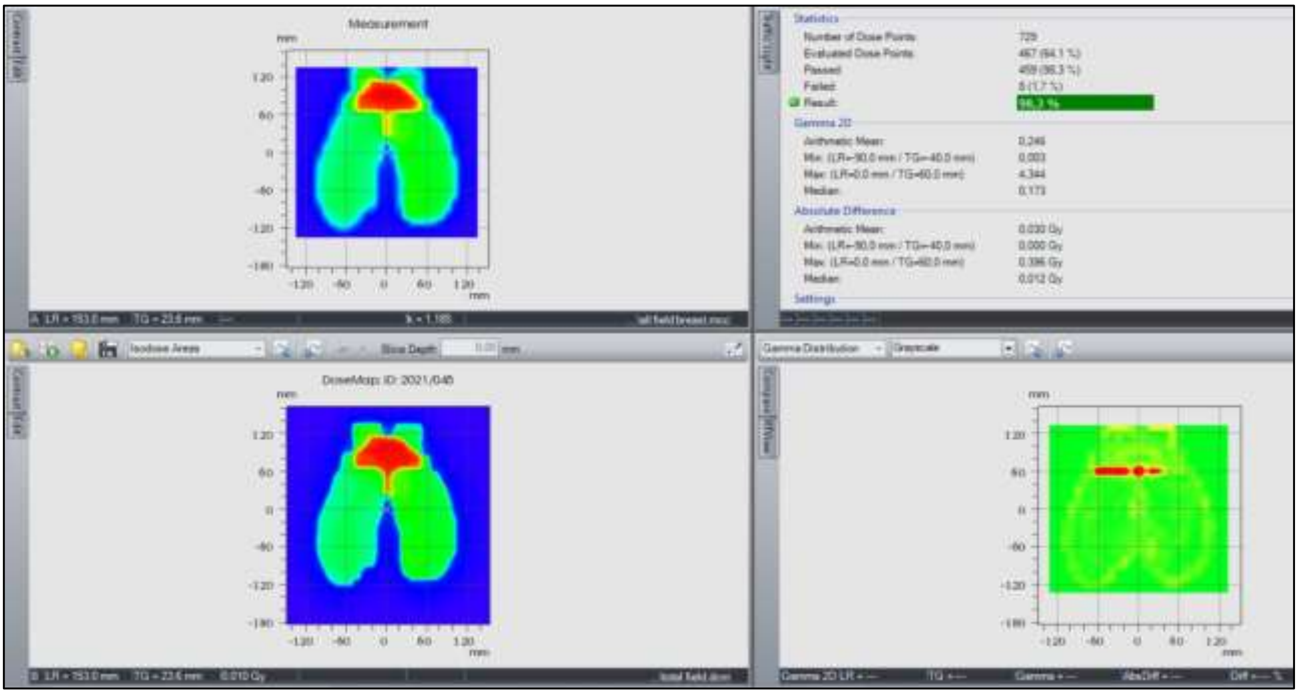

Figure 2. Gamma distribution results obtained by irradiation of all fields.

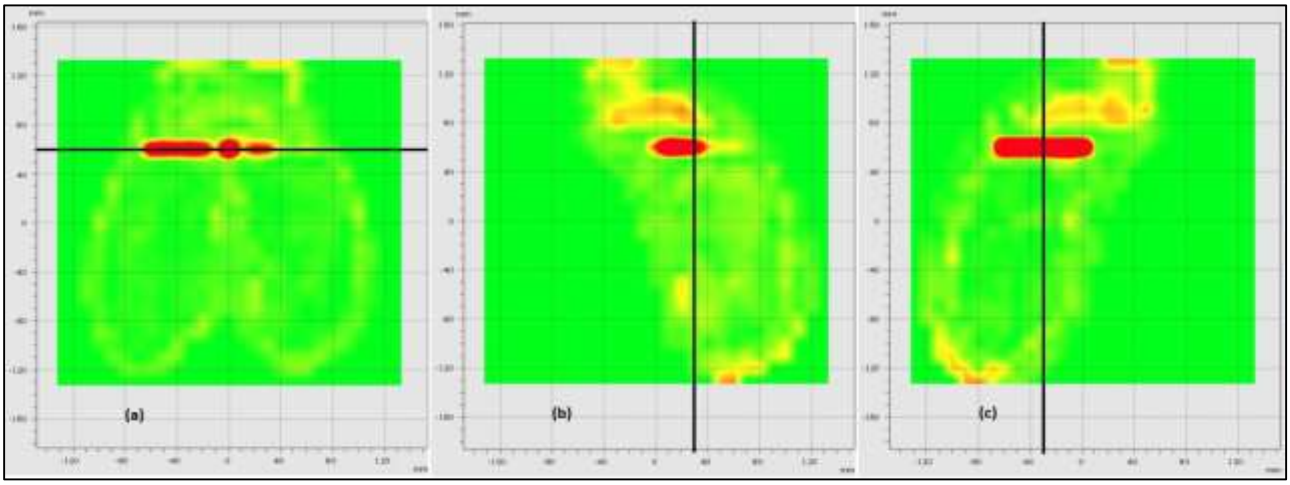

Figure 3. The dose profiles to be analyzed.(a): for irradiation of all fields (b): for the 1st tangential field and AP field irradiation (c): for the 2nd tangential field and PA field.

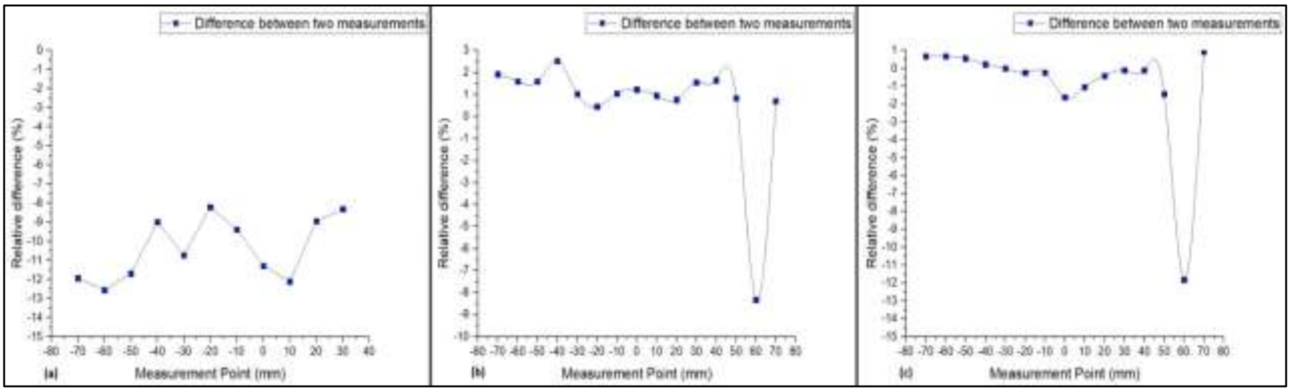

Figure 4. Dose differences between the data obtained from the treatment planning system and the measurement. (a): the profile results analysed according to irradiation of all fields (b): the profile results analysed according to 1st tangential field and AP field irradiation (c): the profile results analysed according to 2nd tangential field and PA field irradiation.

tangential field and AP field irradiation is 8.3% less than the dose obtained in the treatment planning system. For the 2nd tangential field and PA field, this difference was obtained as 11.8%. When the horizontal profile in the junction region was analysed as a result of irradiation of all areas, dose differences were measured between 12.5-8.2%. Kengo Iwaki et al. showed that in the classical technique with the MLCs in the closed position, the dose obtained in the junction region decreased up to 72.6%. In our study, we defined the MLCs in the closed position for only two fields in the central axis and measured the maximum dose reduction as 12.5%.

Discussion

The challenge in designing traditional three-dimensional conformal radiotherapy irradiation for both the breast and supraclavicular regions lies in the concern that hot spots at the junction could potentially induce skin reactions and an excessive number of cold spots might reduce the treatment's efficacy. This is a predicament faced by numerous treatment centers. In this study, irradiation was performed with the multi-leaf collimators (MLCs) open along the central axes of certain fields, and junction dose distribution profiles were measured and analyzed. While similarity ratios on the overall dose distribution may emerge at acceptable levels, our results indicate the potential for relative dose differences exceeding 10% in the junction region. Due to the examination of a region with a high dose gradient, parameters such as the tongue-and-groove effect of MLCs, jaw calibration, parameters included in the treatment planning system's calculations, and measurement setup can directly impact the obtained data. Doses in the junction region should be planned with different techniques by treatment centers, examined with different dosimetric equipment, and the acceptability of the obtained doses should be verified. In conclusion, this study was performed with different devices, different dosimetric equipment, and more data, requiring further interpretation of more predictions in terms of clinical outcome.

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