Original Article

Dosimetric Comparison of Different Planning Techniques in Left-sided Whole-Breast Irradiation: A Planning Study

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Abstract

Purpose: This planning study compared the various dosimetric parameters of different types of intensity-modulated radiotherapy (IMRT) and volumetric-modulated arc therapy (VMAT) techniques for left-sided breast cancer radiotherapy. **Materials and Methods:** Treatment of 22 left-sided breast cases was planned using two IMRT and VMAT techniques for the prescription of 40 Gy in 15 fractions. For tangential IMRT (Tan_IMRT), five beams were placed as conventional tangential beams. For equally spaced IMRT (Equi_IMRT), six beams were placed equidistantly at 40° interval from 300° to 140°. For tangential VMAT (Tan_VMAT), two arcs were used with the avoidance sector in such a way that the beam covered like tangential fields. For full-arc VMAT (Full_VMAT), similar arcs as Tan_VMAT were used, without avoidance sector. All treatment plans were generated using Eclipse planning system for TrueBeam STx linear accelerator. For planning target volume (PTV), dose parameters including $D_{95\%,}$ $D_{99\%,}$ $V_{105\%,}$ homogeneity index (HI), and conformity index (CI) were analyzed. Different dose parameters for the left lung, heart, left anterior descending artery (LAD), right lung, and right breast were also analyzed. In addition, low-dose spillage in the normal tissues and the number of monitor units (MUs) required for the treatment were compared. **Results:** IMRT technique exhibited superior $D_{95\%}$ and $D_{99\%}$ for PTV compared with VMAT techniques. VMAT plans provided more $V_{105\%}$ (6%) compared with that of IMRT plans (approximately 1%). HI was better in IMRT plans (Tan_IMRT, 0.085 ± 0.015; Equi_IMRT, 0.094 ± 0.011) than in VMAT plans. CI was better in VMAT plans. The mean lung dose (7.7 Gy ± 1.788 Gy) and V_{5Gy} (34.99% ± 6.799%) were better achieved in Tan_IMRT plan than other plans. Right lung, heart, and right breast sparing were better achieved in Tan_IMRT plan. Moreover, low-dose spillage was very less in the Tan_IMRT compared with all other techniques. **Conclusion:** Dosimetric comparison in this study showed that tangential IMRT technique is superior in terms of target coverage, sparing of lung, heart, and right breast, and low-dose spillage control in the left-sided breast-only radiotherapy.

Keywords: Left-sided breast cancer, intensity-modulated radiotherapy,volumetric-modulated radiotherapy

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Introduction

The incidence of breast cancer is increasing globally and is one of the most common cancers among women.[1] Its incidence in young females is also increasing in India.[2,3] Technological advancement in diagnosis and screening along with awareness programs have contributed to breast cancer detection at early stage. Breast-conserving surgery (BCS) combined with postoperative radiotherapy is a well-known practice for early stage breast cancer cases.[4] Adjuvant radiation therapy is administered to reduce local recurrence and to increase survival in patients.

Radiotherapy planning for breast cancer, especially for the left side, is challenging, due to its concave shape of target and its proximity to the heart and to the lung. In addition, the location of organs at risk (OARs) such as lung, heart, and contralateral breast in proximity to the target necessitates minimizing dose to these organs without compromising the dose conformity and homogeneity of the target. OAR sparing is also imperative to reduce the long-term radiation-induced complications and to improve the quality of life of patients.

Using two tangential photon beams is a common clinical practice for the treatment of whole breast at various centers.

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In this technique, two non-divergent beams with or without wedge filters were used. Tangential technique was improved as field-in-field technique to achieve a superior target dose homogeneity and to minimize dose to OARs.

Several advanced techniques, such as intensity-modulated radiation therapy (IMRT), volumetric-modulated arc therapy (VMAT), and helical tomotherapy, have been introduced. IMRT technique improves the dose homogeneity, conformity of the target dose, and better OARs sparing at the cost of increased low-dose spillage, monitor units (MUs), and treatment time. Many authors have investigated the effect of number and orientation of beams in treatment planning of left-sided breast cancer.[5-8] VMAT technique was introduced to combine the advantage of optimization of treatment plan and to reduce the treatment time. Many authors have reported variable outcomes by comparing IMRT and VMAT treatment plans with different beam orientation.[5-8]

In this planning study, we assessed the advantages and disadvantages of variable field placement and arc length for IMRT and VMAT delivery technique in the left-sided breast cancer treatment planning using dosimetric parameters. We selected patients who received radiation only to left-sided whole breast and no regional lymphatic node involvement.

Materials and Methods

Patient selection procedure

We selected 22 female patients with left breast cancer who underwent BCS and postoperative radiotherapy in our center between May 2017 and October 2019. The selection criteria included radiotherapy only to the whole breast and no regional lymph nodes to be treated, followed by tumor bed boost. The mean age of patients was 49.7 years (range, 29–66 years). In this study, only whole-breast radiotherapy treatment plans were compared and boost plans were not considered.

Linear accelerator

All plans were generated for TrueBeam STx linear accelerator (Varian Medical Systems, Palo Alto, CA) equipped with the high-definition multileaf collimator (MLC) with 120 leaves (central high resolution at 2.5 mm leaf width for 8 cm and outer at 5 mm leaf width for 14 cm, defined at the isocenter); 6 MV photon beam was used in the planning.

Setup and imaging

Patients were immobilized using All-in-One immobilization system (Orfit Industries, Belgium) in supine position with both arms raised above the head. The 5° wedge was given to raise the chest, which helps to reduce dose to ipsilateral lung and avoid skin folds. Four-clamp thermoplastic cast (Orfit Industries, Belgium) was prepared in this position. Radiopaque markers were placed around the palpable breast as well as in the inferior, superior, lateral, and medial border of the radiation field. Markers were also placed around the palpable right breast. Computed tomography (CT) images were taken from the mandible to 7 cm below the inframammary fold, with 5-mm slice thickness in CT simulator Discovery RT (GE Medical Systems, Chicago, USA).

Delineation procedure

CT images were imported and contoured in Eclipse planning system version 13.7 (Varian Medical Systems, Palo Alto, CA).

Target volumes

Clinical target volume (CTV) and planning target volume (PTV): The breast CTV includes the palpable breast tissue as demarcated by markers before simulation and the entire glandular breast parenchyma as per the CT scan. The CTV was generally contoured as per the European Society for Radiotherapy and Oncology guidelines.[9] Anteriorly, breast CTV was cropped from skin by 5 mm.

The PTV was created by adding a 5-mm margin to the CTV to cover daily setup uncertainties and respiratory motion. The PTV was also cropped from the skin by a 5-mm margin.

Organs at risk

Right breast was contoured as per the Radiation Therapy Oncology Group (RTOG) breast atlas[10] including visible glandular breast tissue on CT scan and palpable breast tissue as demarcated by markers before CT simulation.[9] Both lungs were contoured with the help of autosegmentation and corrected manually as and when required. The heart and the left anterior descending artery (LAD) were contoured as described by Feng *et al*.[11] Superiorly, the heart starts just inferior to the left pulmonary artery and inferiorly it extends up to the diaphragm. Ascending and descending aorta and inferior vena cava were excluded for heart contour. The LAD was contoured from its origin (that is from left coronary artery) and then followed its path in inter-ventricular groove, extending upto the apex of heart.

Treatment planning

Treatment plans were generated using the Eclipse planning system, version 13.7 (Varian Medical Systems, Palo Alto, CA). For tangential IMRT (Tan_IMRT), five beams were placed at gantry angle 300°, 315°, 115°,127°, and 140°. For equally spaced IMRT (Equi_IMRT), six beams were placed equidistantly at 40° interval from 300° to 140°. For tangential VMAT (Tan_VMAT), two arcs were used, gantry angle from 295° to 145° in clockwise and counterclockwise direction with avoidance sector 0° to 90°, to ensure that the beam covers only the tangent fields. For Full-arc VMAT (Full_VMAT), arcs similar to those used in the Tan_VMAT were used, without avoidance sector. In simpler terms, two tangent techniques (Tan_IMRT and Tan_VMAT) mimicking classical tangential technique and all around equally spaced techniques (Equi_IMRT and Full_VMAT) were used for planning. Beam arrangements for all techniques are illustrated in Figure 1.

Prescribed dose to the PTV was 40 Gy in 15 fractions (2.667 Gy/fraction). Photon optimizer, version 13.7.16 was used for inverse optimization with 2.5 mm optimization resolution.

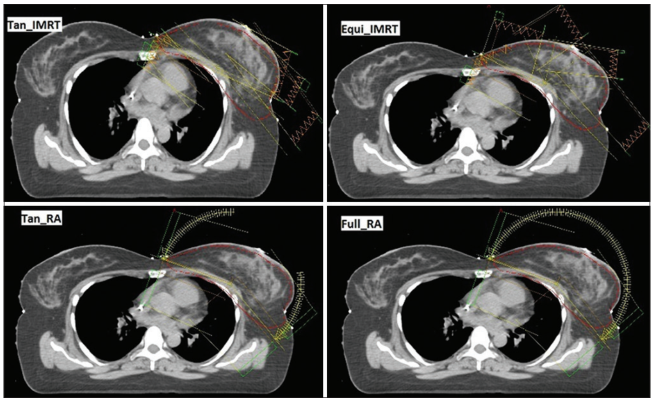

Figure 1: Beam arrangement for different techniques

For calculation, anisotropic analytical algorithm (version 13.7.16) was used and the calculation grid was 2.5 mm. Jaw-tracking option was selected to reduce the MLC leakage dose and inhomogeneity correction was applied for all plans. The isocenter was placed at the center of the PTV volume. The collimator and couch angle were set at 0°. The main objective of the plan was to ensure that 95% of the PTV received >95% of the prescribed dose and dose to OARs should be minimized. Table 1 describes our institutional treatment planning objectives in detail.

Plan evaluation parameters

Target volume

For PTV, $D_{95\%}$, $D_{99\%}$, and $V_{105\%}$ were analyzed for all plans. $D_{95\%}$ is the minimum dose received by 95% of PTV, which indicates the dose coverage. $D_{99\%}$ is the minimum dose received by 99% of PTV, which indicates the minimum dose within the PTV. $V_{105\%}$ is the volume of the PTV receiving 105% of the prescribed dose, which indicates the maximum dose within the PTV.

Organs at risk

For the left lung, the parameters V_{5Gy}, V_{10Gy}, V_{20Gy}, and V_{30Gy} and mean lung dose (MLD) were analyzed. These parameters indicate the volume of lung receiving low, middle, and high dose. For the right lung, V_{2Gy}, V_{5Gy}, and MLD were analyzed. For the heart, V_{5Gy} and V_{25Gy} and the mean heart dose were analyzed. For the LAD, $D_{2\%}$ (dose to 2% volume) and mean dose were analyzed. The mean dose for the right breast was analyzed. V_{xGy} represents the volume of organ receiving x Gy dose and $D_{x\%}$ represents the minimum dose received by x% of the Target/OAR.

Indices

Homogeneity index

The homogeneity index (HI) has been defined in several ways in literature.[12-15] We used the following formula to calculate the homogeneity index.[15]

$$HI = (D_{2\%} - D_{98\%)}/D_p) \times 100$$

In the given formula, $D_{2\%}$ represents the minimum dose received by 2% of the PTV (maximum dose), $D_{98\%}$ represents the minimum dose received by 98% of the PTV (minimum dose), and D_p represents the prescribed dose. The value HI close to zero indicates a more homogeneous dose within the PTV.

Table 1: Institutional treatment planning objectives

Structure	Parameter	Constraints
PTV	$D^{95\%}$ (%)	≥95% of prescribed dose
	$D^{99\%}$ (%)	≥90% of prescribed dose
	$V^{105\%}$ (%)	<3% of PTV
Left lung	V_{5Gy} (%)	≤70%
	V_{10Gy} (%)	≤55%
	V_{20Gy} (%)	≤33%
	V_{30Gy} (%)	≤10%
	MLD (Gy)	≤18 Gy
Right lung	V_{2Gy} (%)	ALARA
	V_{5Gy} (%)	ALARA
	MLD (Gy)	≤2 Gy
Heart	V_{25Gy} (%)	≤3%
	V_{5Gy} (%)	ALARA
	Mean dose	≤4 Gy
LAD	$D_{2\%}$ (Gy)	≤35 Gy
	Mean dose (Gy)	≤20 Gy
Right breast	Mean dose	≤2 Gy

PTV: Planning target volume, MLD: Mean lung dose, LAD: Left anterior descending artery, V_{xGy}: Volume of organ receiving x Gy dose, $D_{x\%}$: Minimum dose received by x% of volume

Conformity index

Conformity index (CI) has been defined in RTOG as:[16]

$$CI_{RTOG} = V_{95\%RI}/TV$$

where $V_{95\%RI}$ represents the volume encompassed by the 95% of prescription dose and TV represents the target volume.

Apart from these parameters, the unintended low-dose spillage was analyzed using the volume Body-PTV receiving 5 Gy, 3 Gy, and 2 Gy. MUs of all plans were compared. Wilcoxon matched-pair signed rank test (two-tailed, $P < 0.05$) was used for statistical analysis.

Results

Target volumes

The mean volume of PTV was 1214.8 cc ± 376.80 cc (range, 832.7 cc–1511.5 cc). We were able to achieve good dose coverage of PTV with all techniques. $D_{95\%}$ and $D_{99\%}$ to PTV was better achieved in IMRT techniques than VMAT techniques. $V_{105\%}$ was higher in VMAT plans (Tan_VMAT: 6.53% ± 4.14%; Full_VMAT: 6.26% ± 4.51%) compared with IMRT plans (Tan_IMRT: 0.66% ± 1.22%; Equi_IMRT: 1.13% ± 1.32%). HI was significantly better in Tan_IMRT plan (0.085 ± 0.015) than other plans (Equi_IMRT: 0.094 ± 0.011; Tan_VMAT-0.125 ± 0.01; and Full_VMAT: 0.121 ± 0.02). Comparison of CI indicated that VMAT plans are more conformal plan than IMRT plans. Table 2 describes the results in detail. Figures 2 and 3 present the dose distribution and dose–volume histogram (DVH) comparison of PTV, respectively.

Table 2: Dosimetric parameters comparison of PTV and OARs in four plans (n=22)

Structure	Parameters	Tan_IMRT	Equi_IMRT	Tan_VMAT	Full_VMAT	*P* value Tan_IMRT versus		
						Equi_IMRT	Tan_VMAT	Full_VMAT
PTV	$D_{95\%}$ (%)	96.71±0.58	96.84±0.45	95.82±0.91	95.98±0.65	0.4532	0.0005	0.0009
	$D_{99\%}$ (%)	93.11±1.08	93.01±0.71	91.72±1.10	92.13±1.14	0.7641	0.0003	0.0107
	$V_{105\%}$ (%)	0.66±1.22	1.13±1.32	6.53±4.14	6.26±4.51	0.0209	0.0001	0.0001
	HI	0.085±0.02	0.094±0.01	0.125±0.01	0.121±0.02	0.0244	0.00008	0.0001
	CI	1.108±0.04	1.068±0.02	1.062±0.03	1.024±0.02	0.0001	0.0001	0.00001
Left lung	V5Gy (%)	34.99±6.77	59.95±10.06	50.30±7.73	53.75±7.83	<0.00001	<0.0001	<0.00001
	V_{10Gy} (%)	25.02±5.52	24.62±4.48	30.54±5.74	20.37±5.09	0.5222	0.00008	0.0019
	V_{20Gy} (%)	13.51±4.37	10.41±4.09	16.08±4.10	13.54±3.13	0.0009	0.0002	0.865
	V_{30Gy} (%)	7.5±3.29	3.95±2.17	8.59±2.85	5.57±1.85	0.00001	0.0004	0.0128
	MLD (Gy)	7.72±1.79	8.69±1.04	9.51±1.52	9.1±1.17	0.0021	0.00006	0.0008
Right lung	V_{2Gy} (%)	3.21±2.62	41.86±3.25	4.61±3.25	38.23±14.46	<0.00001	0.0111	<0.00001
	V_{5Gy} (%)	0.3±0.65	5.11±6.18	0.31±0.49	8.37±6.77	<0.00001	<0.00001	<0.00001
	MLD (Gy)	0.36±0.12	2.09±0.53	0.74±0.20	2.18±0.59	<0.00001	<0.00001	<0.00001
Heart	V_{5Gy} (%)	23.35±5.73	22.97±8.23	34.7±7.44	35.44±11.47	0.4122	<0.0001	<0.0003
	V_{25Gy} (%)	2.66±1.22	1.31±0.78	4.44±2.30	3.18±1.94	<0.00001	<0.0001	0.1868
	Mean (Gy)	4.33±0.85	4.57±0.77	6.04±1.18	5.88±1.40	0.0324	<0.00001	0.0001
LAD	$D_{2\%}$ (%)	30.35±6.60	25.10±6.89	33.63±4.77	29.48±5.65	<0.00001	0.0005	0.4354
	Mean (Gy)	13.77±4.49	11.50±3.36	18.41±5.80	16.28±5.42	0.0002	<0.00001	0.0030
Right breast	Mean (Gy)	0.54±0.26	1.66±0.51	1.17±0.50	2.59±0.75	<0.00001	<0.00001	<0.00001
Body-PTV	V_{5Gy} (cc)	2260±548	4036±930	2911±559	3821±672	0.00008	0.0001	0.00008
	V_{3Gy} (cc)	2897±672	6337±1394	3905±695	5746±1022	<0.00001	<0.00001	<0.00001
	V_{2Gy} (cc)	3529±832	8241±1749	5059±1023	7638±1417	<0.00001	<0.00001	<0.00001
Monitor units	MUs	1133±189	1391±118	553±38	718±69	0.0001	<0.00001	<0.00001

PTV: Planning target volume, MLD: Mean lung dose, LAD: Left anterior descending artery, V_{xGy}: Volume of organ receiving x Gy dose, $D_{x\%}$: Minimum dose received by x% of volume, IMRT: Intensity-modulated radiotherapy, VMRT: Volumetric-modulated arc therapy, MU: Monitor unit, HI: Homogeneity index, CI: Conformity Index

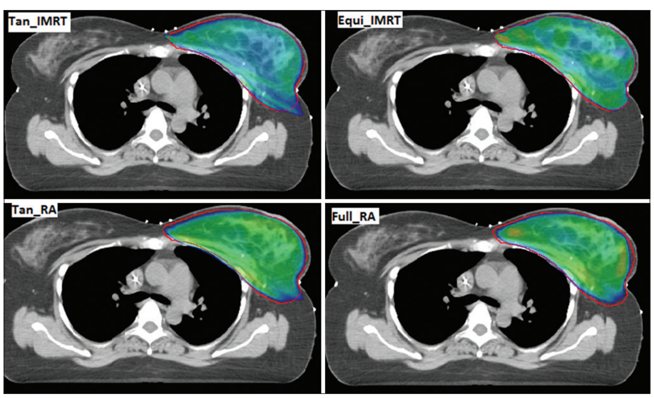

Figure 2: Dose coverage (95% isowash) of planning target volume for different techniques

Organ at risk

Left lung

The V_{5Gy} of the left lung was significantly lower in the Tan_IMRT plan (34.99% ± 6.77%) compared with all other plans (Equi_IMRT: 59.95% ± 10.06%; Tan_VMAT: 50.3% ± 7.73%; and Full_VMAT: 53.75% ± 7.83%). Compared with other plans, the lowest V_{10Gy} was found in the Full_VMAT plan (20.37% ± 5.09%) and the lowest V_{20Gy} was found in the Equi_IMRT plan (10.41% ± 4.09%). The left lung V_{30Gy} was lower in the Equi_IMRT (3.95% ± 2.17%) and the Full_VMAT (5.57% ± 1.85%) plans. MLD was significantly lower in the Tan_IMRT plan (7.72 Gy) compared with all other plans (approximately 9 Gy). Detailed DVH parameters are tabulated in Table 2. Figure 4 shows the pictorial representation of DVH for the left lung.

Right lung

All parameters such as V_{2Gy} and V_{5Gy} and MLD of the right lung were better achieved in tangential plans (MLD: Tan_IMRT: 0.36 Gy ± 0.12 Gy and Tan_VMAT: 0.74 Gy ± 0.2 Gy) than all around plans (Equi_IMRT: 2.09 Gy ± 0.53 Gy and Full_VMAT: 2.18 Gy ± 0.59 Gy). Detailed DVH parameters are tabulated in Table 2.

Heart

Heart dose was extremely controlled in the IMRT plans. All parameters such as V_{5Gy} and V_{25Gy} and mean dose were found to be favorable to IMRT plans. The mean dose to heart was approximately 4.5 Gy in the IMRT plans and 6.0 Gy in the VMAT plans. In addition, V_{5Gy} of heart was lower in the IMRT plans (approximately 23%) compared to the VMAT plans (approximately 35%). Figure 5 shows the pictorial representation of DVH for heart.

Left anterior descending artery

The pattern similar to the heart was observed for LAD. The IMRT plans provided superior LAD sparing than the VMAT plans.

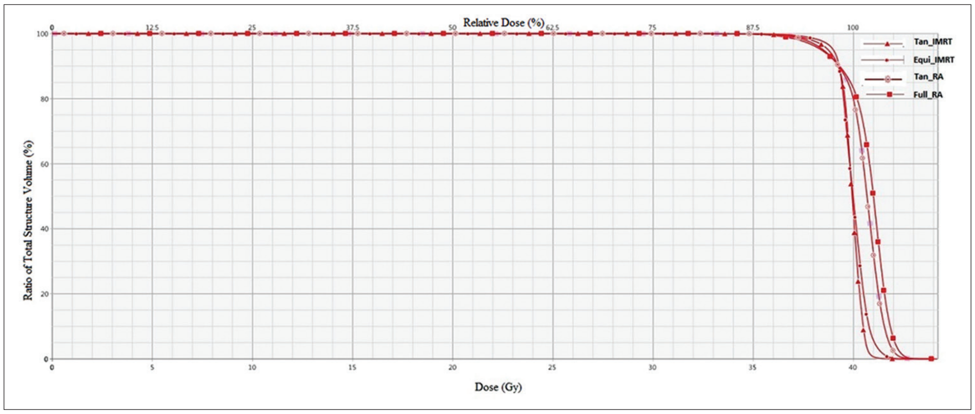

Figure 3: Dose–volume histogram comparison of different techniques for planning target volume

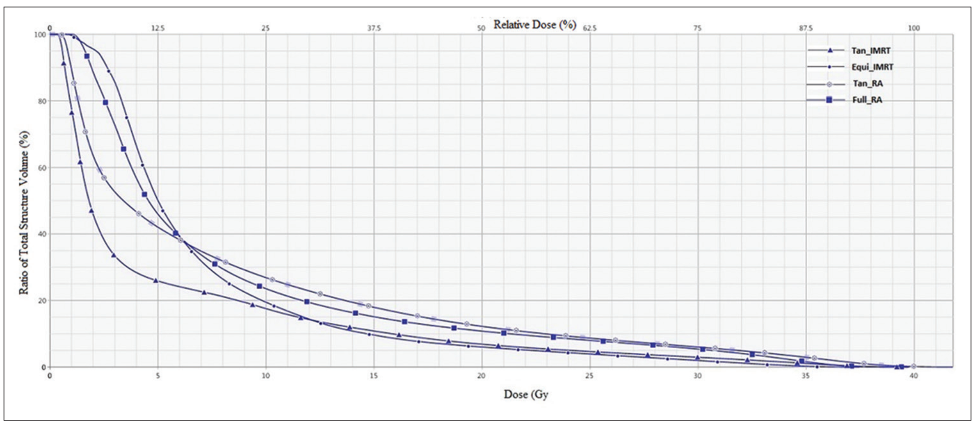

Figure 4: Dose–volume histogram comparison of different techniques for the left lung

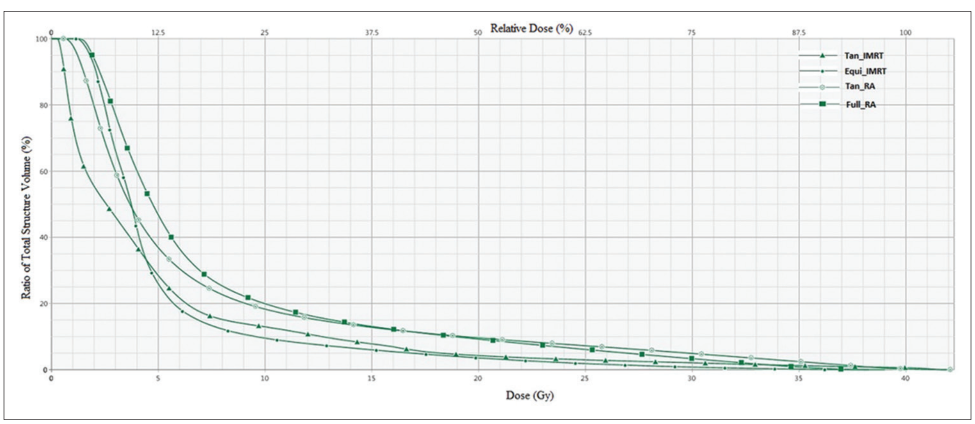

Figure 5: Dose–volume histogram comparison of different techniques for the heart

Right breast

Tangential plans, particularly Tan_IMRT plan, provided better sparing of right breast than the Equi_IMRT and Full_VMAT plans. We were able to achieve desired constraint (mean dose to the right breast < 2 Gy) in all plans except the Full_VMAT plan.

Normal tissue

V_{5Gy}, V_{3Gy}, and V_{2Gy} of the normal tissue were analyzed to account for low-dose spillage. Significantly, less volume of the normal tissue received low dose in the Tan_IMRT plan. The volume was increased by 30%–45% in the Tan_VMAT plan and by 70%–135% in the Equi_IMRT and Full_VMAT plans. Comparison of 5 Gy dose spillage between different techniques is shown in Figure 6.

Monitor units

The mean values of monitor units for the VMAT plans (Tan_ VMAT: 553 ± 38; Full_VMAT: 718 ± 69) were significantly

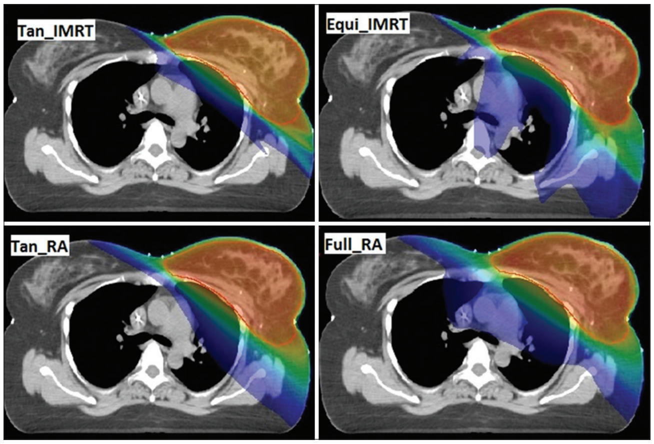

Figure 6: Comparison of low-dose (5 Gy) spillage for different techniques

less than that of the IMRT plans (Tan_IMRT: 1133 ± 189; Equi_IMRT: 1391 ± 118).

Discussion

There is an increase in the survival rate of early-stage breast cancer patients who undergo postoperative radiotherapy.[17,18] To improve the quality of life for these patients after treatment, selection of an optimized technique is essential, in which radiation-induced acute and late toxicities are minimized without compromising the cure rate.

Breast cancer treatment planning has evolved from the conventional tangential technique, which is practiced in telecobalt unit with breast cone to avoid divergence of beam in the lung. In linear accelerator, asymmetric jaws are used to avoid beam divergence in the lung. In the classic tangential breast radiotherapy, the beam is placed in such a way that the field covers only target volume when sparing the contralateral breast, the lung, and the heart and minimizing the dose to the ipsilateral lung. After incorporation of the MLC in linear accelerator, field-in-field technique was introduced to increase the homogeneity and reduce the dose to the heart. Technical development and the introduction of inverse planning have increased the use of IMRT and VMAT planning for breast cancers. Although inverse planning provides a superior dose coverage to tumor and spare OARs, low-dose spillage in normal tissue which increases the risk of secondary malignancies is also a concern.[7,19,20]

Borges *et al*. have conducted planning and dosimetric comparison of IMRT and arc techniques using different beam arrangements, energy, and algorithms.[21] Their results showed that larger volume of OARs receiving low dose when beams are placed other than tangential technique. The most appropriate technique for the left-sided breast cancer is still debated due to proximity of the heart to the target area. Moreover, radiation-induced cardiovascular disease is the main complication in the treatment of left-sided breast cancer.[22-24]

In this study, we compared the dosimetric parameters of two IMRT plans (one with tangent beam arrangement and another with equally spaced beam arrangement) and two VMAT plans (one with tangent arc and another with full arc). We achieved good dose coverage to target volume in all the techniques. However, VMAT showed slight increase in $V_{105\%,}$ (approximately 6% as acceptable limit is 3%), resulting in reduced homogeneity of the distribution [Figure 3 and Table 2].

In breast case planning, minimizing dose to ipsilateral lung is essential to avoid radiation pneumonitis (RP).[25] In our study, dose parameters such as MLD and V_{5Gy} were significantly less in Tan_IMRT plan compared with other three plans. Furthermore, the volume of lung exposed to beam was less in tangential plans compared with all around plans. Mixed results were achieved for dose parameters V_{10Gy} and V_{20Gy}. The most favorable result for V_{30Gy} was achieved in the Equi_IMRT and Full_VMAT plans. Several studies have demonstrated that dosimetric parameters such as irradiated volume of lung and MLD are predictors of radiation-induced lung injury.[25,26] Hernando *et al*. demonstrated an association between MLD and RP rate; MLD <10 Gy and 11–20 Gy we associated with a 10% and 16% RP rates, respectively.[26] Our study indicates low MLD in the Tan_IMRT plan compared with other plans [Figure 4].

Many studies have demonstrated that IMRT plans better scored as compared to VMAT plans with respect to mean heart dose, low-dose parameter V_{5Gy}, high-dose parameter V_{25Gy}, and LAD dose.[5-7] Some studies have shown a linear increase in complications such as myocardial infarction and ischemic heart disease by approximately 7%/Gy increase in the mean heart dose.[23,27,28] Adverse impact of radiation to the heart is manifested mainly in first three decades after radiation therapy.[23] Chung *et al*. reported that no significant changes were found in cardiac function (ejection function, summed stress defect scores) after radiotherapy with a mean heart dose of <5 Gy.[29] In our study, the mean heart dose was low in the Tan_IMRT plan than other plans [Figure 5 and Table 2]. However, dose distribution of the heart was not homogenous. As per the anatomy of the heart and the site of tumor, maximum cardiac doses can be received to the apex and the anterior segment in the region of LAD, resulting in higher dose to the LAD. A study has confirmed that rate of stenosis of LAD is high in the regions of higher mean dose.[30] Wennstig *et al*. also demonstrated a positive association between mean radiation doses to mid-LAD and coronary stenosis.[31] In our study, the mean dose to LAD was less in the IMRT plans than the VMAT plans [Table 2].

The Tan_IMRT plan was found to be superior in terms of mean dose to the contralateral breast and the lung. This is because the contralateral lung and breast are located away from the beam in tangential field planning, which reduces the dose to contralateral structures.

Acute and late reactions are induced by the high radiation dose. The risk of radiation-induced secondary malignancies depends on the number of MUs and the volume of health tissue receiving low dose.[16,32,33] In the present study, MU for Tan_IMRT plan is higher than VMAT plans; however, the low-dose spillage in normal healthy tissues is greatly decreased, which may reduce the risk of secondary malignancies [Figure 6 and Table 2].

VMAT is a rotational IMRT that allows variable field size, dose rate, and gantry rotational speed concomitantly when delivering the treatment, which helps reduce the number of MUs. Conversely, IMRT plans are delivered at a fixed gantry angle requiring more MUs than VMAT. Zhang *et al*. showed that VMAT needs 24% less MU than IMRT for the left-sided chest wall and internal mammary irradiation.[34] Similarly, Liu *et al*. demonstrated 49.33% reduction in the number of MUs for VMAT plan compared with IMRT plan for left-sided breast cancer.[35] Our study also showed that the tangential VMAT plan requires 48.8% less MU than the tangential IMRT plan. Moreover, Full_VMAT plan showed 51% reduction in MU compared with the Equi_IMRT IMRT plan [Table 2]. Less MUs in VMAT plans reduce the beam-on time and patient spends less time on couch. Such a reduction in beam-on time can have impact on clinical throughput of the machine.

To avail the advantages of conventional, IMRT and VMAT techniques, hybrid technique is being practiced at many centres. Combination of these techniques is used according to patient anatomy and need.[36] Often, hybrid techniques are used to minimize the ipsilateral lung and cardiac doses.

To minimize the cardiac dose, deep inspiration breath hold (DIBH) technique is also being practiced at many centers. In DIBH, the distance between PTV and the heart is increased, which reduces the cardiac dose.[37] In this technique, the lung volume is increased, which provides an advantage of reducing mean dose to the lung. Some centers have adopted immobilization techniques for cardiac sparing for the patients who are ineligible for breath-hold techniques.[38]

The main disadvantage of Tan_IMRT is the high-dose spillage outside the target when planning simultaneous integrated boost. When IMC is included in the treatment, more lung volume will be included in the field, which may lead to high-dose to ipsilateral lung.

The merit of this study is that it analyzed different planning techniques used in the left-sided breast only treatment. However, this study has some limitations, including small sample size and the lack of assessment of clinical parameters, particularly complications related to the dose received by OARs. Furthermore, the size of the breast is not considered in this study.

Conclusion

In this dosimetric study, we compared IMRT and VMAT techniques with different beam arrangements. Our results show that in Tan_IMRT is superior in terms of target coverage, lung and heart sparing, and spillage dose in the normal tissue. Better lung sparing in the Tan_IMRT will further reduce the radiation-induced pneumonitis. Similarly, heart-sparing in Tan_IMRT will reduce the risk of radiation-related cardiovascular diseases. Reduced low-dose spillage in Tan_IMRT will also reduce the risk of secondary malignancies. We have adopted the Tan_IMRT technique for the left-sided breast-only treatment in our routine clinical practice. More studies with larger patient cohort with different techniques are required to derive more robust conclusions.

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Conflicts of interest

There are no conflicts of interest.

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