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Original Article

Oncology Section

Evaluation of Doses to Target Volume and Organs at Risk by Conventional versus RTOG Contouring Based 3D Conformal Plans in Breast Cancer: A Prospective Study

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ABSTRACT

Introduction: In radiotherapy, conventional field borders have often little anatomical correlation with the draining lymphatics. So, with the availability of more conformal techniques and delineation guidelines, an evident need exists to optimise our treatment plans with more focus on planning and dosimetric aspects.

Aim: To evaluate the differences in dosimetric parameters to the Organs at Risk (OARs) and target volumes in patients treated with conventional plans vis-à-vis Radiation Therapy Oncology Group contour-guided treatment plans.

Materials and Methods: A prospective interventional study was conducted in which 30 patients of histopathologically proven Infiltrating Ductal Carcinoma (IDC) breast, with age range of 18 to 80 years were enrolled. Patients were treated with 50 Gray in 25 fractions of radiation with additional 10 Gray in 5 fractions boost in Breast Conserving Surgery (BCS) patients by conventional treatment plans. Radiation Therapy Oncology Group (RTOG) guidelines were used for breast/Chest Wall (CW), axillary nodes, Supraclavicular Fossa (SCF), and Internal Mammary Node (IMN) delineation. OARs included heart, Ipsilateral (I/L) lung, Contralateral (C/L) breast, oesophagus and spinal cord. Dose-Volume Histograms (DVHs) for these contours were generated from conventional treatment plans. Further, new treatment plans were generated to cover >90% of Planning Target Volume (PTV) by 90% isodose line. DVH parameters of these two plans were compared using paired t-test. A p-value of <0.05 was considered statistically significant.

Results: Of the total 30 cases, the mean volume of breast/CW PTV covered by 90% isodose line (V90) was better in RTOG plan as compared to Conventional plan (93.39 vs 90.39, p-value=0.001). Similarly, mean V90 for total axilla (97.44 vs 90.39, p-value=0.0001) and combined PTV (92.60 vs 88.81, p-value=0.0001) was better with RTOG plan. For OARs, conventional vs RTOG plans; Dmean for heart was 2.56 vs 2.60 Gy, p-value=0.63), I/L lung V20Gy was 28.77 vs 28.94%, p-value=0.71) and V5Gy for C/L breast was 0.48 vs 0.54%, p-value=0.47), respectively. In cases where IMN was irradiated, mean doses to the heart, I/L lung V20Gy, and contralateral breast V5Gy increased significantly.

Conclusion: The present study showed that RTOG target volumes had inadequate coverage in conventional plans. On the contrary, plans directed at RTOG contours provided statistically better coverage for target volumes without increase in the doses to the OARs. In patients with IMN irradiation, the doses to some OARs were increased in RTOG as compared to conventional plans.

Keywords: Dose-volume histograms, Radiotherapy, Radiation therapy oncology group

INTRODUCTION

Breast cancer is the most common cancer diagnosed among women worldwide and the leading cause of cancer death, with an estimated new cases of 2.3 million, representing 11.7% of all cancer cases in 2020 [1]. Breast/CW radiotherapy forms an important component of adjuvant treatment in the multi-disciplinary management of breast cancer patients. Evidence from large, randomised studies supports the use of Whole Breast Radiotherapy (WBRT) with the boost in Breast Conserving Therapy (BCT) and Postmastectomy Radiotherapy (PMRT) for women with high-risk breast cancer [2,3]. However, there had been controversies in treating regional lymph nodes. Earlier studies suggested that women with ≥4 involved lymph nodes should receive Regional Nodal Irradiation (RNI). However, long term follow-up of these trials has shown a Locoregional Control (LRC) and survival benefit in patients with one to three involved lymph nodes as well [4-6]. This has recently been supported with the publication of several randomised trials. These studies have enumerated an improvement in locoregional Disease-Free Survival (DFS), distant DFS and overall DFS after RNI in all node positive breast cancer patients [7-9]. After Mapping of the Axilla: Radiotherapy or Surgery (AMAROS) trial reported that axillary irradiation provides similar axillary recurrence free and survival outcomes and lower rates of lymphoedema compared to axillary lymph node dissection [10]. Thus, with the growing indications for inclusion of the RNI including axilla, there is a need for better optimisation of nodal target volumes.

Conventional radiation treatment fields for PMRT used in the studies provide excellent oncologic outcomes but can result in heterogeneous dose distribution, as bony landmarks used for field boundaries have often little anatomical relation with the draining lymphatics, with high interobserver and intercentre variability [11]. Also, using bony landmarks as a reference for radiation planning variability may occur in radiation doses to the heart and lung due to anatomical differences, setup errors and organ motion from 2-Dimensional (2D) tangential radiotherapy [12]. Moreover, tangential fields cannot ensure optimal lower axillary nodal coverage because of individual patient anatomy, positioning, collimation and multileaf collimator use. Therefore, contouring of regional nodes is necessary if the low axilla is intended to be included in radiation treatment [13]. Now-a-days, 3-dimensional (3D) Computed Tomography (CT) based planning for breast cancer is evolving and with the advancement of more conformal techniques like 3D-Conformal Radiotherapy (3D-CRT) and Intensity-Modulated Radiation Therapy (IMRT), an evident need exists to optimise the existing delineation guidelines with more focus on planning and dosimetric aspects.

For delineation of target volumes, several contouring guidelines have come up which incorporate soft tissue/vascular anatomy based delineation for breast/CW and individual regional lymph node stations (Axillary, SCF and IMN) and are more conformal to draining lymphatics [14-17]. Out of the available guidelines, RTOG guidelines use soft tissue/muscular landmarks based delineation and are most widely accepted and used. It has been seen that the conventional breast/CW irradiation technique exposes lungs, oesophagus and heart to excessive radiation doses. Some studies suggest that using RTOG guidelines for target delineation may improve dose coverage to regional lymph nodes, breast/CW while decreasing doses to OAR but these studies had limitations like use of electron/photon combination and none of these studies represented Indian population [18,19]. Therefore, the present study aimed to assess the target coverage and doses to OARs in breast cancer patients treated with conventional versus RTOG guideline based targeted planning using 3D-CRT.

MATERIALS AND METHODS

This was a prospective interventional study conducted in the Department of Radiation Oncology at Dr. Ram Manohar Lohia Institute of Medical Sciences, Lucknow, Uttar Pradesh, India, between December 2016 to October 2018. Ethical approval was obtained from the Institutional Ethical Committee (IEC No. 25/16, dated 04.04.2017).

Inclusion criteria: Thirty breast cancer patients of histopathologically proven infiltrating ductal carcinoma breast, with Karnofsky performance status ≥80 and age between 18-80 years including both mastectomy and BCS with an indication for postoperative radiation therapy were included in the present study.

Exclusion criteria: Any histopathology other than IDC was excluded. Patients having a surgical scar reaching the midsternal line or surgical scar extending beyond the mid-axillary line were excluded. Patients having second malignancy, previous chest or neck irradiation, uncontrolled Human Immunodeficiency Virus (HIV), Hepatitis B or C, or those unfit for radiotherapy or unwilling to undergo radiotherapy and pregnant or lactating women were excluded from the study.

Procedure

All patients underwent a free breathing contrast-enhanced CT scan on the breast board in the supine position, with arms abducted and externally rotated and head turned to the opposite side. Radiopaque wires were placed and field borders were defined. In cases of BCS, radiopaque wires were placed encircling breast tissue. Scar sites were marked using radiopaque markers. CT images were acquired with a 3 mm slice thickness from C2 cranially to L2-L3 vertebral interspace caudally. CT images were transferred using Digital Imaging and Communications (DICOM) 3.0 protocol to the Treatment Planning System (TPS) (Monaco Version 5.0) for target and OAR delineation.

Delineation of target volumes and OAR: Treatment targets included the I/L breast/CW, SCF, axillary and IM nodes as per clinical indications and physician's discretion. All the target volumes and OAR's delineation were performed on TPS Monaco version 5.0. OARs were contoured as per RTOG consensus guidelines and included heart, ipsilateral, and contralateral lungs, C/L breast, oesophagus and spinal cord. Target volume delineation was done using RTOG consensus guidelines and Clinical Target Volumes (CTVs) of breast/CW, level I, II, and III axillary nodes, SCF and IMN nodes were delineated [14]. The CTV was then isotropically expanded by 10 mm to yield the PTV, which was then edited 3 mm off the skin surface and was not allowed to extend more than 5 mm beyond the inner surface of the ribs into the ipsilateral lung.

Supraclavicular fossa and axillary irradiation were done in all node positive patients with extensive extracapsular extension, sentinel lymph node positive with no dissection, inadequate axillary dissection, high risk with no dissection, and one to three positive nodes with unfavourable histopathological factors (grade 3 tumours and/or lymphovascular invasion). Out of 30, in 15 patients IMN irradiation was also done (positive axillary lymph nodes with central/medial lesions and pathological N2-3 disease).

Treatment planning was done on Monaco Version 5.0 TPS. The field borders were determined by the treating radiation oncologist and initially conventional anatomical landmarks based planning was done. Planning was done using parallel opposed tangents with a juxta opposed matched SCF field using a mono isocentric technique. Superiorly, the tangential beams were matched to a half beam oblique SCF photon beam. The tangential fields included a maximum of 2-3 cm of lung tissue to cover the breast/CW tissue. IMN was irradiated using wide tangential fields based on the indication. DVHs for the target volumes were generated from conventional treatment plans (Conventional plan). Further, new treatment plans were generated to cover >90% PTV of RTOG target volumes by 90% of the isodose line (RTOG plan). These target volume based plans were made for dosimetric purposes only. DVH parameters studied were: V90 breast/CW, V90 SCF, V90 IMN, V90 axillary level I, II and III nodes, V90 combined axilla, and combined PTV total V90.

All the patients were treated with field borders based 3D-CRT plans (Conventional plans), on a linear accelerator, using megavoltage radiation beams of appropriate energy (6-15 MV). All the treatment plans were modified based on patient and tumour factors and, were approved by a radiation oncologist before treatment. Radiation dose was 50 Gray in 25 fractions in case of Modified Radical Mastectomy (MRM) with an additional 10-16 Gray boost in 5-8 fractions to the lumpectomy cavity in BCS cases by appropriate energy photons. Treatment delivery was assessed biweekly (two times a week) using onboard Electronic Portal Imaging Device (EPID).

STATISTICAL ANALYSIS

In the present study, dosimetric differences in RTOG target volumes coverage and OARs doses were compared between clinical bony landmarks-based conventional plans vis-à-vis RTOG volume directed RTOG plans. Subsequent boost volumes were not considered for this study to keep homogeneity and to reduce bias in results. DVH parameters of the two sets of plans were compared using student's paired t-test. Statistical package for the social sciences software version 20.0 (SPSS Inc, Chicago, IL), was used for all data analyses. All p-values were based on a two-sided hypothesis using paired t-test and p-value <0.05 was considered significant for all statistical analysis.

RESULTS

A total of 30 patients were included in the study, none of them defaulted and all were evaluated for the results. Of total, 23 were postmastectomy patients and seven were post BCS patients. The patient characteristics have been enunciated in [Table/Fig-1].

Initially, coverage of RTOG target volumes were evaluated in conventional bony anatomy/field border based plans and it was seen that RTOG target volumes were not fully covered, So, authors planned these cases again with RTOG contour directed 3D-CRT plans and dosimetric differences in coverage of RTOG target volumes were compared between the two plans [Table/Fig-2]. The mean volume of breast/CW PTV covered by 90% isodose line (V90) was better in the RTOG target volume guided plan as compared to the conventional plan as summarised in [Table/Fig-3].

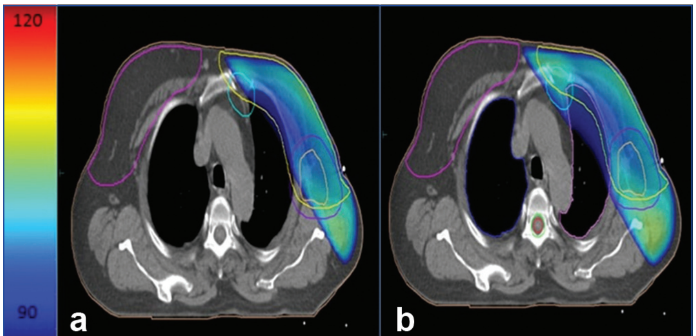
However, the major issue that we usually encounter with the RTOG target volumes is that these volumes are larger and it is assumed that coverage of these volumes may increase the doses to nearby OARs. So, authors also compared the doses to OARs in between conventional and RTOG plans. It was observed that the mean dose to OARs were slightly higher but non significantly different as enunciated in [Table/Fig-4]. In cases where IMN was irradiated, doses to OARs increased significantly in RTOG contour-based plans for heart, ipsilateral lung and contralateral breast [Table/Fig-5].

Variables		N (%)
Median age (range)		48 years (32-70)
Side	Left	18 (60)
	Right	12 (40)
Surgery	Breast conservation surgery	7 (22)
	Modified radical mastectomy	23 (77)
Location of tumour	Outer	20 (67)
	Inner	10 (33)
Stage (Pathological) [20]	IIA	1 (3.3)
	IIB	9 (30)
	IIIA	10 (33.3)
	IIIB	9 (30)
	IIIC	1 (3.3)
Target volumes	Breast/Chest wall+Supraclavicular fossa+Axilla	15 (50)
	Breast/Chest wall+Supraclavicular fossa+Axilla+Internal mammary nodes	15 (50)
Immunohistochemistry status	Triple negative	13 (43)
	ER+/PR+/Her2Neu-	8 (27)
	ER-/PR-/Her2Neu3+	6 (20)
	ER+/PR-/Her2Neu-	1 (3)
	Triple +	2 (7)
Median radiation time	Breast conservation surgery: 42 days	
	Modified radical mastectomy: 35 days	
Median follow-up	36 months	

[Table/Fig-1]: Patient characteristics N=30.

Indices (N=30)	Conventional plan RTOG PTV (%) Mean±SD	RTOG targeted plan RTOG PTV (%) Mean±SD	p-value
Chest wall/Breast V90*	90.39±4.21	93.39±3.31	0.001
Supraclavicular Fossa V90	88.51±8.82	96.02±3.37	0.0001
Internal Mammary Node V90	78.69±20.02	93.62±7.30	0.007
Axilla level I V90	89.35±12.90	97.43±3.92	0.001
Axilla level II V90	91.20±10.34	97.00±5.47	0.001
Axilla level III V90	91.95±10.47	96.94±8.09	0.029
Combined axilla V90	90.39±9.17	97.44±2.92	0.0001
Combined planning target volume V90	88.81±4.54	92.60±3.53	0.0001

[Table/Fig-2]: Mean coverage of target volumes (dose volume histogram parameters).
*Vx refers to the volume of the target volume receiving x% of the dose (i.e., V90 refers to the volume of target receiving 90.0% of the prescription dose); p-value <0.05 was considered statistically significant; RTOG: Radiation therapy oncology group; PTV: Planning target volume



[Table/Fig-3]: a) Chest wall planning target volume (PTV), internal mammary node and axilla are not well covered with 90% isodose line; b) RTOG contour-based plans, these are well covered with 90% isodose line.

Indices (N=30)	Conventional plan	RTOG targeted plan	p-value (Paired-t test)
Heart Dmean (Gy)	2.56±1.31	2.60±1.42	0.63
Heart V5 Gy* (%)	7.08±5.83	7.38±6	0.15
Ipsilateral lung V20 Gy (%)	28.77±6.31	28.94±5.21	0.71
Contralateral breast V5 Gy (%)	0.48±1.22	0.54±1.25	0.47
Spinal cord Dmax (Gy)	37.47±4.13	38.37±4.26	0.17
Oesophagus Dmean (Gy)	7.06±2.43	7.35±2.12	0.25

[Table/Fig-4]: Doses to Organs at Risk (OAR).
*V(x)Gy refers to volume receiving (x) Gray of radiation dose (i.e., V5 Gy refers to volume receiving 5 Gy); RTOG: Radiation therapy oncology group; Dmax: Maximum dose; Dmean: Mean dose

Indices (N=15)	Conventional plan	RTOG targeted plan	p-value
Heart Dmean (Gy)	2.41±1.42	2.79±1.70	0.031
Heart V5 Gy* (%)	7.10±6.83	7.87±7.39	0.05
Ipsilateral lung V20 Gy (%)	30.32±4.30	31.87±3.20	0.041
Contralateral breast V5 Gy (%)	0.47±1.17	0.74±1.28	0.047
Spinal cord Dmax (Gy)	36.25±3.29	37.59±3.56	0.25
Oesophagus Dmean (Gy)	7.06±2.43	7.35±2.12	0.25

[Table/Fig-5]: Doses to Organs At Risk (OAR) with Internal Mammary Node (IMN) irradiation.
*V(x) Gy refers to volume receiving (x) Gray of radiation dose; RTOG: Radiation therapy oncology group; Dmax: Maximum dose; Dmean: Mean dose

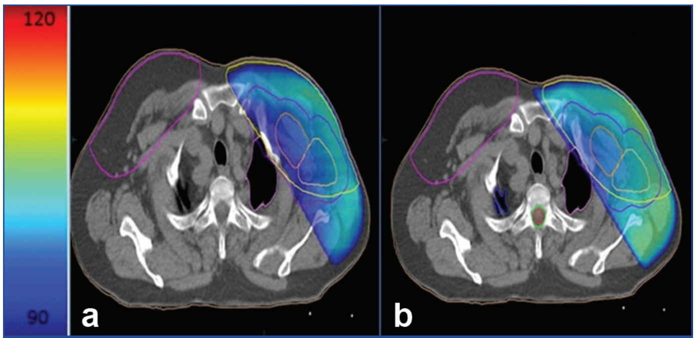
Authors also compared dosimetric differences in OAR doses between left side (18) and right side (12) breast cancer patients. For conventional plans, the mean heart dose was 3.49 Gy for left-sided cases and 1.18Gy for right sided cases. Mean heart V5Gy was 11.19% for left sided cases and 0.91% for right sided cases. While for RTOG contour based plans, the mean heart dose was 3.65 Gy for left sided cases and 1.13 Gy for right sided cases. Mean heart V5 Gy was 11.85% for left sided cases and 0.75% for right sided cases. There was no significant effect of laterality on ipsilateral lung, contralateral breast, spinal cord or oesophagus doses.

DISCUSSION

Breast cancer is the most common cancer of urban Indian women and the second most common in rural women. A study by Leong SPL et al., depicted that about 50-70% of patients diagnosed in India are in stage II-III and about 25% are diagnosed in stage IV [21]. In India, incidence of breast cancer is increasing in the younger population [22]. In the present study, median age of presentation was 48 years. Studies depicted that younger age has been associated with larger tumour size, a higher number of metastatic lymph nodes, poorer tumour grade, lower rates of hormone receptor positive status, earlier and more frequent locoregional recurrences and poorer overall survival [23,24]. Since most patients in India present at a younger age, so breast tumour tends to be more aggressive with higher stage and grade at presentation and increased nodal involvement. This also emphasises the need for a contouring guideline that provides better nodal and target coverage and incorporates the areas at risk adequately.

A practical review from the Transatlantic Radiation Oncology Network (TRONE), for evaluation of locoregional relapse patterns by comparing the various contouring guidelines suggested that the RTOG atlas may more adequately cover the areas at risk for patients with locally advanced disease, or patients with high risk features such as T3/T4 tumours, extracapsular extension, lymphovascular invasion, multiple positive nodes and triple negative disease [25]. But, as the RTOG target volumes are larger, it is assumed that using RTOG guidelines for radiation planning may lead to an increase in doses to the surrounding OAR. So, here in the present study authors prospectively evaluated the target volume coverage and OAR doses in these RTOG contours guided treatment plans compared to conventional plans.

In the present study, all patients had node positive disease (about 66% in stage III and 34% in stage II) and all patients received breast/CW, SCF and axillary irradiation based on indications and in about 50% cases IMN irradiation was also done. Results showed that coverage of RTOG volumes in conventional plans was inadequate, while 3D-CRT plans directed at RTOG contours provide significantly improved coverage for RTOG target volumes. Inadequate coverage of RTOG volumes in conventional plans is attributed to the lack of coverage at the contoured CW/breast-CW interface and posterior/deeper portions of axillary nodal areas and these could be potential sites of locoregional recurrences [Table/Fig-6] [25]. So, in Locally Advanced Breast Cancer (LABC) patients RTOG guidelines should be used preferably with case-to-case modifications.



[Table/Fig-6]: a) Rib-chest wall interface is underdosed with sparing of posterior and deeper part axilla by 90% isodose line in the conventional plan; b) Radiation therapy oncology group directed plans are well covered with 90% isodose line.

A similar study by Fontanilla HP et al., also supported the hypothesis that using RTOG guidelines for target delineation and planning may improve dose coverage to regional lymph nodes, breast and CW. Treatment plans were generated based on clinical landmarks as well as RTOG target volumes in the same 20 patients. Target volume coverage in this study was comparable to the present study results. One major difference appreciated was doses to IMN; V45 Gy was 80% vs 85% in the above study as compared to V90 IMN 78.69% vs 93.62% in the present study. This difference could probably be due to different dosimetry of electrons in their study. In this study improvement was seen in coverage in target volume based plan, although doses to the heart and lungs increased significantly [18]. However, in the present study doses to the OARs were comparable in both the arms, possibly because the authors' focus was on minimising dose to the OARs by evaluating slice by slice coverage while ensuring coverage of RTOG volumes.

A similar study by Rudra S et al., also evaluated the effect of RTOG guidelines on dosimetric parameters. In RTOG contour based plans, coverage improved significantly for SCF with V95 of 78.0% vs 93.6% and intact breast V95 was 95.6% vs 99.3%. Doses to the spinal cord, lung and C/L breast were not different [19]. However, one major drawback of their study was comparing dosimetric coverage in two different groups of patients, which may itself lead to differences in dose to target volumes and OARs, owing to different patient anatomy and position. Details of the literature review are given in [Table/Fig-7] [18,19].

It was seen that rates of major coronary events increased linearly with the mean dose to the heart by 7.4% per Gray [26]. In the present study, authors tried to keep the mean heart dose below 5 Gy for left sided cases and below 2.5 Gy for right side cases, with the help of multileaf collimators and ensured slice by slice coverage for both target volumes and OARs. No significant difference was observed in heart volume receiving 5 Gy, 10 Gy, 20 Gy, or mean dose to the heart. An increase in Dmean heart was seen only in cases of IMN irradiation especially in left sided cases, where Dmean heart was 3.61 vs 4.24 Gy, (p-value=0.028).

A study by Goldman UB et al., suggest that minimising dose to the ipsilateral lung to V20 <30% significantly reduced postradiotherapy radiological changes on chest X-ray or CT scan of the breast cancer patients receiving locoregional RT [27]. With 3D-CRT planning and an ipsilateral lung dose-volume constraint of V20 ≤30%, the rates of radiation pneumonitis can be reduced [28]. In the present study, there was no significant difference in I/L lung receiving 20 Gy or 30 Gy in between conventional or RTOG plan. However, in cases where IMN was irradiated, V20 Gy of ipsilateral lung was increased 30.32 vs 31.87%, (p-value=0.041). So, it was observed that in cases where IMN was irradiated, doses to OARs increased significantly in RTOG plans. The reason for the increase in OARs doses could be the wide tangential fields used to cover the RTOG IMN volumes. So, we need to be a bit cautious while irradiating IMN by using RTOG guidelines and need to keep a check on the OARs doses in such scenarios by ensuring the slice-by-slice coverage and respecting the constraints to OARs.

While this dosimetric study supports, that the RTOG guidelines can be implemented safely with some modifications on case-to-case basis. It is unclear whether, using these guidelines will improve oncologic outcomes. Long term follow-up data of patients treated with RTOG contouring based plans would be more confirmatory.

Study	Fontanilla HP et al., [18] (Prospective series)	Rudra S et al., [19] (Prospective study)	Current study (Prospective study)
Content	Comparison of conventional plans with RTOG contour based plans	Dosimetric comparison of clinically derived and RTOG target volume based plans.	Dosimetric comparison of Conventional vs RTOG target volume guided plans.
Patients in the study	20 patients in both arms	14 patients in each arm	30 patients in each arm
Target volume in Conventional Vs RTOG contour based plans	V90 i.e., V45 Gy for Chest Wall (CW) 74 versus 94% Axilla level I 84 vs 95% Axilla level II 88 vs 97% Axilla level III 96 vs 98% Supraclavicular Fossa (SCF) 84 vs 98% Internal Mammary Node (IMN) 80 vs 85%	V95 for Breast/CW 95.6 vs 99.3% SCF 78 vs 93.6%	Volume covered by 90% isodose line i.e., V90 for Breast/CW 90.39 vs 93.39% Axilla level I 89.35 vs 97.43% Axilla level II 91.20 vs 97% Axilla level III 91.95 vs 96.94% SCF 88.51 vs 96.02% IMN 78.69 vs 93.62% Combined PTV 88.81 vs 92.60
Organs at risk in Conventional Vs RTOG plans	**Heart V10 Gyfor** Left sided tumour 11 vs 14% Right sided tumour 6 vs 12% **Ipsilateral Lung V20 Gy for** Left-sided 28 vs 32% Right-sided 34 vs 45%	Heart V5 Gy 48.7 vs 27.3% Heart V10 Gy 33.5 vs17.5% Ipsilateral Lung V5Gy 84.5 vs 69.3%	Heart Dmean 2.56 vs 2.60 Heart V5 Gy 7.08 vs 7.38 Ipsilateral Lung V20 Gy 28.77 vs 28.94% Contralateral Breast V5Gy 0.48 vs 0.54 % **For left-sided tumour** Heart Dmean 3.49 vs 3.65 Gy Heart V5 Gy 11.19 vs 11.85 % **For right-sided tumour** Heart Dmean 1.18 vs 1.13 Gy Heart V5 Gy 0.91 vs 0.75% If IMN irradiated, Heart, lung and contralateral breast dose increased significantly
Outcome	Coverage improved for RTOG contoured plans with slight increase in dose to heart and ipsilateral lung.	Coverage improved for RTOG target volume based plans with no increase in dose to heart, ipsilateral lung or contralateral breast.	Coverage improved for RTOG target volume guided plans with non significant increase in dose to heart, ipsilateral lung or contralateral breast, except in cases with IMN irradiation.
Drawback	Mean Dose to heart, contralateral breast dose not commented. IMN treatment by electron in all patients, so dosimetry not comparable	Doses to axilla level I, II, III not evaluated, IMN dose evaluation not done	Limited patient number.

[Table/Fig-7]: Comparison of present study with previous literature [18,19].
RTOG: Radiation therapy oncology group

Limitation(s)

The limitations of the present study are small sample size and short follow-up period. RTOG plans were used for dosimetric purpose only, so its impact on clinical setting is not clear.

CONCLUSION(S)

Radiation therapy oncology group based target volumes had inadequate coverage in conventional field border based plans. On the contrary, 3D-CRT plans directed at RTOG contours provided statistically significant better coverage for target volumes with a non significant increase in dose to the OARs, except in some case scenarios, where, IMN irradiation was done wherein dose to heart, lung and contralateral breast increased significantly. Although, the present study patients were treated with conventional plans, authors did not notice any locoregional recurrence, even after a median follow-up of 36 months. Studies with larger sample size and long term follow-up are required to validate the dosimetric advantage of RTOG contour-based plans over conventional field border based plans in the clinical setting.

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