Effects of Collimator and Gantry on Dose Delivery Accuracy for Patients Undergoing Radiation Therapy of the Breast on Theratron Equinox 80 cm SSD

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Abstract: ***Introduction**: In some developing countries the problem of low cure rate of breast cancer might be compounded by manual placement of the beam during treatment using anatomical land marks. The combination of manual placement of the beam and patient positioning inevitably introduce collimator and gantry adjustments errors. **Material and Methods**: Breast phantom of dimensions 35 cm x 50 cm was fabricated by using bee wax. The phantom was positioned at source-surface distance (SSD) 80 cm using the information obtained from the Tera-Six simulator and the phantom irradiated and diode collected the readings. Mismatch was then created by increasing the gantry and collimator angles to 1^0, 2^0, 3^0, 4^0 to 5^0. On each increase the phantom irradiated and diodes readings were recorded. **Conclusion**: Accuracy of dose delivery to the breast cancer patients undergoing radiation therapy could be reached when adjustments of both gantry and collimator angles caused by mismatch of the simulator and the cobalt-60, Theratron Equinox 80 minimized not to exceed 2^0.***

Keywords: Breast, diodes, dose delivery, collimator and gantry angles

1. Introduction

Breast cancer which is a leading cause of death and disability among women, in low and middle countries is increasingly becoming a problem in developing countries (1-2). This type of cancer is curable up to 90% when detected and treated at early stage of development (2). In most of East African countries, this cancer has comparatively low cure rate (2-**4**) even when detected and treated early. In this work, it hypothesized that, this low cure rate is associated with low dose delivery accuracy (**4)** since it well established that for radiotherapy to cure cancer, dose delivery accuracy must be within ±5% (5). In cobalt-60 dose delivery accuracy may be caused by different parameters related to the treatment planning, the patient and treatment machines (5). Recent studies have shown that, shape of the breast is among a factor that lower delivery accuracy (6-7). In some developing countries, this problem is compounded by manual placement of the beam during treatment using anatomical land marks (7-8). The combination of manual placement of the beam and patient positioning inevitably introduce collimator and gantry adjustment errors.

Since 2008 breast cancer treatment in our hospital, has been based on the conventional MT-350 breast board from CIVCO as standard immobilization device for irradiation (**4).** Treatment of patients with such a cancer type is done mostly using Theratron Equinox 80 cm SSD on a specific parameters retrieved from the simulator. Often there is a mismatch between retrieved parameters used in the previous fraction and desired parameters needed to reproduce the land marks in current treatment fraction. The mismatch requires small corrections to be made on previous parameters by adjusting collimator and gantry angles. The effect of this adjustment on dose delivery accuracy in Theratron Equinox Co-60 is not clearly known. Therefore the aim of this paper was to investigate the effects of these adjustments on dose delivery accuracy for breast cancer patients using manual beam placement.

2. Material and Methods

Since it was difficult to carry out this study in human, a breast phantom of dimensions 35 cm x 50 cm was fabricated by using bees wax was positioned at source –surface distance (SSD) 80 cm from the Tera-Six simulator. Similar field sizes, gantry and collimator angles used for the patients were determined for appropriate beam placement. The phantom was then positioned at SSD 80 cm from Theratron Equinox 80 cm which has a tolerance collimator and gantry of 1^0. The diodes manufactured by Sun Nuclear Corporation used to measure absorbed dose in this study were calibrated against a secondary standard the ionization chamber model (W-30002), serial number 2136 and electrometer model (UNIDOS) and serial number 20359 calibrated by International Atomic energy Agency (IAEA) in 2012. The calibrated diode was positioned at the entry point of the beam. The field sizes of the phantom were selected from 7 cm x 7 cm, 9 cm x 10 cm, 10 cm x 12 cm and 12 cm x 15 cm. At each field size, phantom separation was measured and treatment depth calculated using the dose rate 133.7 cGy/min and the Percentage Depth dose (PDD) and Total scatter factor were obtained from the BJR supplement 25 and hospital table respectively. The treatment time was then calculated using equation (1) to give the delivered dose of 1.0 Gy to the breast phantom and the phantom irradiated three times. The readings recorded by diode were collected and average was taken. Gantry and collimator were simultaneously rotated to 1^0, 2^0, 3^0, 4^0 to 5^0. In each case the phantom was irradiated and diode readings were recorded. Similar procedures were repeated for all field sizes and results are presented in table 1-4.

$$Treatment\ time = \frac{Prescribed\ \ dose}{Dose\ rate \times PDD \times Total\ scatter\ \ factor} \quad (1)$$

Table 1: Percentage dose deviations for 7 cm x 7 cm at various gantry and collimator angles

Gantry Angles (^{0})	Collimator Angles(^{0})	Mean diode readings (cGy)	Dose deviations (cGy)	Percentage dose deviations
315	0	118.5	0	0
316	1	118.5	0	0
317	2	118.5	0	0
318	3	118.5	0	0
319	4	119.6	1.1	0.93%
320	5	119.6	1.1	0.93%

Table 2: Percentage dose deviations for 9 cm x 10 cm at various gantry and collimator angles

Gantry Angles (^{0})	Collimator Angles(^{0})	Mean diode readings (cGy)	Dose deviations (cGy)	Percentage dose deviations
315	0	122.6	0	0
316	1	122.6	0	0
317	2	125.6	3	2.45
318	3	125.5	2.9	2.37
319	4	127.7	5.1	4.16
320	5	127.7	5.1	4.16

Table 3: Percentage dose deviations for 10 cm x 12 cm at various gantry and collimator angles

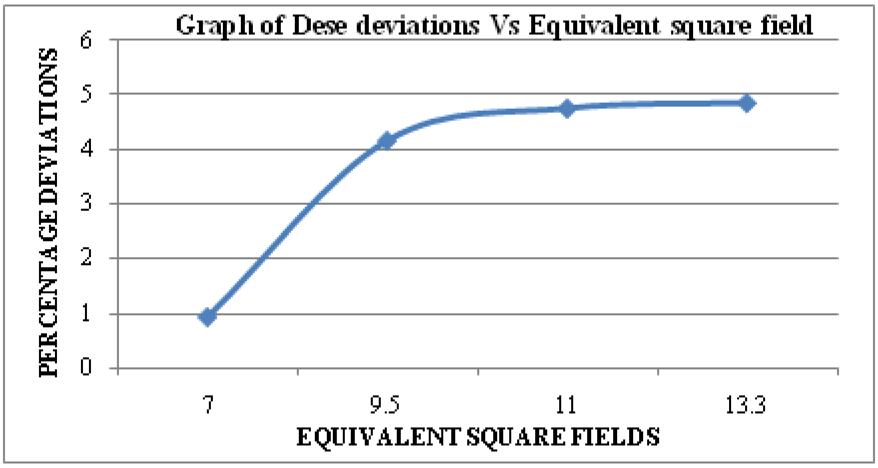
Gantry Angles (^{0})	Collimator Angles (^{0})	Mean diode readings (cGy)	Dose deviations (cGy)	Percentage dose deviations
315	0	119.6	0	0
316	1	119.6	0	0
317	2	123.2	3.6	3.01
318	3	123.2	3.6	3.01
319	4	125.2	5.6	4.68
320	5	125.2	5.6	4.68

Table 4: Percentage dose deviations for 12 cm x 15 cm at various gantry and collimator angles

Gantry Angles (^{0})	Collimator Angles (^{0})	Mean diode readings (cGy)	Dose deviations (cGy)	Percentage dose deviations
315	0	126.0	0	0
316	1	126.0	0	0
317	2	130.1	4.1	3.25
318	3	130.1	4.1	3.25
319	4	132.1	6.1	4.84
320	5	132.1	6.1	4.84

3. Discussion

Several studies mentioned different factors that lead to the difference between delivered and prescribed dose to be more than recommended tolerances which lead to decrease tumor control probability (9-11). Radiotherapy of cancer is a complex multistep process from beam calibration to verification during treatment (12). Each step includes measurements uncertainties, risk of systematic and occasional deviations which sum to the treatment of patient (13). Manual treatment time calculations and beam placement have been reported as also a contributing factor for a deviation to be higher than recommended (**3, 7).** Some studies reported the deviations of prescribed and delivered doses to be higher than ±5% but the reasons were not clearly prescribed (3). In this study which uses Co-60, it found that for the large field size used adjustments of gantry and collimator angles to 5^0 could results the dose deviations of 4.84%. Further studies are carried out to investigate the contribution of patient movement on dose delivery accuracy. The data of large percentage deviations from the tables are summarized in the graph below.



4. Conclusion

Several studies mentioned different uncertainty during treatment of breast. When these uncertainties combined with the adjustments of gantry and collimator angles that have been changed due to manual beam placement in the treatment, the deviations between prescribed and delivered dose should be more than the recommended tolerances. The graph above showed that, as gantry and collimator were adjusted, the deviations from prescribed is much worse for large field size. From this study, it can be concluded that, to minimize the dose deviations caused by mismatch in the radiation treatment, gantry and collimator adjustment can be done to 5^0 prior to portal imaging for equivalent square field less of than 8 x 8 cm and for higher equivalent square field adjustment of 1^0 to 2^0 can to be used.

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