

EVALUATION OF SCATTER DOSE RECEIVED BY THE THYROID REGION IN PATIENTS WITH BREAST CANCER RECEIVING ADJUVANT CHEST WALL IRRADIATION USING 2-D RADIOTHERAPY

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ABSTRACT

According to the Global Cancer Observatory 2020 report, breast cancer is the top most cancer among females in Sri Lanka. It has been reported that thyroid can receive a significant amount of radiation dose in breast cancer patients who received adjuvant two dimensional (2D) conventional therapy. The aim of this study was to evaluate the scatter dose received by thyroid region during chest wall radiation in conventional 2d-radiotherapy. 41 breast cancer patients who had adjuvant 2D-conventional radiotherapy were included in this study. All selected patients were treated by Theratron™ 780e cobalt teletherapy at Apeksha Hospital, Maharagama, Sri Lanka. Polimaster PM1610 dosimeter was used to measure the scatter dose. A statistical analysis was performed using IBM SPSS. The mean values for the total scatter dose from the glancing fields and the SCF (supraclavicular fossa) field were 112.33 ± 5.50 mSv and 421.79 ± 32.49 mSv respectively. The mean value of the total scatter dose was 534.10 ± 34.11 mSv. Moreover, 78.97% of the scatter dose was received by the SCF field while 11.36% and 9.66% were received by medial and lateral glancing fields. A considerable amount of radiation has been received by the thyroid region among breast cancer patients who received chest wall irradiation with SCF irradiation. In order to reinforce the conclusion, further studies need to be performed with accurate dose measurement especially with Thermoluminescent dosimeter (TLD).

KEYWORDS: Breast cancer, Chest wall irradiation, Cobalt teletherapy, 2D-conventional radiotherapy, Scatter dose, Dosimeter

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1. INTRODUCTION

Cancer is one of the leading causes of death for both males and females worldwide. According to the Global Cancer Observatory 2020 report, about 10 million deaths and 19.3 million new cases have been reported globally (Sung et al., 2021). Surgery, chemotherapy and radiotherapy are three main pillars in cancer treatment. Due to the efficiency of treatment and low cost compared with other radiotherapy treatment options, about 50% of cancer patients receive radiation therapy during their course of treatment (Byron et al., (2013), Ramanathan et al., (2022)). At present, there are various types of treatment to explore radiation in radiotherapy such as 2D-conventional radiotherapy, three-dimensional conformal radiotherapy (3D-CRT), intensity modulated radiotherapy (IMRT), image guided radiotherapy, tomotherapy, stereotactic radiosurgery, particle therapy, etc. (Ramanathan, 2017). Even though, there are several advanced teletherapy treatment modalities currently available, still most of the developing countries use cobalt teletherapy due to its simplicity, relatively low initial cost and less workforce requirement (Ramanathan, 2021). Currently, 9 cobalt teletherapy machines are functioning in Sri Lanka (Ramanathan et.al 2022).

Breast cancer is the topmost cancer among women in Sri Lanka, and 3975 new cases were reported in 2022 (GLOBOCAN 2022). Approximately 3000 new cases of breast cancer are diagnosed every year (NCCP, 2023 and Balawardena et al., 2020). Breast cancer is formed in breast tissue. The most common type of breast cancer is ductal carcinoma which starts in the lining of the milk ducts. Another type of breast cancer is lobular carcinoma which starts in the lobules of the breast (NCI-USA, 2020). Appropriate use of adjuvant radiotherapy is necessary for better prognosis. Adjuvant radiotherapy is given in addition to breast surgery. It is used to destroy the remaining cancer cells in the breast or lymph nodes after surgery. Usually, adjuvant radiation therapy may last 3 to 7 weeks. Adjuvant radiotherapy is recommended in patients with a high risk of local or regional relapse. This includes patients with large primary

tumours (> 5 cm) and with 4 or more involved lymph nodes (Chev, 2001).

Generally, 2D-conventional radiotherapy, 3D-CRT and IMRT treatments are practiced for breast cancer radiotherapy in Sri Lanka. 3D-CRT and IMRT are more conformal radiation therapy in which the tumour control probability is high comparing with 2D conventional radiotherapy. Adjuvant radiotherapy with 2D- conventional radiotherapy planning is not a computed tomography (CT) image-based procedure. It uses only a trans axial contour of breast for planning. The contour is taken at the middle level of the breast along the trans axial axis. The chest wall is irradiated by two parallel opposed tangential beams which are rectangular shaped and large enough to irradiate the interested area of the breast. The ipsilateral supraclavicular fossa is irradiated with a direct anterior beam which is almost square shaped and large enough to irradiate the interested area of supraclavicular fossa with lymph nodes. The 2D-conventional treatment planning is performed only in central or single transverse plan by considering the patient data contained that plane only. There is no knowledge of off axis dose distribution. This is the major disadvantage in 2D-conventional radiotherapy.

Scatter radiation received by the patient during radiotherapy is unavoidable. The patient can receive scattered radiation which comes outside the direct photon beam. The scattered radiation can be arising from different sources such as leakage radiation, scattered from the collimator, scattered radiation from floor, wall, and ceiling, radiation scattered from the patient, etc. The scattered radiation received by the patient is unwanted additional radiation dose to the patient. Akin et al., (2014) evaluated thyroid dose received by the patient who received postoperative chest wall/breast and regional nodal irradiation during 3D-conformal radiotherapy. The authors used thyroid gland contouring in treatment planning to evaluate thyroid dose. The mean dose received by thyroid gland was reported as 22.5 Gy. Similar studies were conducted by Akyurek (2014) and Kanyilmaz et al. (2017), and the reported mean thyroid doses were 31 Gy and 18.98 Gy respectively.

According to the World Health Organization (WHO) estimation, breast cancer is the most common cancer among women in Sri Lanka. Therefore, studying of benefits and risks of breast cancer radiotherapy is important. As the survival of breast cancer patients is increasing, incidence of radiation induced thyroid dysfunction was found to be relatively common late radiation toxicity. Adjuvant 2D conventional radiotherapy is still practiced for the breast cancer patient in Sri Lanka. But there is no evidence of estimating thyroid gland toxicity to radiation among the breast cancer patients in Sri Lanka. This study evaluates the scatter dose received by the thyroid region during the chest wall irradiation among breast cancer patients who received adjuvant 2D-conventional radiotherapy by using Polimaster1610 dosimeter.

2. MATERIALS AND METHODS

Descriptive cross-sectional prospective approach was used in this study. Patients who received radiation to chest wall and supraclavicular fossa (SCF) as adjuvant radiotherapy (2D conventional) for carcinoma of breast in TheratronTM 780E 60Co teletherapy machine at Apeksha Hospital, Maharagama from 02nd September 2020 to 15th February 2021 was the population of the study. Convenience sampling was used to select samples from the population. 41 patients were selected for this study.

Patients who had chest wall adjuvant radiotherapy with supraclavicular fossa treatment (2D conventional) for carcinoma of breast as primary cancer were included. Patients who were between the ages of 18 to 80 years were included in this study. Patients who underwent thyroid surgery, thyroid disorder patients, patients who underwent radioiodine treatment, patients who had previous treatment to ipsilateral supraclavicular fossa were excluded. Ethical approval was granted by the ethical review committee, Faculty of Medicine, General Sir John Kotelawala Defence University, Sri Lanka. In addition, the permission was obtained from the director of Apeksha Hospital, Maharagama to conduct this study.

The pamphlets were distributed among the patients who received radiation to chest wall as adjuvant radiotherapy (2D conventional) for carcinoma of breast at TheratronTM 780E 60Co teletherapy machine which was located at the department of radiotherapy, Apeksha Hospital, Maharagama. The purpose and the requirements for the research were explained to the participants by an investigator of the research team and each participant was given an information sheet. The written consent was obtained from the participants who were satisfied with the criteria of the research study.

An interview was held with participants by one of the investigators before data collection. The required data was collected from the treatment prescriptions of participants during the interview. Participants were needed to hold the dosimeter on their neck at the level of the thyroid gland during the treatment. The investigators were helped for placement and fixation of dosimeter with a specially made and pre-tested neck band as shown in figure 1.



Figure 1: Specifically made and pre-tested neck band to fix the dosimeter.

The selected participants for this study were positioned/aligned on the breast board which was laid on the treatment couch using the laser system. The correct placement of dosimeter and comfortability of the participants were ensured by the research team. Radiation treatments as prescribed by the consultant radiation oncologist was delivered by the radiation therapists. The gantry angles for medial glancing, lateral glancing, and for SCF treatment fields were accumulated from each patient. Moreover, body evaluation angle, field-size of glancing and the field size of SCF were gathered.

Finally, the dosimeter was detached from the

participants and participants were removed safely from the treatment couch, after the delivery of radiation treatments. Participants were educated in post treatments / procedures by the research team, and they were discharged from the treatment room. Dosimeter was connected to the computer and the readings were retrieved using dosimeter application software. The scatter dose received by the thyroid region by medial glancing, lateral glancing, and SCF irradiation were retrieved using Polimaster1610 dosimeter. The procedure was repeated for all participants and data was collected. Collected data was tabulated in a master chart using Statistical Package for the Social Science software provided by International Business Machines Corporation (IBM-SPSS 23). All the tabulated data were statistically analysed to achieve the objective of the study. Explanatory variables were evaluated and presented with frequency tables and scatter plots. Pearson correlation coefficient was also used to express both direction and degree of correlation

3. RESULTS

Adjuvant two-dimensional (2D) conventional radiotherapy is the most common in developing countries due to the lack of linear accelerators. Therefore, this study focused on evaluating scatter dose received by the thyroid region during 2D-conventional radiotherapy for breast cancer patients as all government radiotherapy centres in Sri Lanka use this kind of treatment. Furthermore, this study was to examine how the scatter dose correlates to the treatment parameters.

Table 1 shows the descriptive statistics of dose measurements. The mean scatter dose to the thyroid region by the medial glancing is 61.34 mSv. The mean scatter dose received to the thyroid region by the lateral glancing is 50.99 mSv. The mean scatter dose received to the thyroid region by SCF field is 421.79 mSv. The mean value of the sum of the scatter dose to the glancing fields is 112.33 mSv. The mean of total scatter dose received to the thyroid region by the glancing and SCF beam is 534.10 mSv. Other descriptive statistics of measured doses are shown in

table 2.

Table 1 shows the descriptive statistics of measured dose. The notations are indicated as follows: MG- Medial Glancing, LG- Lateral Glancing, GD- Glancing dose, Min.- minimum, Max.- maximum, Var.- variance, SD-standard deviation, and Per.- percentile. All measured doses are in mSv.

	Dose by MG	Dose by LG	Dose by SCF	Sum of GD	Total Dose
Mean	61.34	50.99	421.79	112.33	534.10
Median	57.12	45.45	419.79	107.09	542.19
Min.	30.91	23.58	60.08	56.68	129.15
Max.	108.65	121.92	728.66	206.07	878.24
Range	77.74	98.33	668.58	149.39	749.09
SD	18.27	24.89	202.91	35.24	213.05
SD of mean	2.85	3.89	32.49	5.50	34.11
Per. 25	47.69	32.95	231.07	89.98	327.08
Per. 75	75.33	65.57	636.93	125.82	756.20

Table 2: Descriptive statistics of irradiated field variables. The notations are indicated as follows: Min.- minimum, Max.- maximum, Var.- variance, SD-standard deviation, and Per.-percentile.

	Glancing Height (cm)	Glancing Width (cm)	Area (cm ²)	SCF Area (cm ²)
Mean	17.82	11.07	197.32	51.90
Median	18.00	11.00	195.00	49.00
Min.	15.00	7.00	126.00	35.00
Max.	20.00	15.00	300.00	81.00
Var.	1.72	4.47	1682.3	100.3
SD	1.31	2.11	41.02	10.01
SD of Mean	0.20	0.33	6.41	1.60
Range	5.00	8.00	174.00	46.00
Per. 25	17.00	10.00	165.00	45.00
Per.75	18.00	13.00	220.00	60.00

The mean glancing height among 41 patients is 17.82 cm. The mean glancing width is 11.07 cm. The mean glancing area is 197.32cm². The mean SCF area is 51.90 cm².

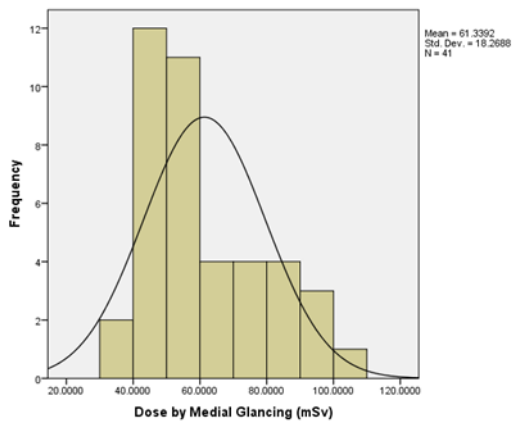


Figure 2: Distribution of scatter dose received by medial glancing.

The distribution of scatter dose received by the thyroid region from medial glancing is explained by histogram (figure 2). The mean scatter dose to the thyroid region by medial glancing is 61.34 mSv. Most patients from the sample receive the scatter dose between 40 mSv and 60 mSv. About 12 patients received the high scatter dose of 50 mSv which is 29.26% of the sample population. The bell-shaped curve demonstrates the distribution as almost normal.

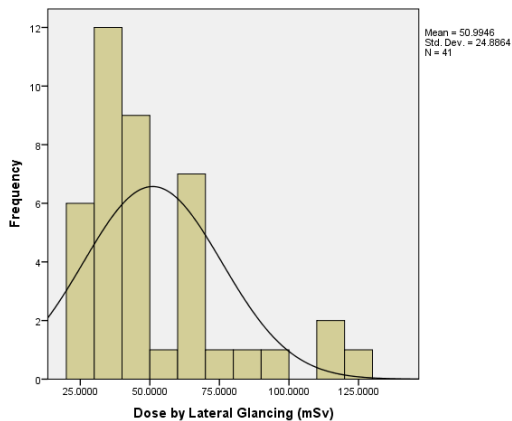


Figure 3: Distribution of scatter dose received by lateral glancing

The distribution of scatter dose received by the thyroid region from lateral glancing is explained by histogram (figure 3). The mean scatter dose to the thyroid region by lateral glancing is 50.99 mSv. 12 out of 41 patients get the scatter dose of 35 mSv which is the highest frequency in the histogram. The

lowest scatter dose for thyroid region is 20 mSv and the highest scatter dose is 150 mSv. The curve is moderately skewed positively and has a platykurtic distribution.

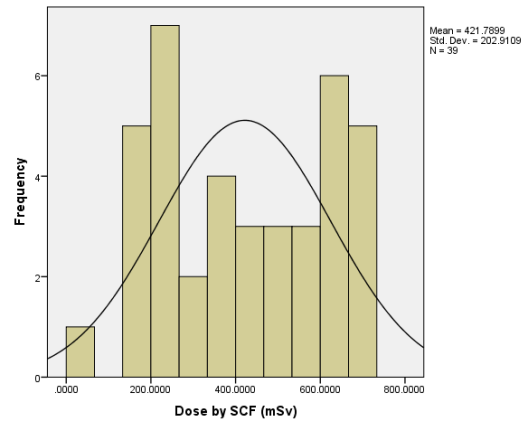


Figure 4: Distribution of scatter dose received by SCF.

The distribution of scatter dose received by the thyroid region from SCF is explained by histogram (figure 4). The mean scatter dose to the thyroid region by SCF exposure is 425.99 mSv. Most patients have received a scatter dose of more than 200 mSv to the thyroid region, and the dose is distributed up to 720 mSv. The bell-shaped curve demonstrates the distribution as almost normal.

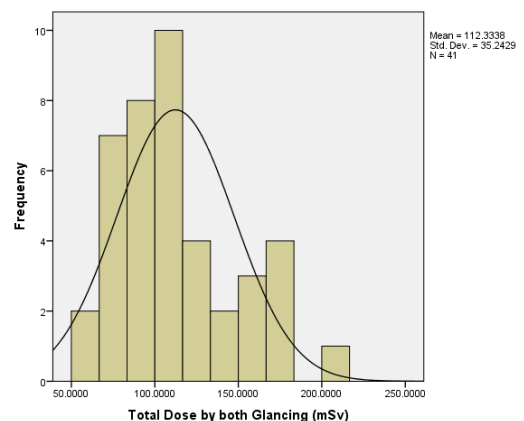


Figure 5: Distribution of scatter dose received by both glancing.

The distribution of sum of scatter dose by glancing is explained by the histogram of figure 5. The mean scatter dose to the thyroid region by both glancing fields is 1685.01 mSv. Most patients have received scatter doses between 1000 mSv and 2000 mSv. 10 out of 41 patients have received scatter doses of 1625 mSv as the highest frequency. Most of the patients have received scatter doses below 2000 mSv. The curve is bell shaped and displays a small degree of platykurtic distribution. The bell-shaped curve demonstrates the distribution as almost normal.

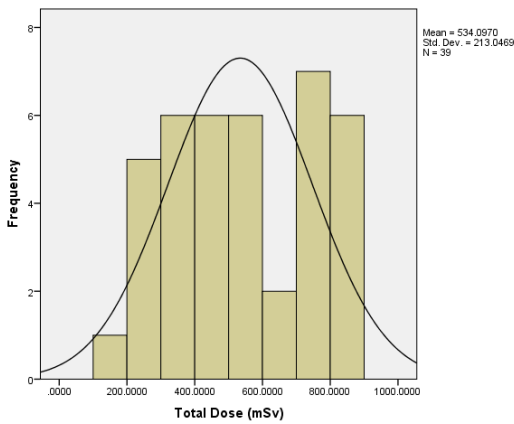


Figure 6: Distribution of total scatter dose per fraction.

The distribution of total scatter dose per fraction is explained by the histogram of Figure 6. The mean total scatter dose to the thyroid region by a fraction is 8074.98 mSv. Most patients have received scatter doses of more than 5000 mSv. The bell-shaped curve demonstrates the distribution as almost normal.

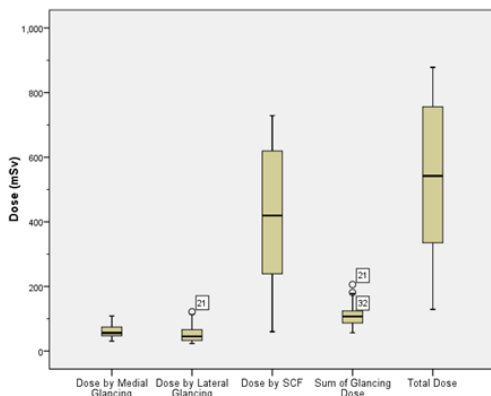


Figure 7: Dose contributions in box plot.

Dose contributions by beams for total scatter dose per fraction is explained by box plots of Figure 7. The box plot of scatter dose by medial glancing, scatter dose by lateral dose and sum of glancing scatter doses are comparatively short. The box plot of scatter dose by the SCF field is comparatively taller than glancing which suggests the SCF field’s scatter dose is holds larger amount of scatter dose received by the thyroid region. The obvious difference between the box plots is worthy for further investigations.

The correlation between glancing width and the scatter dose by the medial glancing is significant at the 0.05 level with Pearson correlation coefficient of $r=0.346$. This indicates that there is a moderate positive relationship between the variables. The correlation between glancing height and the scatter dose by the lateral glancing is significant at the 0.05 level with Pearson correlation coefficient of $r=0.308$. This also indicates that there is moderate positive relationship between the variables. The correlation between glancing width and the thickness of irradiated tissue is significant at the 0.01 level with Pearson correlation coefficient of $r=0.623$. This indicates that there is a strongly positive relationship between the variables.

Further, the partial correlation of doses and radiation beam variables were performed by setting the thickness of irradiated tissue as control variable. It showed that there is a partial correlation between glancing height and the scatter dose by lateral glancing to the thyroid region.

4. DISCUSSION

While radiotherapy has many benefits and increases the survival in cancer therapy, some of the adverse events can occur due to the irradiation of other organs in and around the treatment field that may jeopardize the quality of life. Lungs, and contralateral breasts are considered as organs at risk during chest wall irradiation. But, the thyroid gland is not considered as an organ at risk during the chest wall irradiation even though there is probability of risk. Some studies have reported thyroid disorders that occurred due to scatter

dose received by thyroid gland during chest wall irradiation. There are limited numbers of studies about thyroid dose evaluation in breast patient radiotherapy. However, data availability regarding the dose of the beam delivered to thyroid region during radiotherapy to supraclavicular field is insufficient.

A previous study (Kanyilmaz et al., 2017) showed the mean dose received by thyroid gland during breast cancer treatment with 3D conformal Radiotherapy was 18.98 Gy, when all or part of the gland irradiated with conventional fractionation of 2 Gy per fractions with total 25 fractions. In our study we evaluated and measured the dose received by thyroid region of all 41 patients with breast cancer who were received 2D conventional radiotherapy for breast/chest wall and supraclavicular region, and the mean thyroid dose was 542.19 mSv, per 267 cGy fraction. According to the same previous literature the maximum dose received by thyroid gland was 46.9 Gy and minimum thyroid dose received was 2.25 Gy. In this study the maximum thyroid region dose was 878.24 mSv and the minimum dose was 129.15 mSv, per 267 cGy fraction and the total number of fractions was 15.

In our study, the median dose to thyroid region was 534.10 mSv per fraction, and the standard error was ± 33.28 mSv per fraction. Wolny-Rokicka et al., 2016 have statistically proven in their study that the median dose received by thyroid of the SCRT group that underwent irradiation of the regional lymph nodes and scar or breast was 1957.5 cGy. In the results of our study, it is shown that the range of the total dose to thyroid region per 267 cGy fraction was 749.09 mSv, and the standard error of the mean was 34.11 mSv.

It was needed to find out the correlation between scatter dose to thyroid region and explanatory variables. The study results show that following correlations are significant at 0.05 level, dose by medial and glancing width, and dose by lateral glancing and glancing height. The correlation between glancing width and dose by medial glancing was significant at the 0.01 level with the Pearson

correlation coefficient $r = 0.623$. It shows a strong degree of correlation.

Thyroid disorder is a well-known late effect in head and neck radiotherapy. Most studies focus on evaluating thyroid dose during head and neck radiotherapy but there are few studies related to chest wall irradiation. It is also important to reduce thyroid dose in chest wall irradiation. Only very few studies have been conducted to investigate radiation induced thyroid dysfunction in breast cancer patients receiving RT to the supraclavicular field that involve the part of thyroid gland. There are three different types of radiation induced thyroid dysfunctions such as hypothyroidism (HT), subclinical HT and clinical HT. The previous study, Akyurek, 2014, reported that the overall incidence of hypothyroidism was 21% in patients with breast cancer who had supraclavicular radiotherapy. Also they reported that 2% cases had subclinical HT and 4% cases had clinical HT. Their results showed that the mean thyroid dose of ≥ 36 Gy produced a significant impact on the development of HT. Another study (Bruning et al., 1985) has mentioned that HT was significantly common in breast cancer radiotherapy patients who received radiation to SCF.

Wolny Rokicka et al., 2016 found that the incidence of RT-induced hypothyroidism was exposed after two years since the radiotherapy in 6% population in breast cancer patients receiving SC-RT. Similarly, Kikawa et al., 2017 have reported that the prevalence of HT in patients with breast cancer in their study after irradiation to the SC region was 2.4% which is less than the previously reported. In a previous study, Reinertsen et al. showed a marked increase in the development of hypothyroidism after multimodal treatment of breast cancer that received adjuvant radiotherapy.

Another study carried out by Tunio et al., 2015 among breast cancer patients receiving RT, 3 (15%) patients had hypothyroidism in SC-RT group and one (5%) patient had subclinical hypothyroidism. According to the literature, the previous study conducted by Kanyilmaz et al., 2017, 51 (21%) patients were diagnosed with HT, 22 (9.1%) patients

had clinical HT and 29 (11.9%) patients had subclinical HT. In that they revealed $D_{mean} > 21$ Gy was the threshold value for the development of hypothyroidism.

5. CONCLUSION

The main aim of this study was to determine the scatter dose received by thyroid region during the chest wall irradiation among breast cancer patients who received adjuvant radiotherapy. Our results implied that the mean of the scatter dose received by thyroid region by medial glancing was 61.34 mSv per 267 cGy fraction and by lateral glancing it was 50.99 mSv. The mean scatter dose received by thyroid region was 421.79 mSv per fraction of 267 cGy. It will mainly affect the thyroid region. Further, the total dose received by thyroid region from three fields per fraction was 534.10 mSv. According to the results, we present the evidence that over 75% of the scatter dose is contributed by supraclavicular field while only 21.02% of scatter dose is delivered by both medial glancing field and lateral glancing field. Further, it implied that medial glancing field gives a higher impact on the dose received by thyroid region than the lateral glancing field.

However, according to the results there is a correlation between scatter dose by medial glancing and glancing width with the value of $r = 0.346$ and scatter dose by lateral glancing and glancing height with the value of $r = 0.308$. It shows that the radiation scattered dose to thyroid region by glancing fields significantly depends on the height and width of glancing fields.

According to our results, we suggest the use of imaged based treatment planning techniques to limit the required height and width of glancing beams like 3D CRT and IMRT. Therefore, further studies need to be conducted to estimate the scatter dose by 3D CRT and IMRT treatment plans. According to both literature and our findings, future research should consider the potential effects of radiation on development of hypothyroidism as late toxicity in breast cancer patients more carefully. Similarly, we recommend to avoid unnecessary thyroid gland

radiation especially during irradiation of supraclavicular region, and routinely screening breast cancer patients for hypothyroidism on follow up, and at the same time, thyroid gland should be excluded from the treatment field whenever possible.

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