

# Mono-Isocentric Technique in the Breast Cancer and Organ at Risk Tolerance

Assaoui F<sup>1\*</sup>, Toulba A<sup>2\*</sup>, Nouh M<sup>2</sup>, Lkhouyaali S<sup>2</sup>, Bensouda Y<sup>2</sup>, Kebdani T<sup>2</sup> and Benjaafar N<sup>2</sup>

<sup>1</sup>Medical Physics Unit, Radiotherapy Department, National Institute of Oncology, Rabat, Morocco

<sup>2</sup>Department of Radiation Oncology, National Institute of Oncology, Rabat, Morocco

## Abstract

**Purpose:** To investigate the impact of the single-isocentre technique on the volumetric dose of lung and heart for adjuvant radiation in breast cancer with regional nodal.

**Methods and materials:** Thirty patients treated for breast cancer with supraclavicular fossa irradiation; two techniques of treatment TMT (Traditional Matching Technique) and MIT (Mono-Isocentric Technique) are compared, TMT (tangents in SAD and supraclavicular (SCL) in SSD: Source Skin Distance) and MIT (the all fields in SAD: Source Axis Distance) (Chart 1). Techniques were compared according to dose volume histograms (DVHs) analysis in terms of PTV homogeneity and as OARs (Organs at Risk) dose and volume parameters.

**Results:** The dose distribution in PTV is similar in the both techniques TMT and MIT but with hot spots in the junction of the three fields for the TMT (average 120% for TMT and 110% for MIT). The analysis of DVHs shows a decrease in the mean OARs. Lung and heart dose is improved using the MIT and with significant difference in the V20 and V30 for the lung and in the V10 and V40 for the heart.

**Conclusions:** The results of our study demonstrated that the target volumes were sufficiently irradiated with the MIT and the lung and heart volumes irradiated were small. Furthermore, it should not be over or under dose in the supraclavicular and tangential junction.

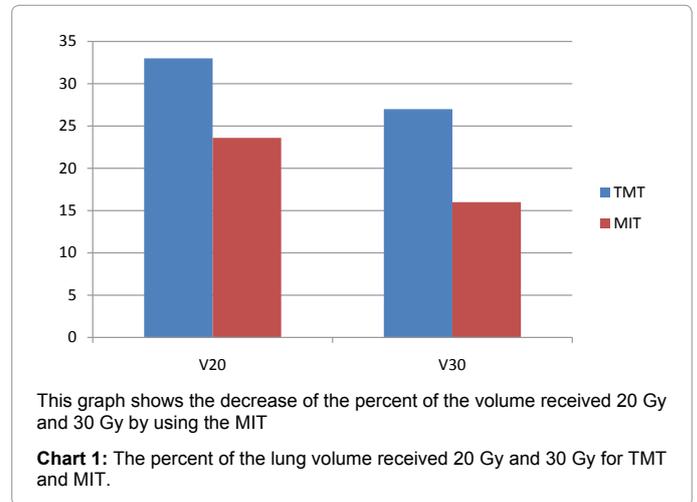
**Keywords:** Breast cancer; Supraclavicular; 3-D conformal radiation therapy; Mono-isocentric technique

## Introduction

Breast cancer will afflict 1 of every 9 women [1]. Improvements in local control with locoregional radiotherapy after surgery for breast cancer in patients at risk for locoregional recurrence have been demonstrated in randomized trials, showed that the 10 years locoregional recurrence rate was 13% in patients with 1 to 3 positive axillary lymph nodes, 29% in patients with at least 4 positive nodes and in breast conservation management [2,3]. However, survival benefits were not demonstrated until recently [4,5]. It is postulated that no increase in survival was seen in the earlier trials secondary to excessive myocardial doses, especially with left-sided breast cancers and internal mammary chain (IMC) irradiation [6,7]. A report from Canada described a 2% incidence of fatal cardiac toxicity for left side breast radiation and 1% from right side radiation [8]. Additionally, as much as 9% of irradiated breast cancer patients suffer from radiation-induced lung sequelae [6,9].

The radiation mortality and morbidity are technique- and dose-volume dependent. Optimized radiation treatment planning plays a critical role in the care of breast cancer patients. Dosimetry planning in breast carcinoma has evolved from evaluation of dose distribution in a single plane (i.e., 2 dimensional [2D] planning) to CT-based 3-dimensional radiotherapy (3DCRT) planning, to intensity modulated radiotherapy (IMRT) [10,11]. The conventional tangential technique uses proper selection of wedge and beam angle based on a single central axis isodose distribution. Although high local control can be achieved, it results in large hot spots, dose non-uniformities and excessive exposure of normal tissue [12,13]. 3-D conformal radiation therapy (3D CRT) and intensity-modulated radiation therapy (IMRT), treatment planning and delivery improved greatly. Many planning studies have shown that 3D CRT is superior to CR [14,15].

The international “Gold Standard” radiotherapy fractionation remains 50 Gy in 1.8-2.0 Gy per fraction, with or without a boost.



**\*Corresponding authors:** Fatima Assaoui, Medical Physics Unit, Radiotherapy Department, National Institute of Oncology, Rabat, Morocco, E-mail: [Assaoui2003@yahoo.fr](mailto:Assaoui2003@yahoo.fr)

Ahmedou Toulba, Department of Radiation Oncology, National Institute of Oncology, Rabat, Morocco, E-mail: [Ahmedoux@gmail.com](mailto:Ahmedoux@gmail.com)

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However, recent data suggest that hypofractionated regimes may provide a viable alternative to this standard approach. These results potentially offer treatment with similar clinical outcomes but with clear potential benefits in terms of cost savings for both radiotherapy departments and patients [16,17].

The purpose of this study was to evaluate the advantages of the single-isocentre technique for adjuvant radiation in breast cancer with regional nodal by analyzing the difference in dose uniformity, planning target volume (PTV) coverage, exposure of organs at risk (OAR).

## Material and Methods

Data of thirty left and right sided breast cancer patients with supraclavicular irradiation, 8 of them had breast conserving therapy and 22 Radical mastectomy, were retrospectively included in this study. The median age was 43 (range 25 years – 64 years). We used accelerated radiotherapy over a shortened time period. All patients were administered 15 fractions of 2.8 Gy (total dose 42 Gy). An additional dose 11.2 Gy (the so called boost) was applied to the post-tumorectomy site in the 8 patients.

In all cases the CT-X ray simulation (Siemens Simulator Scanner 16 barrettes and FOV of 82 cm) was used. The patients are placed supine in a halfbody Vac-lok bag on the scanner table and the both arms placed above the head which is tilted backwards and rotating to the contralateral side. Three fiducial markers are placed in anatomically stable regions, one anterior as reference for the isocenter and two lateral points to assure identical positioning of the patient (laser beams) during computed tomography and irradiation. The scans extended from the supraclavicular region to the most caudal part of the lungs with a 5 mm slice separation. For our study, the treatment fields for the both techniques: traditional matching technique (TMT) and mono isocentric technique (MIT) were defined by using the CT data for all patients.

After the scans have been acquired they are transferred over the network to the treatment planning system and a treatment plan is generated. Treatment planning was performed using the treatment planning system XIO version 4.6. The doses are calculated using heterogeneity corrections and the beams are weighted so that the prescription isodose line encircles most of the PTV.

The contouring of the target volumes, lung and heart were defined in the Focal System using the CT data.

In our department the treatment planning was performed by the Physicist and consisted of setting the beams entries angles, the field's sizes, the shields shapes, the isocenter position and wedge angle in order to provide them maximally homogenous dose within the PTV. Dose to volume histograms, were applied for both techniques in order to assess the homogeneity of the doses and for the choice of isodose distribution.

## Traditional matching technique treatment plan

The fields were set-up on the treatment planning system using the radio opaque markers visible in the CT-slices and the treatment parameters recorded on the patient treatment chart. An anterior photon field (SSD=100 cm, Energy 6 MV), generated by Clinac Elekta, is used to irradiate the medial lymph nodes which is rotated by 10 degrees in order to avoid the spinal cord and the esophagus. Furthermore, one block was drawn to protect the larynx. Two tangential photon (6 MV) fields (SAD i.e SSD<100 cm) are used to irradiate the breast, that there is at 2 cm of the flash above the breast parenchyma and the dorsal edges

are made coplanar to decrease the amount of the lung tissue irradiated, no more than 2-3 cm of the lung are included in the treatment field. The three fields (tangential and supraclavicular) are traditional matching then over and under doses in the junction, using collimator and wedge.

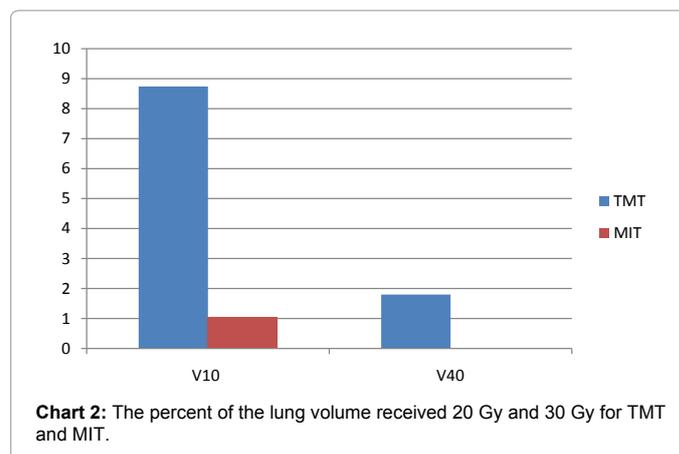
## Mono isocentric technique treatment plan

Marking of the isocenter was the first of planning by using the X-ray simulation. The horizontal line crossing this point formed the border between the supraclavicular and the asymmetric tangential fields. The three photon 6 MV fields (supraclavicular and tangential) were on SAD depending on the position of the isocenter; the collimator angle was always 0 degree because a breast board was used.

The anterior field, irradiated with the upper quarter of the beam, encompassed the supraclavicular. The gantry was rotated laterally by 10 degrees in order to avoid the spinal cord and the esophagus. And one block to shield the larynx was placed. The breast was irradiated from two tangential fields (lower quarter beam) and lower border of the treatment area was positioned 2 cm below the sub mammary position. The gantry varied from patient to other in order to cover all the PTV and to exclude the contralateral breast. The organs at risk lung and heart were maximally shielded with MLC. When the plan of treatment was accepted the next step was to perform it on the Clinac Elekta. The patient was placed in the same position as on the scanner simulator and during the computed tomography, using the pre-tattooed points and the laser beams. We use the shifts that were determined at the time of virtual simulation to move the patient to the intended beam isocenter and the AP and lateral SSDs for the beam isocenter are verified. The isocenter was found and marked on the patient's skin at the junction regions of the superclavicular field and mammary field. Portal images (PI) were made for all patients when a new course of treatment was begun and then one time after 6 fractions.

## Data analysis and statistical study

Dose-volume histograms (DVHs) were computed for the breast and the regional nodal target volumes and the organs at risk (lung and heart). For the target volumes the over doses of the reference dose were compared between the TMT and MIT. The mean doses of the lung and the heart were also compared between both the techniques. The fraction of the lung volume receiving 20 Gy–30 Gy were computed and compared between TMT and MIT by using the test of student method (the value p is significant  $p \leq 0.05$ ) (Chart 2). The volume of the heart receiving 10 Gy and 40 Gy were computed and compared for TMT and MIT. We have chosen 10 Gy to show that there is distinct difference



between the two techniques in this dose region. The volume receiving a dose of 40 Gy or more represents the high dose volume.

## Results

The dose distribution in the breast is similar in the both techniques TMT and MIT (Figure 1).

The DVHs of the target volumes breast and supraclavicular did not differ much between patients and no significant difference exists between the dose coverage of the breast using the TMT and the MIT (Figure 2).

The average of the hot spots 120% is present in the TMT in the junction of the supraclavicular field and the tangential fields. With the mono isocentric technique the maxima of the hot spots in the junction of the three fields is 110% and in the range 110-115% in the breast, then the target coverage is improved (Table 1).

## Organs at risk

For the DVHs of the organs at risk lung and heart, the difference between the TMT and the MIT is significant. An average DVHs of these volumes is representative for the all patients in the both techniques (Figure 3).

## Lung

An increase in the mean lung dose is improved using the MIT (Table 2).

The mean lung dose was on average 10.93 Gy (range: 7.8 Gy - 16.5 Gy) and 8.24 Gy (range: 4.47 Gy -12.05 Gy) for the TMT and MIT, respectively.

We also analysed the mean percents of the lung volumes receiving 20 Gy (i.e V20) and 30 Gy (V30) for each patient with the both techniques (Table 3).

The difference between the TMT and the MIT is statistically significant for mean dose, V20 and V30 regardless of the surgical treatment.

## Heart

The heart receives fewer doses using the MIT (Table 4).

The percents of the heart volumes receiving at least 10 Gy and 40 Gy were analyzed.

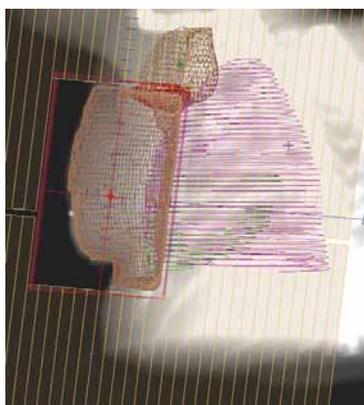


Figure 1: Dose distributions for TMT in DRRs.

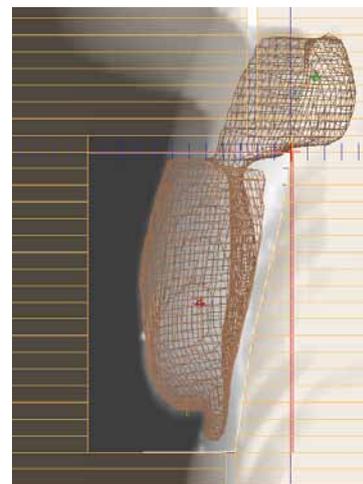


Figure 2: Dose distributions for MIT in DRRs.

Patient	MAXIMUM DOSE IN THE JUNCTION (Gy)	
	TMT	MIT
1	479	441
2	55.3	45.4
3	52.3	45.6
4	52.3	47
5	53.6	44
6	54.7	48
7	53.4	46.3
8	49.4	45.4
9	53.1	44.2
10	54.4	47.2
11	52	43
12	55	47
13	54	43
14	48.5	44.5
15	52	45
16	49	43
17	49	43
18	53	47
19	52.3	46.2
20	51.8	46.8
21	49.6	40.7
22	54	49
23	52	47
24	56	45
25	50.3	49
26	46.6	44.1
27	54.4	49
28	52.4	44.4
29	51.2	46.9
30	54.5	47.1
<b>Mean</b>	<b>52.1333333</b>	<b>45.5966667</b>

Table 1: Dose in the Supraclavicular and Tangential Fields Junction for the TMT and MIT.

The patients with the left breast cancer, heart volume are receiving a dose of 40 Gy was on average 1.8% (range: 0% - 4.8 %) and 0% for the TMT and MIT, respectively. For a dose of 10 Gy these figures are average 8.7 % (range: 1.26%-16.2 %) and 1.04 % (range: 0%-7.2%).

The mean percents using the MIT are inferior to the TMT and significant for V10 and V40 (Table 5).

On the other hand, the work load and time necessary for treatment planning using the MIT was greater than in the planning of the TMT. However, the irradiation time necessary for the application of one fraction was shorter in the MIT, as there was no need to reposition the therapeutic table then to minimise the set-up errors and all these increase the reproducibility.

### Discussion

In some clinical situations breast or chest wall radiotherapy with

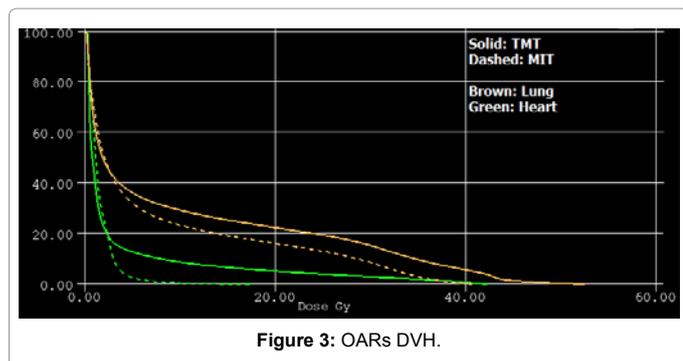


Figure 3: OARs DVH.

	TMT	MIT	P value
V20 (mean)	33%	23%	<0.05
V30 (mean)	27%	16%	<0.05

Table 2: Lung comparison between V20 and V30 in both techniques.

	PATIENTS	MEAN LUNG DOSE (GY) TMT	MIT
BREAST CONSERVING	1	9.6	7.39
	2	10.73	8.39
	3	10	8.6
	4	9.8	7.5
	5	9.68	5.97
	6	7.8	4.47
	7	10.58	6.34
	8	10.97	7.42
RADICAL MASTECTOMY	9	10.47	7.43
	10	10.32	8.66
	11	9.57	6.1
	12	7.76	5.78
	13	10.6	6.94
	14	14.33	12.66
	15	16.41	10.29
	16	10.12	6.61
	17	14.7	10.19
	18	13.72	8.59
	19	11.21	10.17
	20	9.54	11.07
	21	10.2	7.84
	22	9.93	6.1
	23	10.58	7.85
	24	8.36	6.64
	25	10.11	8.39
	26	10.52	8.8
	27	11.91	10.7
	28	11.29	9.52
	29	10.78	8.88
	30	16.57	12.05

Table 3: The Lung's Mean Doses of the all Patients on Function of the Both Techniques TMT and MIT.

Patients	V10 TMT (%)	V10 MIT (%)	V40 TMT (%)	V40 MIT (%)
1	1.2	0	0	0
2	8.4	0	0	0
3	1.3	0	0	0
4	2	0	0	0
5	11.4	0	2.4	0
6	8.4	1.2	1.2	0
7	12	1.2	3.6	0
8	7	1.2	0	0
9	15.6	7.2	2.4	0
10	1.2	0	0	0
11	9.6	1.2	3.6	0
12	16.2	0	4.8	0
13	14.4	2.4	4.2	0
14	12.8	1.2	3.6	0
15	9.6	0	1.2	0
Mean	8.74	1.04	1.8	0

Table 4: Mean heart dose for the TMT and the MIT for patient with left-sided breast cancer.

	TMT	MIT	P value
V10 (mean)	8.74%	1.8%	<0.05
V40 (mean)	1.04%	0%	<0.05

Table 5: Heart comparison between V10 and V20 in both techniques.

supraclavicular irradiation is used to improve local control. Often the treatment is delivered by two tangential fields to the breast or chest wall and an anterior field that irradiates the supraclavicular region. The tissue between the breast or chest wall and the supraclavicular region may be under or overdosed, because of the junction between the two tangential fields and the anterior field, therefore there was an increase of toxicity or tumor control probability reduced [18,19].

An important factor affecting the complication rate is the radiation technique. Many ways have been reported including matching fields using shielding blocks, multi leaf collimators (MLC) or independent asymmetric jaws to irradiate the target volumes i.e., breast and regional nodal and to minimize the dose in the organs at risk [20-22].

Previous studies have reported that the wedged tangential field technique has dose nonuniformity of around 15–20% in the superior and inferior regions of the breast [23,24]. In addition, the medial and lateral aspects of the breast may also be exposed to higher doses of radiation because of lower attenuation of lung tissue in the treatment field [14, 25]. Furthermore, because the breast is close to critical organs lungs and the heart, it is not easy to attain homogeneous dose distribution using the wedged tangential field technique. Therefore, various radiation therapy methods were studied to solve these problems [23,26].

In our study, the analysis of the TMT and MIT results show that with one isocenter for all the fields and with the MLC the dose in organs at risk is lower, for example 1.8% of the heart volume received 10 Gy and V40 on 0%, without affecting the local control, the target volumes received at least 95% of the prescription. From the statistical study of this work we deduced that the decrease of the dose in OAR is very important. The increase of the dose in the lung is due to a large part of the lung being irradiated in the TMT and the part which receives a high dose due to the tangential fields is usually smaller for the MIT. We also deduced that DVH of the supraclavicular and OAR vary considerably between the patients due to their different anatomy and body outline not just between the techniques.

Several studies showed that the mono isocentric technique in the breast cancer, the reproducibility of positioning is simple and precise then the time consuming of everyday therapeutic sessions decrease while the work load of the treatment plan increase [27-29].

## Conclusion

The mono isocentric technique decreases the dose in organs at risk, lung and heart, and allows the avoidance of the cold and the hot spots. The reduction of the execution time of the daily workload Linac was achieved. The reproducibility of positioning is precise and simple.

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