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Comparison of tangential-intensity modulated radiotherapy (t-IMRT) and volumetric modulated arc therapy (VMAT) for different sizes of left breast cancer

Background: Radiotherapy is an essential part of the management of left-sided breast cancer, and this requires an optimal balance in target volume coverage and organs at risk, such as the ipsilateral lung and the heart. Advanced techniques such as tangential-intensity modulated radiotherapy (t-IMRT) and volumetric modulated arc therapy (VMAT) are commonly used. However, the dosimetric performance of t-IMRT and VMAT for varying breast sizes has been poorly characterized.
Aim: To compare the effectiveness of tangential-IMRT and VMAT for hypo-fractionated left-sided breast cancers across small, medium, and large breast sizes.
Materials & Methods: A total of 30 CT datasets from female patients with left-sided breast cancer, acquired between 2020 and 2025, were analyzed. Patients were divided into groups based on breast volume, with a mean volume of 781.00 cc. For each patient, two treatment plans were designed using the Monaco treatment planning system, which uses the Monte Carlo method. A dose of 26 Gy in 5 fractions was prescribed according to the FAST-Forward hypo-fractionated protocol. Evaluation of the dosimetric parameters included the Planning Target Volume (PTV) coverage indices D2%, D5%, D95%, Homogeneity Index (HI), Conformity Index (CI), and doses to the heart (V7 and V1.5 Gy), as well as the ipsilateral lung volume receiving V8 Gy. A two-way ANOVA was performed, with a significance ($p < 0.05$).
Results: VMAT showed superior target coverage, conformity, and dose homogeneity compared to t-IMRT across all breast sizes ($p < 0.05$). PTV D95% coverage with the VMAT plans was 99.8%, 98.3%, and 97.0% for small, medium, and large breasts, respectively, whereas the t-IMRT plans failed to achieve the required coverage of ≥95% and resulted in 89.2-90.0% coverage across all the breast sizes. Also, the homogeneity and conformity indices were improved with the VMAT plan. Both plans satisfied the PTV hotspot constraints of D2% < 107% and D5% < 105%. Although the t-IMRT plans resulted in lower hotspot doses for small and medium breasts, the VMAT plans resulted in slightly better hotspot dose control for large breasts. However, the differences were not clinically significant, as they were within 1%. However, the t-IMRT plans resulted in superior OAR sparing, with lower ipsilateral lung V8 Gy and lower high-dose cardiac exposure (Heart V1.5 Gy: 0.9 - 1.1 Gy), compared to the VMAT plans, which resulted in higher high-dose cardiac exposure (2.9 - 3.3 Gy), exceeding the tolerance limit, though the VMAT plans resulted in lower low-dose cardiac exposure (Heart V7 Gy).
Conclusion: VMAT provided superior target coverage, conformity, and homogeneity across all breasts compared to t-IMRT, achieving the required PTV D95% ≥ 95% in all cases. Both techniques were able to meet the PTV hotspot requirements, with slightly improved control for larger breasts with VMAT, while this may not have a clinically significant impact. However, t-IMRT showed superior sparing of OARs, particularly the ipsilateral lung and high-dose cardiac areas. In contrast, VMAT showed increased dose to high-dose cardiac areas and decreased dose to low-dose cardiac areas.
Keywords: VMAT, Tangential-IMRT, Left-sided Breast radiotherapy, Breast sizes, UK FSAT-Forward protocol.

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