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A comparison of dose distribution parameters between conventional and mono isocentric methods of breast irradiation in phantom by gafchromic EBT2 films

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ABSTRACT

Background: This study was set to determine the optimal technique of breast cancer with supraclavicular fossa irradiation.

Methods: Three techniques were compared in this study. Techniques were two point symmetric (2p-sym), two point asymmetric (2p-asym) and single point (SP). In 2p-sym all of beams were symmetric, in 2p-asym Tangential and supraclavicular beams respectively were symmetric and asymmetric, in SP all of beams were asymmetric. In this study has been done dosimetry by gafchromic films in phantom with compact accelerator. Techniques were analyzed by DVHs treatment's volumes and organ at risk (OAR) volumes.

Results: There are no notable differences between dose distributions in three techniques but hot spot in the junction of treatment's beams in single point (SP) technique was 115% and 118% for other techniques. The analysis of DVHs showed a decrease in OAR's doses with SP technique. There was a significant difference of V20%, V20, V30 for lungs and V10, V40 for heart in SP technique compared to other techniques. The profiles of dose that obtained from films showed a gap in matchline, while matchline's dose distribution in software was right and there was no gap.

Discussion: Observed gap in gafchromic films was created because of mechanical limitations in accelerators. Correction methods for this limitation were offered in many articles.

Conclusion: SP technique is optimal technique compared to other techniques if correction methods are done. It seems that Iranian radiotherapy clinics don't pay attention to this correction methods.

Keywords: ***Breast cancer, Mono Isocentric, Phantom, gafchromic EBT2.***

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Introduction

Breast cancer is one of the biggest causes of death in women worldwide. In 2014, National Cancer Institute of America has estimated the number of new patients who suffer from breast cancer 232,231 women and 2321 in the United States of America. Although the spread of breast cancer in Iran is one quarter to one fifth of the western countries but Iran has the highest growth of breast cancer in the world. In addition to the age of affecting breast cancer in Iran is lower 10 years than developed countries. So it is appropriate to consider great treatment for breast cancer. There are different therapies for the treatment of breast cancer.[1, 2] One of the most important therapies is radiotherapy .In 1979 a report was presented that a series of reactions in the skin and muscle function observed in significant number of patients treated using the two-dimensional due to fibrosis in the matchline of tangential and supraclavicular fields . Because in this method tangential and supraclavicular fields match on the skin and due to divergence of beams, tangential and supraclavicular fields overlap on the depth. Studies have shown that organs receive more than 200% of the prescribed dose in an area with 8 mm width and in depth of 3 cm.[3] In 1980 a modified technique was presented that was single point .in this technique by using of lead blocks the bottom edge of supraclavicular beam was matched on the upper edge of tangential fields. With this technique the amount of overlap of beams decreased.[4] Over time, various other methods for setting this technique presented by others that was caused better dose distribution in the matchline of fields and easier setting.[5, 6] Over time with progress of technology and the use of CT images, treatment planner could do their jobs much easier than before. Because they can calculate absorbed dose in organs at risk and treatment planning volumes easily and using three-dimensional treatment planning software could design best treatment plan with minimum absorbed dose to normal tissues while delivering a sufficient dose to the tumor with homogeneous dose distribution.[7] Always matchline's dose distribution and absorbed doses of lung and heart in patients with breast cancer has been discussed. Many studies have been done in this ground and many techniques have been compared.[8-14] The purpose of this study is to evaluate the conventional therapeutic techniques in Iran clinics by analysis of dose distribution and coverage rate of treatment planning and organ at risk volumes. Studied techniques in this research are two point symmetric and two point asymmetric and single point.

Materials and Methods

The phantom witch we used in this study was made of Perspex layers. To simulate of lung and heart respectively has been used cork and red Perspex layers. In **Figure (1)** can be seen image of this phantom.

In this phantom is embedded tracks with 6.7cm width in right side of phantom for obtaining dose in junction of tangential and supraclavicular fields that films placed in the tracks as performing treatment techniques. In order to compare observed dose of the heart in the various treatment techniques films were placed horizontally in layers on left side of the phantom. The films used in the right tracks and the left side respectively have the dimensions of 6.7 * 12.5cm and 10 * 12.5cm.

After attaching markers on the phantom, CT images taken at Supine position. To simulate treatment plans, CT images were transferred to the treatment planning software. Treatment planning performed using the RTDOSEPLAN software. In drawing treatment volume consists of the breast tissue , supraclavicular lymph nodes , internal mammary lymph nodes , axillary lymph node level 1 , axillary lymph node level 2 , axillary lymph node level 3 and heart and lung volumes as organs at risk used recommendations of Radiation Therapy Oncology Group and results of the study in the field of estimating of the approximate depth in the supra and axillary lymph

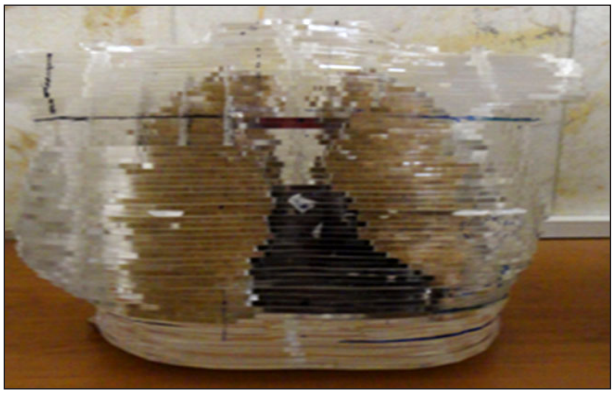

Figure (1): Image of phantom

nodes. In the absence of osseous marker, it cannot be used in drawing lymph node volumes.[15] After drawing the mentioned volumes, the treatment techniques that blew explained, designed with the software. The best treatment planning performed by using these software tools such as setting the beams entries angles, the isocentric position, the size of fields, the shields shapes , wedge angle and different weights applied to the beam in order to provide maximum homogenous dose distribution in the treatment volumes. For being comparable treatment techniques defined two points for dosimetry in the software, one point for tangential fields and other point for supraclavicular field. In definition of these point was taken enough care until had the best coverage in treatment planning and didn't existed hot spots in the area. In all of the treatment planning when defining the supraclavicular field gantry rotated 9 degrees to emit the spine from the radiation field, Dose To Volume Histogram were applied for both techniques in order to assess the homogeneity of the doses and for the choice of isodose.

Two point symmetric technique

In this technique tangential and supraclavicular fields are defined as symmetric .For having an optimum matching of fields used rotating of couch and collimator. In this technique we have two isocenter. One isocenter defined for tangential fields in center of breast and other isocenter defined for supraclavicular field in 3 cm under the skin. In **Figure (2)** can be seen image of this technique.

Two point asymmetric technique

In this technique tangential and supraclavicular fields respectively are defined as symmetric and asymmetric .For having an Optimum matching of fields used rotating of couch and collimator. In this technique we have two isocenter. One isocenter defined for tangential fields in center of breast and other isocenter defined for supraclavicular field in 3 cm under the skin. In **Figure (3)** can be seen image of this technique.

Single Point Technique

In this technique tangential and supraclavicular fields are defined as asymmetric and we have one isocenter. This isocenter defined on the first rib and 3 cm under the skin. In this technique most of the lune was affected by radiation .Because collimator and couch not to be rotated and so the lung was shielded. In **Figure (4)** can be seen image of this technique.

After treatment planning, while the films were placed on specified places in phantom, treatment planning were performed on the left and right side of phantom. The films were scanned with MICROTEK 9800 XL scanner and were analyzed with ImageJ software.

One goal of this study was to compare obtained data

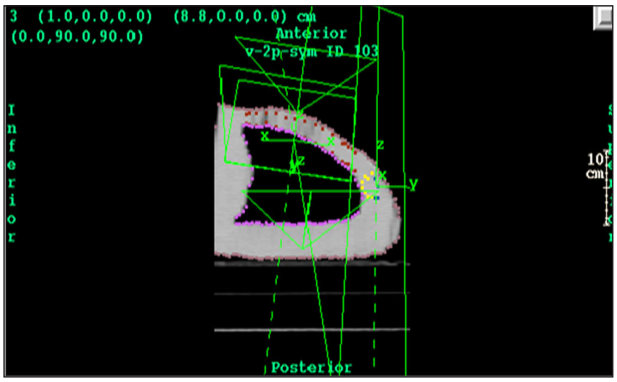

Figure (2): Image of two point symmetric technique

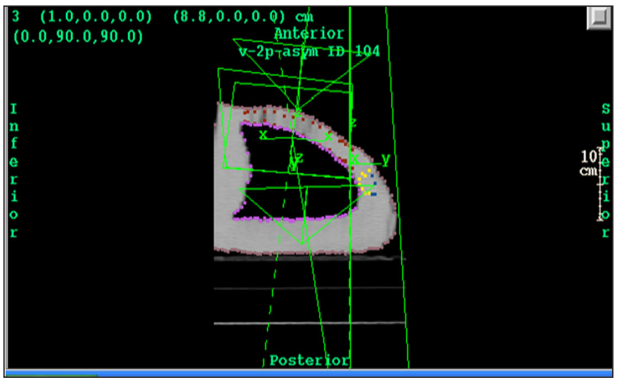

Figure (3): Image of two point asymmetric technique

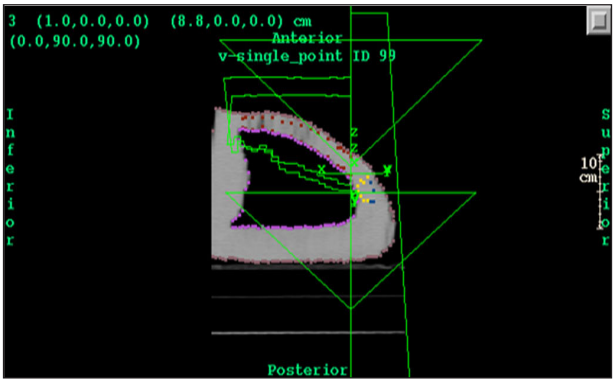

Figure (4): Image of single point technique

from the dosimetry with Treatment planning software. For this purpose, four point were defined in lung on the CT images of phantom. This point were defined in various cut and 6 cm under the skin. At about heart, there is no possibility of comparison dosimetry data with software data and only there is possibility of comparison dosimetry data and software data separately in all of techniques. Because we couldn't find exact location of films in the software. It should be mentioned that dosimetry was performed three times with compact accelerator.

Result

In the obtained profiles of matchline region by the ImageJ software have been seen a decrease in dose severely. In **Figure (5)** and **(6)** respectively can be seen image an example of obtained film and profile from compact accelerator in the phantom's surface. In **figure (5)** could be seen obviously a gap between treatment's fields.

The amounts of gap and inhomogeneity of dose distribution on the surface and 3 cm under the surface of phantom could be seen in **table (1)**.

For comparison of dose distribution between techniques V90% and V95% treatment's volumes were compared that in it Vx% is the percent of the volume received x% of the prescribed dose. There are no notable differences between dose distributions in three techniques but hot spot in the junction of treatment's beams in single point (SP) technique was 115% and 118% for other techniques. In **table (2)** can be seen V90% and V95% treatment's volumes.

In this study for comparison of lung dose V20% and V20 and V30 and for heart V10 and V40 were compared that in it Vx is the percent of the volume received x Gy during the treatment. In single point technique lung dose and heart dose have obvious reduction compared to other techniques. according to the results, V20% and V20 and V30 in 2p-asym compared to 2p-sym , respectively, show reduction as 6.2% , 7.5% and 3.8% and in SP technique compared to 2p-asym, respectively , reduction as 40% ,47% and 56%.V10 and V40 in 2p-asym compared to 2p-sym , respectively, show reduction as 0.6% and 1.8% and in SP technique compared to 2p-asym, respectively , reduction as 75% and 93% .(**Table 3**).

In **table (4)** can be seen obtained lung dose values from dosimetry and RTDOSEPLAN software and also its error values compared to software. The percentages of the second point are negative in all of these techniques, because this point is placed in matchline region that it

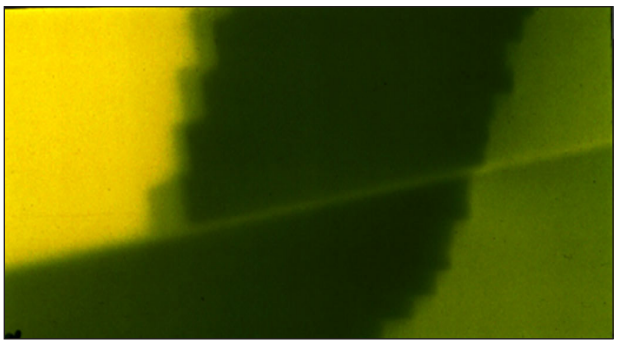

Figure (5): An example of obtained film from compact accelerator in the phantom's surface

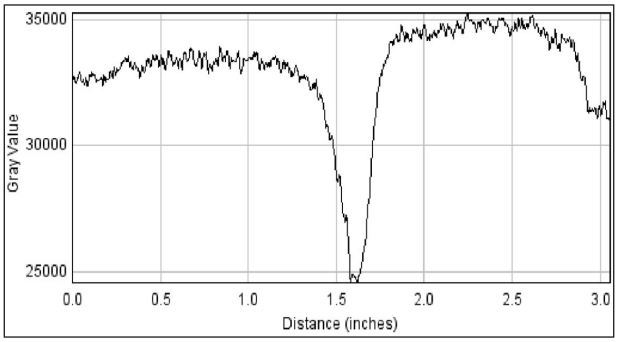

Figure (6): An example of obtained film from compact accelerator in the phantom's surface

Table 1. The amounts of gap and inhomogeneity of dose distribution.

Technique	Surface of phantom			3 cm in depth of phantom		
	Sym	Asym	SP	Sym	Asym	SP
Gap (mm)	3.89	4.02	4.16	3.87	4	4.17
Rate of inhomogeneity	51%	53%	57%	50.2%	52.3%	56.8%

Table 2. V90% and V95% treatment's volumes.

	2 point symmetric		2 point asymmetric		Single point	
	V90%	V95%	V90%	V95%	V90%	V95%
Breast	99.9	99.4	99.9	99.4	99.7	98.8
IMLN	99	98.3	99.1	98.2	99.4	99.1
SCLN	97.9	96.9	100	99.8	97.7	96.9
AL1	100	99.6	98.5	94.3	99.6	98
AL2	99.9	99.2	97.8	96.1	98.4	96.6
AL3	100	100	100	100	100	100

Table 3. Lung and heart comparison between in all of techniques.

	V20% Lung	V20 Lung	V30 Lung	V10 Heart	V40 Heart
2p-sym	30.6	27.9	26.5	16.3	11.4
2p-asym	28.7	25.8	25.5	16.2	11.2
Sp	17	13.6	11.2	4	0.76

Table 4. Obtained lung dose values from dosimetry and software and also its error values.

		First point	Second point	Third point	Fourth point
2p-sym	dose from dosimetry	188.8	189.6	57	20
	dose from software	193	160	59.2	21.3
	error value	2.2%	-15%	4%	6.5%
2p-asym	dose from dosimetry	186.9	168.7	26.1	19.7
	dose from software	192.8	134	27.1	20.7
	error value	3.2%	-20%	3.8%	5%
Sp	dose from dosimetry	186.3	107.3	16.4	14.7
	dose from software	192.4	78.4	17.54	14.95
		3.3%	-27%	7%	1.7%

didn't have good dose distribution.

Discussion

In this study dosimetry was performed three times with compact accelerator. In all three times a space was observed between the tangential and the Supraclavicular fields while matchline's dose distribution was good in software and treatment planning had been performed carefully and light fields had been coincided on the surface of phantom exactly. In the obtained profiles of matchline region by the ImageJ software have been seen a decrease in dose severely. The sharp decrease of dose had an increasing process respectively in 2p-sym, 2p-

asym and SP techniques.

In many studies have been expressed that asymmetric jaws have a mechanical limitation in their opening. This limitation could cause deviation in aligning correct treatment fields. They used film dosimetry to evaluate matchline dose. In this method a film was initially exposed using this field with the collimator set at 90°. The collimator was then rotated 180° and the same film was exposed for the second time to create adjacent asymmetric fields .In their studies a 2 mm overlap and gap produced in homogeneities nearly of 35% and 30% above or below the prescribed dose, respectively. The 4 mm overlap and gap created an inhomogeneity of +65% and -50%. The dose inhomogeneity produced for 1 mm overlap and gap was 22% above and 6.8% below the prescribed dose, respectively. They concluded that asymmetric collimators should evaluate periodically to get the amount of field's misalignment especially in single point technique. Because misalignment causes non-uniformity in dose distribution in matchline of treatment fields.[16, 17]

Many methods were offered to solve this problem that they had many deficiencies. In 2009 used EPID for regular quality assurance of linear accelerator asymmetric jaw junction. They believe that there is a need for better methods to calibrate the jaw positioning.[18] In 2011were presented a new method to calibration which was based on Monte Carlo calculation .According to the results of this study, before jaw calibration the dose heterogeneity in the junction was 12% and after jaw calibration, it was reduced to below 3%. With this method, they were able to reduce the positioning accuracy to 0.2 mm. their method requires complex Monte Carlo simulations and it is not practical to be in clinic.[19] More simple method presented in 2013.they used EPID for calibration too. In this method, the junction dose was determined as a function of jaw position. The shift in the zero jaw position required to correct for the measured junction dose could thus be obtained. The jaw calibration was then modified to introduce the calculated shift and therefore achieve an accurate zero position in order to provide a relative junction dose that was as close to zero as possible.[20]

Obtained result of this study verifies misalignment of light and radiation beams. Because after three times dosimetry with EBT2 gafchromic films, in spite of aligning light beams on the surface of phantom and correct set up of treatment planning , we observed the gap. Then with using radiology films and making adjacent asymmetric fields the test were done in 4 compact and 1 variant accelerators and the gap observed again in all.

Conclusion

In according to the results of this study it seems that single point technique is better than other techniques to cure breast cancer patients. If jaws calibration were not done, single point technique is less effective than other techniques. Because the amount of misalignment in single point technique is more than other technique.

Therefore jaws calibration is necessary and it seems that Iranian radiotherapy clinics don't pay attention to this calibration. To achieve the desired dose distribution which exist in the treatment software, calibration is necessary. According to studies, perform this calibration is sufficient annually.

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