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Dosimetric comparison of 3DCRT versus IMRT in whole breast irradiation of early stage breast cancer

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Original Article

Abstract

Purpose: The counseling regarding the treatment option is an important objective in the management of early stages breast cancer. The purpose of this study is to present a comparison between the dosimetric aspects of 3DCRT and IMRT in the whole breast radiotherapy. **Methods**: Both right and left sided computed tomography simulations of 14 women with early stage breast cancer were used for our retrospective study to compare the 3DCRT and IMRT. The dose prescribed was 50 Gray (Gy) in 25 fractions to the whole breast PTV. The PTV was defined by adding unequal margins to the directional safety margin status of each lumpectomy cavity (i.e., medial, lateral, superior, inferior and deep margins measured from the tumor front after the examination of the surgical specimen: 2, 1.5, and 1 cm for resection margins < 1 cm, 1-2 cm, and > 2cm, respectively) and then modified so that it was no longer closer than 3 mm to the skin surface and was no deep than the lung –chest interface. The prescribed dose delivered in 5 fractions per week schedule. Treatment plans were compared for target minimum dose, maximum dose, mean dose, conformity index, heterogeneity index and doses to organs at risk were compared and analyzed. **Results:** The target coverage was achieved with 90% prescription to the 95% volume of the PTV. Conformity to the PTV was significantly higher with 3DCRT technique than IMRT. 3DCRT technique seems better in sparing critical organs parameters like lung V_{20} and Mean, heart, V_{25}, Maximum, both lungs V_{20}, Mean and Dose to the Normal Healthy tissue. **Conclusion**: We conclude from our study that treatment technique selection for whole Breast irradiation is an important factor in sparing the adjacent normal structures and in determining the associated risk. 3DCRT produces better conformity and heterogeneity indices of the target volume, also reduces dose to OARs and reduces the risk of radiation induced heart diseases.

Keywords: Whole Breast Irradiation; Planning Tumor Volume; Organs at Risk; Conformity Index; Heterogeneity Index; Breast Conservative Surgery

Introduction

An estimated 12.66 million people were diagnosed with cancer across the world in 2008, and 7.56 million people died from the disease. Just four cancer sites lung, female breast, colorectal and stomach accounted for two-fifths of the total cases diagnosed worldwide. Breast cancer is the most common cancer in females worldwide. As per World Health Organization (WHO) estimate, in Bahrain the incidence of breast cancer was 116.47 per 100,000 in 2008. Unlike other cancers, breast cancer is successfully treatable if detected at an early stage.[1]

The incidence of breast cancer has increased globally over the last several decades.[2, 3, 4] The greatest increase has been in Asian countries.[5] In Asia, breast cancer incidence peaks among women in their forties whereas in the United States and Europe, it peaks among women in their sixties. In India premenopausal patients constitute about 50% of all patients.[6] It is expected that in the coming decades, these countries would account for majority of new breast cancer patients

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diagnosed globally. Over 100,000 new breast cancer patients are estimated to be diagnosed annually in India.[7]

Radiotherapy is an integral part of breast cancer management after Breast Conservative Surgery (BCS) in early stage breast cancer. Survival rates are similar for BCS with adjuvant Radiotherapy (RT) and mastectomy for early stage breast cancer and Breast Conservative Surgery (BCS) is known as a gold standard.[8, 9, 10] Whole breast irradiation is the commonest method of management for early breast cancer treatment after BCS. The greatest challenge for radiation therapy or any cancer therapy is to attain the highest probability of cure with the least morbidity. The simplest way in theory to increase this therapeutic ratio with radiation is to encompass all cancer cells with sufficient doses of radiation during each fraction, while simultaneously sparing surrounding normal tissues. In practice, however, we have been hampered by our abilities to both identify the cancer cells and target them with radiation. The modern radiotherapy has evolved from non-site-specific techniques using bony anatomy and hand-drawn blocking toward specialized planning incorporating three-dimensional reconstructions of images and computer optimization algorithms. Corresponding to these changes, there has been specialization in the types of technology used for different cancer sites. Two-dimensional (2D) radiotherapy consisted of a single beam from one to four directions. Beam setups were usually quite simple; plans frequently consisted of opposed lateral fields or four field "boxes". Three-dimensional (3D), or Computed Tomography (CT) based, planning was a major advance because it took into account axial anatomy and complex tissue contours and while 3D planning allows for accurate dose calculations to such irregular shapes, we are still limited in the corrections we could make. The intensity-modulated radiation therapy (IMRT) allows us to modulate the intensity of each radiation beam, so each field may have one or many areas of high intensity radiation and any number of lower intensity areas within the same field, thus allowing for greater control of the dose distribution with the target. By modulating both the number of fields and the intensity of radiation within each field, we have limitless possibilities to sculpt radiation dose. Advanced treatment planning software has furthered our ability to modulate radiation dose. Instead of the clinician choosing every beam angle and weighting, computer optimization techniques can now help determine the distribution of beam intensities across a treatment volume, which often include a non-intuitive distribution of "beamlets," or 1-cm^2 areas of isointensity.[11]

There are various methods to employ radiotherapy for breast cancer in women. Conventionally tangential fields are employed to treat the whole breast. With the recent advances in treatment planning technology and Multi Leaf Collimators (MLC), Three Dimensional Conformal Radiotherapy (3DCRT) is widely used for treatment of breast carcinoma. Conformal therapy reduces normal tissue doses and increases conformity to target volume. With the advent of advanced sophisticated treatment planning software intensity modulated radiation therapy is becoming increasingly popular. The aim of our study is to compare three dimensional conformal radiation therapy (3DCRT) versus intensity modulated radiation therapy (IMRT) planning based on standard plan indices using Computerized Medical Systems (CMS) Xio (4.70.02 version, ELEKTA) treatment planning system.

Methods and Materials

CT Imaging

This study is conducted using treatment plans done on the Computed Tomography (CT) simulation data sets (2.5 mm slice thickness) of 14 consecutive patients (7 right sided breast carcinoma, 7 left sided breast carcinoma) with T_1 or T_2 axillary node negative invasive carcinoma of breast for our retrospective analysis. The Planning Tumor Volume (PTV) size varied from 855.73 cm^3 to 1347 cm^3 with a mean value of 1025.35 cm^3. These patients were already treated with IMRT. Radiation Therapy was started within three weeks after the breast conservation surgery consisting of removal of primary tumor with a margin referred as lumpectomy or segmental mastectomy and chemotherapy. A radio opaque wire was placed around the ipsilateral breast by Radiation Oncologist to define the treatment ports for the PTV. The same CT data sets target volumes and organs at risk volumes were used for 3DCRT study.

Target and organ at risk delineation

After planning CT was done, the Digital Imaging and Communication in Medicine (DICOM) images were transferred to CMS Xio (4.70.02 version, ELEKTA) treatment planning system. The contours that were generated were the Gross Tumor Volume (GTV), Clinical Tumor Volume (CTV), Planning Target Volume (PTV), ipsilateral lung, contralateral lung, contralateral breast, heart, spinal cord and body. The GTV which is the gross tumor volume is the total lumpectomy cavity which can be identified with the help of surgical clips placed at the time of surgery. The CTV was defined by the three dimensional uniform 1.5 cm margin expanded in all directions around the GTV, however this volume was constrained to lie 5 mm within the external contour and up against the major muscle. The PTV volume was defined to lie within the radio-opaque wire kept during CT simulation as deep as the anterior chest wall muscles. The lungs and external surfaces contoured using semi-automatic contouring techniques. The CTV, PTV, and Organs at Risk (OARs) were generated in accordance with the Radiation Therapy Oncology Group (RTOG) 0319 protocol.[12]

Treatment Planning Details and Dose Prescription

All treatment plans were generated with 6 MV (Mega voltage) photon beams to maintain the comparison between the two treatment techniques. Treatment plans were done using

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CMS Xio (4.70.02 version, ELEKTA) for IMRT treatment and 3DCRT treatment.

The treatment fields were almost evenly placed within an arc of 180 degree swept by the gantry. The gantry angles ranged from 300 to 160 (clockwise) for left side tumors and from 60 to 210 (counter clockwise) for right side tumors were chosen to create optimum IMRT plans. The dose prescribed to the Breast volume (PTV) was 50 Grays (Gy) in 25 fractions (2.0 Gy/fraction). The dose uniformity and conformity were calculated and evaluated.

The Conformity Index (CI) as defined in the International Commission of Radiological Units (ICRU) report 83 is

$$CI_{(ref)} = \frac{Volume\ of\ PTV\ covered\ by\ the\ reference\ dose}{Volume\ of\ PTV}$$

C.I = 1.0 (one) is the ideal value.

The Homogeneity Index (HI) as defined in ICRU report 83 is

$$HI = \frac{D_{5\%} - D_{95\%}}{D_{50^c}}$$

H.I = 1(one) is the ideal value.

Where, $D_{5\%}$, $D_{95\%}$, $D_{50\%}$ is the dose received by 5%, 95%, 50% volume.

3DCRT Planning

Two opposite tangential beams were constructed to conform to whole breast PTV. A margin of 1 cm between the MLC and PTV was set for coverage. Using Beam's Eye View (BEV) fields were set up to minimize the dose to heart, left descending coronary artery (LAD), contralateral breasts and ipsilateral lung and maximize the target coverage. The "isocenter" of the treatment machine was positioned at the center of the midline joining the two parallel opposite fields. The plans were created for 3DCRT, in which tangential coplanar beams were used to produce adequate dose coverage for Planning Target Volume (PTV). Critical organs were shielded using MLC without compromising with the PTV coverage. Beam weights were adjusted until the optimum coverage and acceptable hot spots were achieved. The PTV was set to receive 95% of the prescribed dose. Also, hot spot volumes blocking subfields were determined to achieve the better dose homogeneity and to avoid the overdose in the PTV. By viewing the 105% dose cloud in a beam's eye view projection of the treatment fields, subfields were designed by blocking the volume of PTV receiving greater than 105% of the prescribed dose to boost the low dose volume of the PTV (volume of the PTV receiving less the 95% of the prescribed dose) by delivering 5 to 10 monitor units. The shape of the subfield was iteratively modified with aided visualization of 105% dose cloud in the beam's eye view. The main field and subfields were merged into one portal.

IMRT Planning

TABLE 1: Dose constraints for 3DCRT and IMRT planning.

Organ	Parameter	Dose (cGy)	Volume (%)
PTV	Maximum Dose	5500	0
	Minimum Dose	4700	100
Ipsilateral Lung	Mean Dose	2000	30
Contralateral Lung	Mean Dose	2000	33% volume of (Lung-PTV)
Contralateral Breast	Mean Dose	1500	5%
Heart	Mean Dose	3500	0
	Point Dose	500	Less than the Prescribed dose

In this technique, the fluence based step and shoot IMRT optimized plans were generated to achieve the same objectives described for the 3DCRT plans, the number of beam segments was not restricted during optimization and no attempts have been made for beam angle optimization as CMS Xio does not support beam angle optimization. The PTV for IMRT was the same as used for the 3DCRT plans plus an extension into the air anterior of the PTV of 1.5 cm in order to compensate the set up uncertainties and up and down movement of the chest due to respiration. The dose was prescribed to the PTV and the dose constraints presented in the **Table 1** were set to the treatment planning system. Tissue heterogeneity was considered in the treatment planning optimization process and the dose calculation was done by using superposition/ convolution algorithm.

The CMS Xio (4.70.02 version, ELEKTA) treatment planning system Dose Volume Histogram (DVH) window was used to analyze the PTV's mean, maximum and minimum doses and for OAR's mean, maximum, minimum doses, percentage of volume receiving 3000cGy (V30), percentage of volume receiving 2000 cGy (V_{20}), percentage of volume receiving 1000 cGy (V_{10}), and isodose volumes for 50%, 30% and 10%. Also to illustrate the low dose volume effects, Dose Volume Histogram for normal healthy tissue are also incorporated and Monitor Units (MU) were also noted in order to access and understand integral dose (ID) contribution, the Monitor Units (MU) for both the plans were noted and taken for analysis. The more monitor unit signifies the more integral dose. The integral dose ID to an organ j divided into m voxels is given by the following equation:[13]

$$ID = \sum_{k=1}^{m} V_{kj} D_{kj} \rho_{kl}$$

Where, V_{kj}, D_{KJ} and P_{kl} are respectively the volume, dose and density of voxel k in organ j. If the voxels have all the same size and the organ can be assumed to have a uniform density, the integral dose equation can be reduced to $ID = V_j \rho_j D_j$

Statistical Analysis

For qualitative analysis of the two techniques, a very suitable method of investigation is provided by Wilcxon's Signed Rank sum test, which operates as follows. First, put all the observations in ascending order of their magnitude, ignoring the signs. Any zero values are ignored and the remaining non-zero values are assigned rank 1 to *n*. If any of the observations are numerically equal they are each assigned an average rank calculated from the rank that would otherwise have been used. Such ranks are said to be tied. Next calculate the sum of the ranks of the positive observations and refer the table for appropriate significance level.[14]

The above said statistical analysis was performed for qualitative ranking of the two techniques using Statistical Package for Social Sciences (SPSS) version12.0 (SPSS Inc., Chicago, USA) software. This matched pair t-test was applied to determine the statistical difference between the dose volume data for IMRT versus 3DCRT. The reported p-value is two tailed and p-values of < 0.05 are considered significant or else non-significant (NS).

Results

TABLE 2: (a) Comparison of average dosimetric characteristics for left Whole Breast PTV for IMRT and 3DCRT technique. (Prescribed dose 5,000 cGy in 25 fractions).

Dosimetric Parameter	IMRT	3DCRT	p-Value
Max Dose (cGy)	5594.34	5606.43	0.055*
Min Dose (cGy)	2249.47	1714.17	0.039
Mean Dose (cGy)	4984.34	5041.63	0.031
95% volume	4567.4	4565.24	0.063*
Conformity Index	0.90	0.89	0.063*
Heterogeneity Index	1.16	1.14	0.023
Monitor Unit (MU)	761.4	260.6	0.008

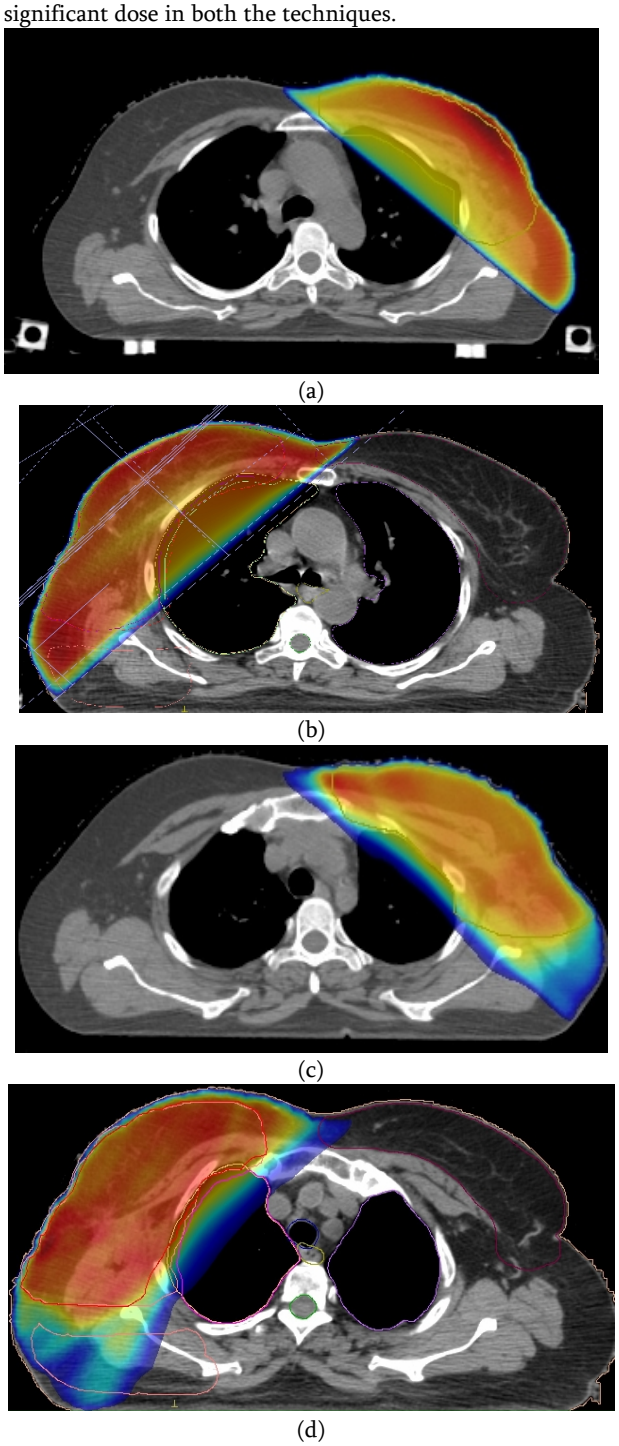
*= statistically insignificant

TABLE 2: (b) Comparison of average dosimetric characteristics for right Whole Breast PTV for IMRT and 3DCRT technique. (Prescribed dose 5,000 cGy in 25 fractions).

Dosimetric Parameter	IMRT	3DCRT	p-Value
Max Dose (cGy)	5618.96	5565.96	0.063*
Min Dose (cGy)	2842.13	1171.70	0.008
Mean Dose (cGy)	4945.33	5172.94	0.039
95% volume	4537.56	4681.44	0.016
Conformity Index	0.94	0.95	0.125*
Heterogeneity Index	1.12	1.10	0.024
Monitor Unit (MU)	2502	1297.4	0.008

*= statistically insignificant

The treatment plans were optimized to meet the planning objectives in both the treatment techniques and to achieve the prescribed dose delivery for more than 90% of the prescribed isodose to encompass greater than 95% of the PTV volume. The PTV size varied from 855.73 cm^3 to 1347 cm^3 with a mean value of 1025±35 cm^3. In 3DCRT, 105% dose (hot spots) was observed in less than 5% of the target volume. The normalized target coverage for IMRT and 3DCRT in PTV and for both classes of the patients were presented in the **Table 2a and 2b**. **Figure 1** demonstrates the dose distribution in axial sections for the two classes of patients (right sided diseases patient and left sided disease patient) for IMRT and 3DCRT plans of the same patient. The axial sections clearly depict the concave target PTV coverage and in all left sided breast patients, the left anterior descending coronary artery (LAD) is little away from the PTV and not receiving any significant dose in both the techniques.



(a) (b) (c) (d)

FIG. 1: Represents the 20 Gy volume of dose color wash in 3DCRT (a, b) and IMRT (c, d) breast plans.

The comparison and dosimetric analysis for the Planning Target volume (PTV) presented in the **Table 2a, 2b** depicts that there is no significant difference in maximum dose and conformity index in both the treatment techniques. However, the heterogeneity index was found to be 1.16 for IMRT and 1.14 for 3DCRT (p = 0.023) in left breasts and 1.12 for IMRT and 1.10 for 3DCRT (p = 0.024) in the right breasts. All the dosimetric parameter calculated for the Planning Target Volume (PTV) except mean dose has appreciably higher values in IMRT plans than 3DCRT plans. Moreover, the dosimetric analysis carried out for ipsilateral lung dose parameters like mean dose, V_5, V_{10} were found to have higher values in all IMRT plans than 3DCRT plans. The difference is presented in **Table 3** for both classes of the patients.

TABLE 3: Comparison of mean values for ipsilateral lung parameters for IMRT and 3DCRT in left sided breasts patients.

Dosimetric Parametric	IMRT	3DCRT	p-value
V_5 (%)	57.70	24.76	0.008
V_{20} (%)	34.0	41.00	0.039
V_{30} (%)	26.94	32.65	0.031
V_{10} (%)	57.51	28.97	0.008
Mean Dose (cGy)	1377.96	1065	0.023

Figure 6 illustrates the Dose Volume Histogram (DVH) for heart. A comparison of dosimetric parameters for heart is presented in **Table 4a, 4b**. These parameters show much higher values in IMRT technique than 3DCRT technique except the dose value to the 33% of the heart volume and the volume encompassed by 25% isodose line.

TABLE 4: (a) Comparison of mean values for heart dose parameters for IMRT and 3DCRT in right sided breasts patients.

Dosimetric Parameter	IMRT	3DCRT	p-value
Max Dose (cGy)	3308.41	2315.05	0.039
Min Dose (cGy)	259.77	17.96	0.008
Mean Dose (cGy)	1198.1	149.84	0.047
33% Volume (cGy)	710.5	124.56	0.008
V_{25} (%)	2.34	1.80	0.055*
V_{10} (%)	20.72	2.95	0.016

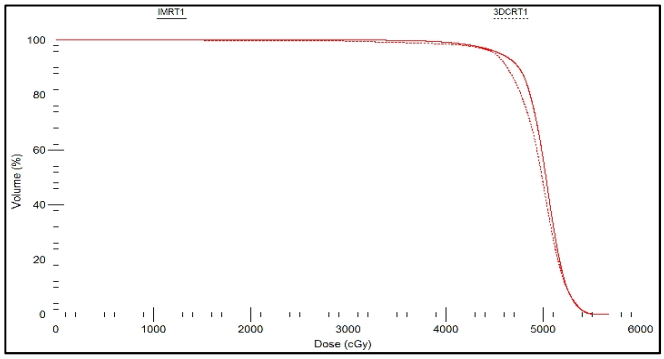
*= statistically insignificant

TABLE 4: (b) Comparison of mean values for heart dose parameters for IMRT and 3DCRT in left sided breasts patients.

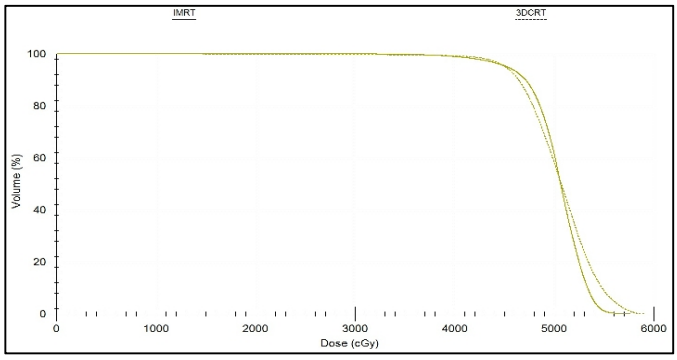
Dosimetric Parameter	IMRT	3DCRT	p-value
Max Dose (cGy)	4699.99	4515.53	0.039
Min Dose (cGy)	330.30	50.57	0.008
Mean Dose (cGy)	1499.57	1184.24	0.008
33% Volume (cGy)	1035.84	1465.79	0.055*
V_{25} (%)	16.02	20.66	0.063*
V_{10} (%)	47.73	27.06	0.016

*= statistically insignificant

A comparison of average plan parameters for contralateral breasts and both lungs is presented in **Tables 5, and 6** respectively. Dose Volume Histograms (DVHs) describing the dose volume relation of the target as well as normal tissue for both the techniques is presented in **Figure 2-7**. The mean value of Monitor Units (MU) for left sided diseases in IMRT technique was found to be 761.4 Monitor Units (MUs) as compared to 260.0 Monitor Units (MUs) in 3DCRT with (p = 0.008) and for right sided diseases the average value of Monitor Units in IMRT technique was observed to be 2502 Monitor Units (MUs) compared to 1297.4 monitor units (MUs) in 3DCRT (p = 0.008). The value of the monitor unit will depend on the depth that we are going to treat. The higher value of MUs in case of right sided breast disease may only because of large breast volume or because of the pendulous breasts. Also, the DVH shows considerably better normal tissue sparing with 3DCRT than IMRT for the intact whole breasts.



(a) DVH of PTV in IMRT and 3DCRT plans for right breast cancer case



(b) DVH of PTV in IMRT and 3DCRT plans for left breast cancer case

FIG. 2: Cumulative dose volume histogram (DVH) of PTV comparing 3DCRT and IMRT plans for (a) right breast, and (b) left breast cancer cases.

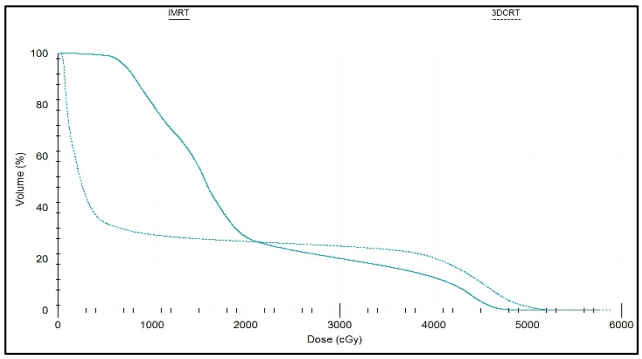


FIG. 3: Cumulative dose volume histogram (DVH) of ipsilateral lung comparing 3DCRT and IMRT plans.

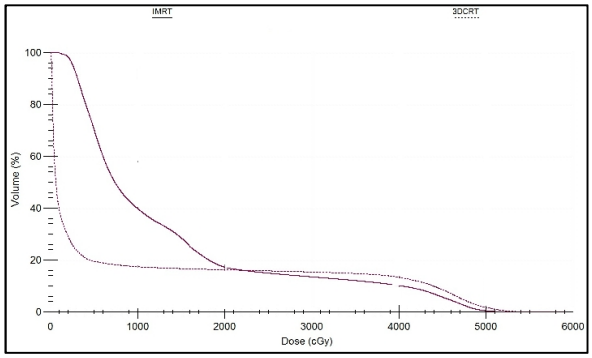


FIG. 4: Cumulative dose volume histogram of both lungs comparing 3DCRT and IMRT plans.

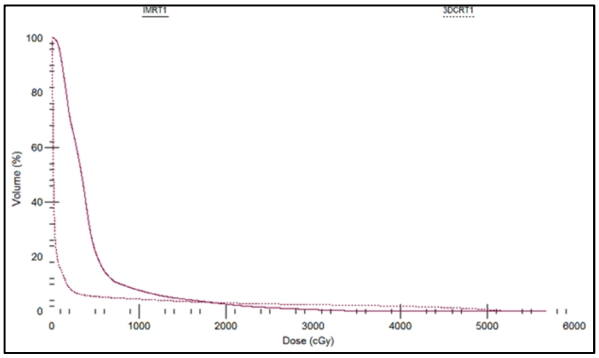
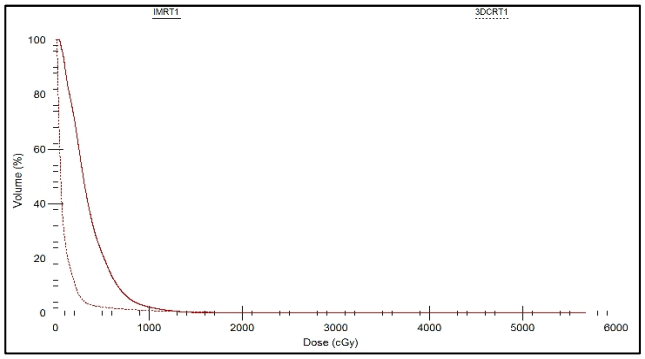
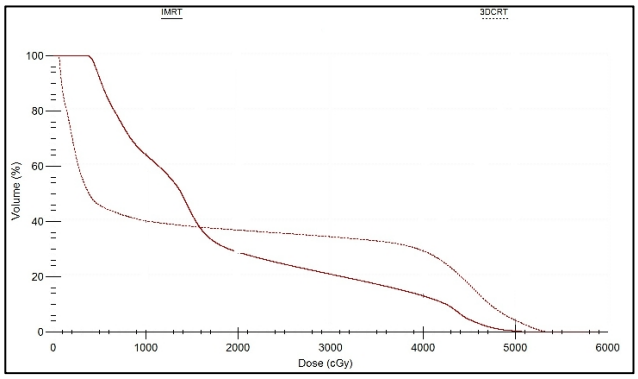


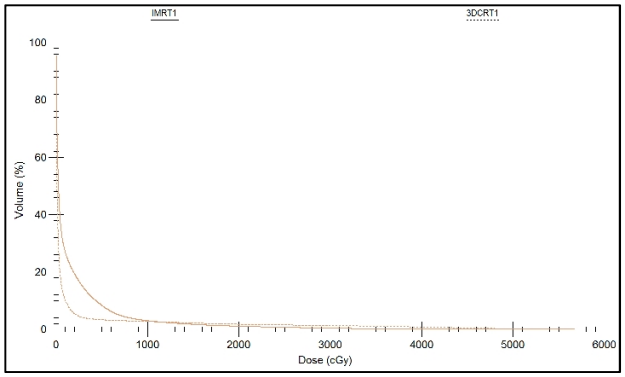
FIG. 5: Cumulative dose volume histogram of contralateral breast comparing 3DCRT and IMRT plans.



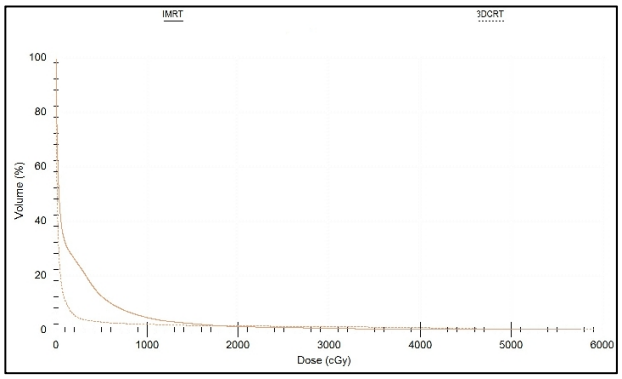
(a)DVH of heart in IMRT and 3DCRT plans for right breast cancer case



(b) DVH of heart in IMRT and 3DCRT plans for left breast cancer case. **FIG. 6:** Cumulative dose volume histogram of heart comparing 3DCRT and IMRT plans for (a) right breast cancer, and (b) left breast cancer cases



(a) DVH of normal tissue in IMRT and 3DCRT plans for right breast cancer case



(b)DVH of normal tissue in IMRT and 3DCRT plans for left breast cancer case

FIG. 7: Cumulative dose volume histogram (DVH) of normal healthy tissue comparing 3DCRT and IMRT plans for (a) right breast cancer, and (b) left breast cancer cases.

TABLE 5: Comparison of mean values for contralateral Breast dose parameters for IMRT and 3DCRT in right sided breasts patients.

Dosimetric parameter	IMRT	3DCRT	p-value
V_5 (%)	12.065	8.30	0.031
Min Dose (cGy)	188.92	181.63	0.039
D_5 (%)	737.38	786.2	0.027
Max Dose (cGy)	3861.00	4755.55	0.008
Mean Dose (cGy)	269.71	226.20	0.039

TABLE 6: Comparison of mean values for both lungs dose parameters for IMRT and 3DCRT in left sided breasts patients.

Dosimetric Parametric	IMRT	3DCRT	p-value
V_{20} (%)	20.45	17.00	0.016
Mean Dose (cGy)	1892.17	778.69	0.016

Discussion

Several epidemiological studies have shown that in country like India breast cancer patients usually come in advanced stage of breast cancer, breast conservative surgery is not possible, so mastectomy is the treatment of choice and early stage breast cancer is rare. In early stage breast cancer, breast conservative surgery is known as gold standard. There are distinct geometric differences between the target volume of the chest wall and the whole breast, and these differences might have an impact on the resulting dose distribution. In general,

there is an optimum plan for every patient that treats the breast tissue while sparing the organs at risk. However, the technique one may use could vary depending on the patient geometry and technology available in a particular radiotherapy center. The number of studies has been carried out to present the superiority of one technique over other. A very recent study by Suresh Moorthy *et al.* [15] presents a Dosimetric study of SIB-IMRT versus SIB-3DCRT for breast cancer with breath-hold gated technique. The study envisages that in comparison to 3DCRT, IMRT reduced the maximum dose to the target volume, and dose to OAR was reduced too.

However, 3DCRT technique was superior in terms of low dose volume of normal tissue, integral dose, and treatment time. Consequences of these low doses would have to be weighed against the benefits of reducing high doses on individual patient selection basis. With the use of breath-hold gated technique in IMRT, it can further improve the target coverage and reduction of doses to the heart, lung, and LAD. SIB technique could reduce the overall treatment duration by about one week. The present study is intended to compare the planning and dose delivery efficiency among two treatment techniques of radiation therapy to the whole breast namely three dimensional Conformal Radiotherapy (3DCRT) and Intensity Modulated Radiotherapy (IMRT) in fair manner for post lumpectomy breast cancer patients with CMS Xio (4.70.02 version, ELEKTA) treatment planning system.

In this study tangential beam 3DCRT of the whole breast PTV is compared to IMRT. **Table 2** depicts that the IMRT results are comparable to the 3DCRT technique in terms of the PTV coverage, delivering 90% of the prescribed dose to greater than 95% volume of the PTV, maximum dose delivered to the whole breast PTV, and conformity index. The Monitor Units in IMRT technique was higher than 3DCRT technique with p – values 0.008. This envisages that the integral dose would be higher probably due to multiple beams used in the IMRT plans than tangentially oriented beams used in three dimensional conformal plans to spare adjacent normal healthy tissue structures. The leakage and scatter dose to the non-target tissue is proportional to the number of Monitor Units used. Some studies reported, increased low dose volumes with increased number of beam angles increase the integral dose.[16]

In general, both IMRT and 3DCRT provided similar results regarding the PTV coverage. But, in depth analysis of dosimetric data reveals significant difference in the quality of the target coverage and normal tissue doses. For tangential beam 3DCRT technique the heterogeneity index for both left and right sided breasts disease was nearer to the ideal value compared to IMRT technique. While as, conformity indices were found more or less equal. The 3DCRT technique reduces the values for lung dose volume, heart dose volume, dose to contralateral breast and dose to both lungs than IMRT technique without compromising the target coverage. In this study, all most all the ipsilateral lung dose parameters were observed to have higher values in IMRT technique than 3DCRT technique. The Radiation Induced Pneumonitis is related to the ipsilateral lung volume irradiated, [17] the ipsilateral lung V_{20} for IMRT (34.0%) is significantly less than (41.00%) in 3DCRT (p = 0.039). Both lungs V_{20} parameters have significantly lower values in 3DCRT technique than IMRT with p – values 0.016. There is no absolute safe Mean Lung Dose (MLD) below which there no Pneumonitis.[18] The clinically acceptable risk of radiation therapy depends on the risk benefit ratio of the individual patient selection.

In patients with left sided breast cancer, it is intended that the irradiated heart volume be minimized to the greatest possible degree without compromising the target coverage as the risk of pericardial events is probably related to both dose and volume of irradiation. Stewart J R *et al.* [19] concludes that the dose volume should be limited to 60 Gy for less than 20% of the cardiac volume and 45 Gy for more than 65% of cardiac volume. A very recent study on "Risk of Ischemic Heart Diseases in Women after Radiotherapy for Breast Cancer" by Sarah CD *et al.*[20] suggests that the exposure of heart to ionizing radiations during radiotherapy for breast cancer increases the subsequent rate of ischemic heart diseases. The increase is proportional to the mean dose to heart, begins within few years after exposure, and continues at least for 20 years. Woman with preexisting cardiac risk factors have greater absolute increase in risk from radiotherapy than other women. Also, the rate of major coronary events increased linearly with the mean dose to the heart by 7.4% per Gray, with no apparent threshold. The risk starts within 5 years after radiotherapy and continuous up to the third decade after radiotherapy.

The IMRT plans contribute a modestly higher dose to adjacent healthy tissues. The main concern of with the healthy soft tissue dose increases of such magnitude is an increased risk of late secondary malignancy.[21, 22]

Conclusion

The objective of this study was to compare the dosimetric characteristics of IMRT and 3DCRT techniques and to evaluate the characteristics of each modality when applied to the whole breast radiotherapy in the early stage of the breast cancer. The quality of the treatment plan dependence on the many factors, in general, there is an optimum plan for every patient that treats the breast tissue while sparing the organs at risk. However, the technique one may use could vary depending on the patient geometry and technology available in a radiotherapy center such as treatment planning system available, beam energy, TPS algorithm and the skills of the planner as shown by Lu[23], Rana[24], and Pokharel.[25]

IMRT is now considered to be a mature radiotherapy technique and has become a frequently used modality in all most

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all the radiotherapy centers. The MLC-based IMRT technique delivers non-uniform fluences to the patient from any given position of the treatment beam to optimize the composite dose distribution and to spare the adjacent organs at risk.

We infer from this study that treatment technique selection for whole-breast irradiation is an important factor in sparing the adjacent normal structures and in determining the associated risk. 3DCRT reduces the dose to the OARs and increases the heterogeneity index on CMS Xio (4.70.02 version, ELEKTA) treatment planning system. Quantification of dose to OARs may be useful for clinicians as they counsel women with early stage breast cancer about their treatment option Moreover, according to the Sarah CD *et al.* [19] recent study on "Risk of Ischemic Heart Diseases in Women after Radiotherapy for Breast Cancer", the 3DCRT reduces the risk of radiation induced heart diseases by a factor of about 9.62 in right sided breast diseases than IMRT and by a factor of 1.27 in left sided breast diseases.

Conflict of interest

The authors declare that they have no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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