Optimum reckoning of contra lateral breast dose using physical wedge and enhanced dynamic wedge in radiotherapy treatment planning system

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► ***Original article***

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ABSTRACT

Background: It was intended to investigate the effect of physical wedge (PW) and enhanced dynamic wedges (EDW) on contralateral breast dose during primary breast irradiation in radiotherapy treatment, using high energy photon beams. ***Materials and Methods:*** The Varian's Clinac dual mode linear accelerator model 2100 C/D and Siemen's Primus accelerators were used for radiation doses with 6 MV and 15 MV. Doses were delivered using Tangential field techniques and asymmetric collimator jaws. Eclipse three-dimensional Treatment Planning System (3DTPS) was used to measure contralateral breast dose for all fiend settings. Sixty five patients (with cancerous breast as well as chest wall) were taken and their contralateral breast doses were measured at a point 5 cm across, at 2 cm depth from the end of the medial field. ***Results:*** The contralateral breast dose mean difference was 0.25 cGy and 0.24 cGy during the comparison of PW and EDW on Varian's Clinac and 0.19 cGy and 0.18 cGy were found for medial EDW and without medial EDW for the same machine in breast cases and chest wall cases respectively as per total prescribed dose. The mean difference for PW (Clinac) and PW (Primus) was found 0.08 cGy and 0.31 cGy and during the comparison of medial PW and without medial PW on primus machine this mean difference was 0.25 cGy and 0.51 cGy in breast cases and chest wall cases respectively as per total prescribed dose. ***Conclusion:*** The investigation demonstrates the significance that the EDW produces less scattered dose, which can cause second breast malignancy, compared to PW. Furthermore, the medial wedge, too, can cause second breast malignancy and should be avoided in planning.

Keywords: *Radiotherapy, contralateral breast, treatment planning system, scatter dose.*

INTRODUCTION

Contralateral breast receive scattered radiation dose and leakage radiation dose from collimators and other mediums present in the beam path during primary breast radiotherapy treatment. This dose to contra lateral breast is the major concern for radiation oncologists and physicists, as this can lead to the development of second breast malignancy [1-3]. Naturally breast is highly radio-sensitive organ and therefore must be treated as Organ at Risk (OAR) [4-7]. So, different modulating tools and treatment techniques have been formulated [8-10] to reduce this dose and to protect normal surrounding tissues. Resultantly tumor localization, desired dose optimization and dose homogeneity are achieved [11-12]. The Wedge filter technique is commonly used for this purpose. Wedge is an absorbing material made by steel or lead, and it can title the Isodose curves to achieve desired dose distributions.

Physical wedges (PW) have continuously been used in radiation therapy treatment to compensate the patient contours or tumor shape. Later on, the Enhanced Dynamic wedges replaced the physical wedges quite effectively. PW is a static wedge, manually inserted into the beam path at LINAC output. PW is an absorbing block made by metallic materials and so it gives more scattering photons when primary photon beams interact with its materials. It is provided with four wedge angles (15^0,30^0,45^0 and 60^0) and four orientations (In, Out, Right and Left) [13-18]. EDW works by achieving wedged-shaped dose distributions by computer controlled movement of one of the collimator jaws assigned to Y1 and Y2. EDW is provided with seven wedge angles (10^0, 15^0, 20^0, 25^0, 30^0, 45^0, and 60^0) and two orientations Y1 and Y2 [19-20]. It gives less scatter dose compared to PW due to absence of scattering which results from the interactions of primary incident photons with PW metallic materials [21].

Customarily different treatment techniques were used in treating breast cancer such as Tangential field techniques with SSD, SAD, Half Beam (HB) with Custom Blocks, HB using asymmetric collimator jaws, iso-centric techniques with JCRT and recorded different results [22-26].

In this study, Tangential field Techniques with Half Beam (Full Beam symmetric field for breast case) using Asymmetric collimator Jaws by employing PWs both on Varian's Clinac, Siemens Primus Machines and EDW on Varian's Clinac Machine were exercised under iso-centric treatment setup. Two types of patients (breast as well as chest wall) under the age of fifty were examined. Wedged shape dose distributions were optimized by using 15^o wedge (medial and lateral) and without medial in case of breast patients and 30^o wedge (medial and lateral) and without medial wedge in case of chest wall patients.

We intended to evaluate the effect of PW and EDW on contralateral breast dose during primary breast irradiation using radiotherapy treatment planning system. So, PW and EDW were compared in view of their contralateral breast dose contributions. Medial and non-medial tangential beams were also analyzed for both wedges. Major concern was to evaluate the wedge effect.

MATERIALS AND METHODS

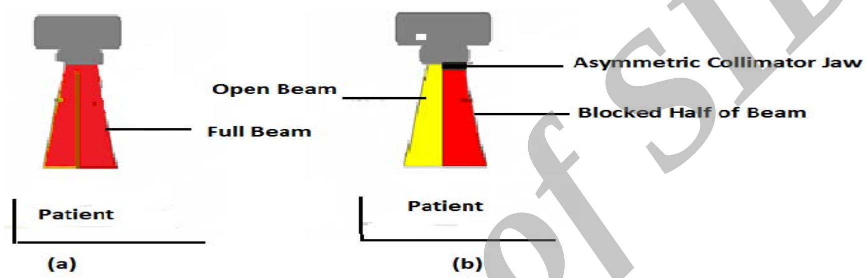
Breast is typically made up of Lobules, Lobes, ducts, Lymphatic nodes and is highly radiosensitive tissue. Tangential field Techniques with Half Beam (Full Beam symmetric field for breast case as in figure 1(a) using Asymmetric collimator Jaws by employing PWs both on Varian's Clinac 2100 C/D (Varian Medical systems, Inc. Alto, CA), Siemens Primus (Siemens Medical Solutions, Concord, CA) and EDW on Varian's Clinac Machine were exercised under iso-centric treatment setup as in figure 1(b). Absolute dose measurements were performed with a cylindrical ionization chamber N30001 (PTW Freiburg, Germany). The calibrated output is adjusted to be 1 cGy = 1MU to water with a field size of 10 × 10 cm and source to surface distance (SSD) of 100 cm with the detector at the depth of the maximum dose according to TG-51 protocol-13 [27-30].

The treatment setups are shown in figure 1 and figure 2 below, where the dose distribution was optimized by using 15^o wedge for breast patients and 30^o wedge for chest wall patients. Sixty five patients, all under the age of 50 years, were analyzed. Three Dimensional Eclipse treatment planning (Varian Medical systems, Inc. Palo Alto, CA V 8.9.17) was used to measure contra lateral breast dose for symmetric and asymmetric fields. PWs and EDWs on Siemens' Primus Machines and Varian's Machines respectively were employed as modifying tool. Two tailed paired t-test (MS Excel 2007) was used for statistical analysis. Photon beams of energy 6 MV and 15 MV produced by Varian linear accelerator and Siemens were used in treating primary breast malignancy.

RESULTS

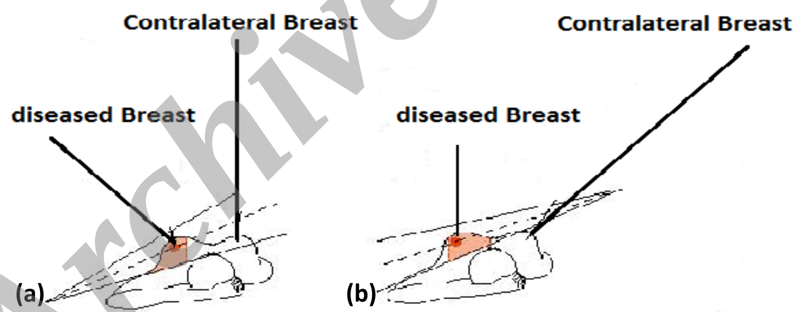
The dose to the contralateral breast has been associated with an increased risk of developing a second breast malignancy. Varying techniques have been devised and described in the literature to minimize this dose. Physical wedges such as standard wedges are used to improve the dose distribution in the treated breast, but unfortunately introduce an increased scatter dose outside the treatment field, in particular to the contralateral breast. The enhanced dynamic wedge is a means of remote wedging created by independently moving one collimator jaw through the treatment field during dose delivery. The external beam radiotherapy has become a standard and principle modality to treat the breast malignancy. Studies have shown that the major contribution to contralateral breast dose is due to scatter radiation dose and collimation leakage dose. Treatment plans for breast as well as chest wall patients were made on Clinac and Primus machines by using 15^0 and 30^0 wedges respectively. PW and EDW were compared with respect to their contralateral breast dose contribution. This work is split up into two parts, one for 29 breast patients, and second for 36 chest wall patients. The compassion of PW and EDW for the first 29 breast patients is presented below.

In figure 3, the dark line represents Contralateral Breast Dose (CBD) for EDW and the light line represents CBD for physical wedge (PW). It clearly depicts that for each patient, the contralateral breast dose for EDW is less as compared to PW which demonstrates the significance of EDW.



Treatment Methods:

Figure 1. (a) Full Beam Technique (Symmetric field) for breast patients. (b) Half Beam Technique (Asymmetric Collimator Jaw) for chest wall patients.



Tangential Field Techniques:

Figure 2. (a) Lateral Tangential Beam. (b) Medial Tangential Beam.

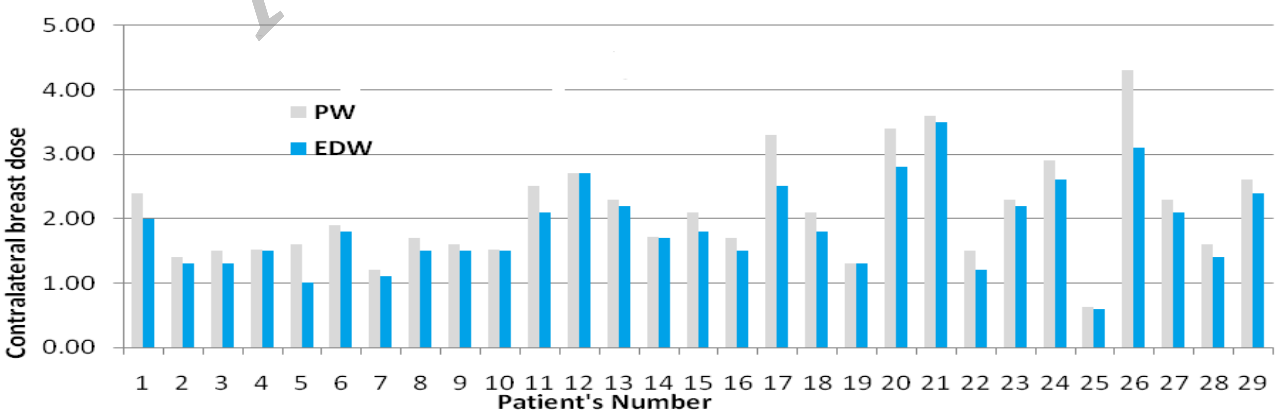


Figure 3. Comparison of contra lateral breast dose: PW vs. EDW on Varian's Clinac machine.

In figure 4, the dark line represents contralateral breast dose (CBD) for medial EDW and the light line represents CBD for without medial EDW. This again confirms that the contralateral breast dose for medial EDW is greater as compared to non-medial EDW which advocates for non use of medial EDW.

In figure 5 the dark line represents contralateral breast dose (CBD) for PW at Primus [P] machine and the light line represents CBD for PW at Clinac [C] machine.

In figure 6, the dark line represents contralateral breast dose (CBD) for medial wedge and the light line represents CBD for without medial wedge on Primus machine. It clearly depicts that for each patient, the contralateral breast dose for medial wedge is more compared to non-medial wedge which advocates avoiding of medial wedge. The second part for thirty six chest wall patients is.

In figure 7, the dark line represents contralateral breast dose (CBD) for EDW and the light line represents CBD for physical wedge (PW). It demonstrates that the contralateral breast dose for EDW is less compared to PW and so confirming the significance of EDW.

In figure 8, the dark line represents contralateral breast dose (CBD) for medial EDW and the light line represents CBD for without medial EDW. It clearly depicts that for each patient, the contralateral breast dose for medial EDW is more compared to without medial EDW which advocates for non use of medial EDW.

In figure 9, the dark line represents contralateral breast dose (CBD) for PW at Primus [P] machine and the light line represents CBD for PW at Clinac [C] machine.

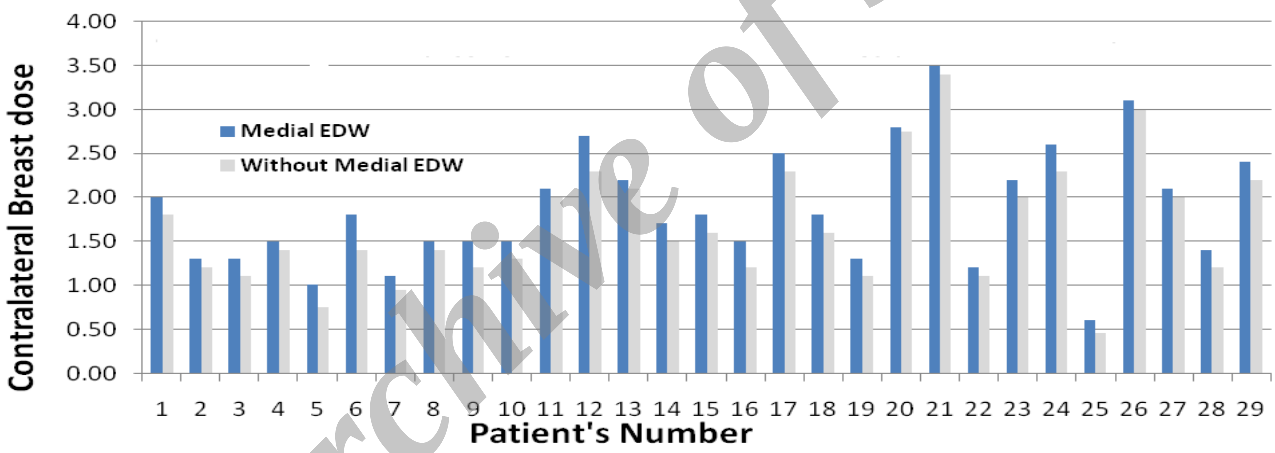


Figure 4. Comparison of contralateral breast dose: Medial EDW vs. without medial EDW on Varian's Clinac.

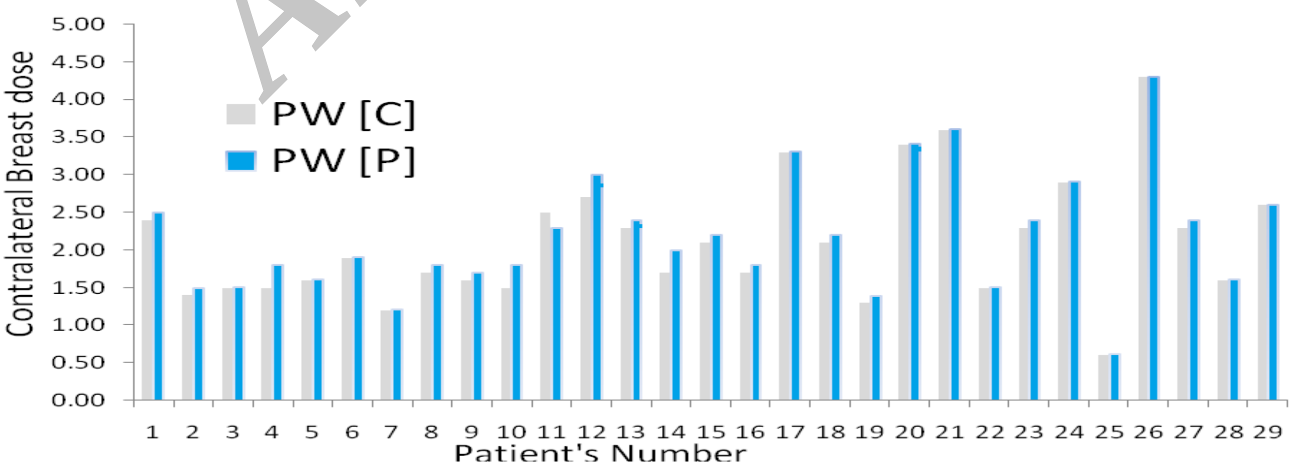


Figure 5. Comparison of contra lateral breast dose: PW [C] vs. PW [P].

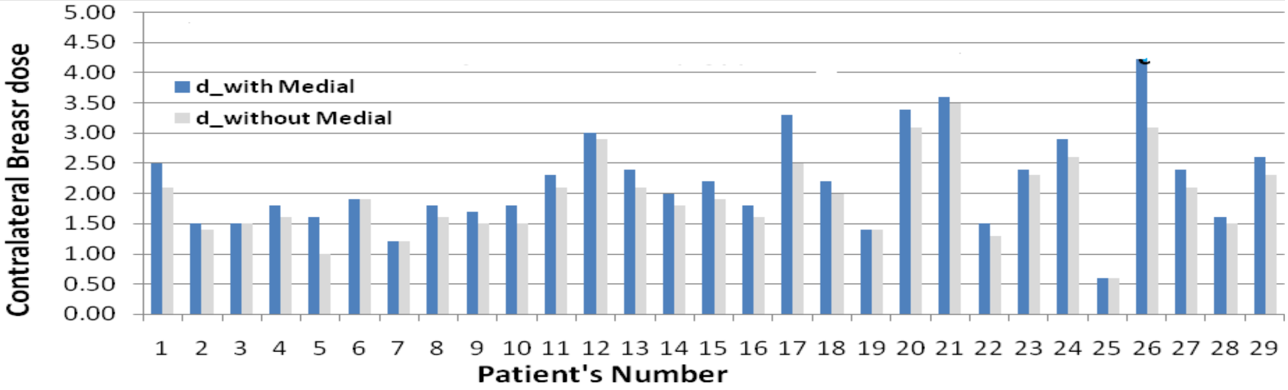


Figure 6. Comparison of contra lateral breast dose: Medial wedge vs without medial wedge on Primus.

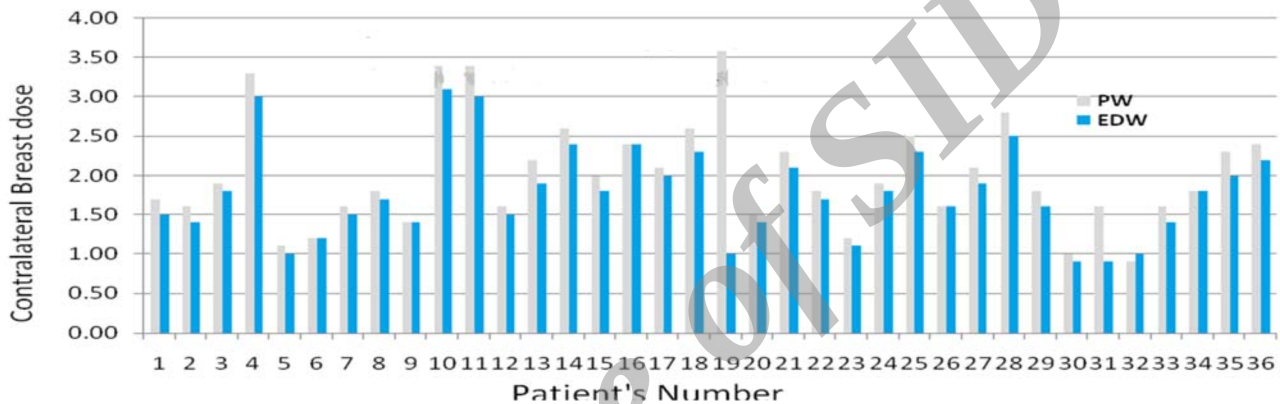


Figure 7. Comparison of contra lateral breast dose: PW vs. EDW on Varian's Clinac machine.

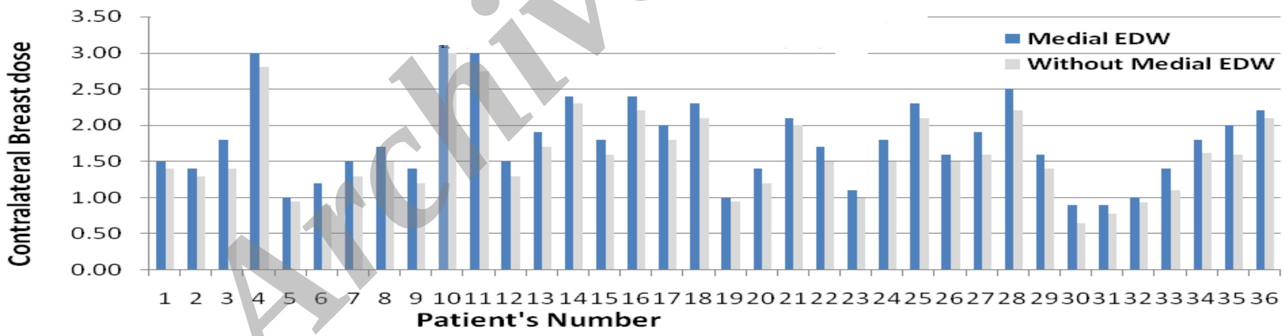


Figure 8. Comparison of Contra lateral breast dose: Medial EDW vs. without medial EDW on Varian's Clinac.

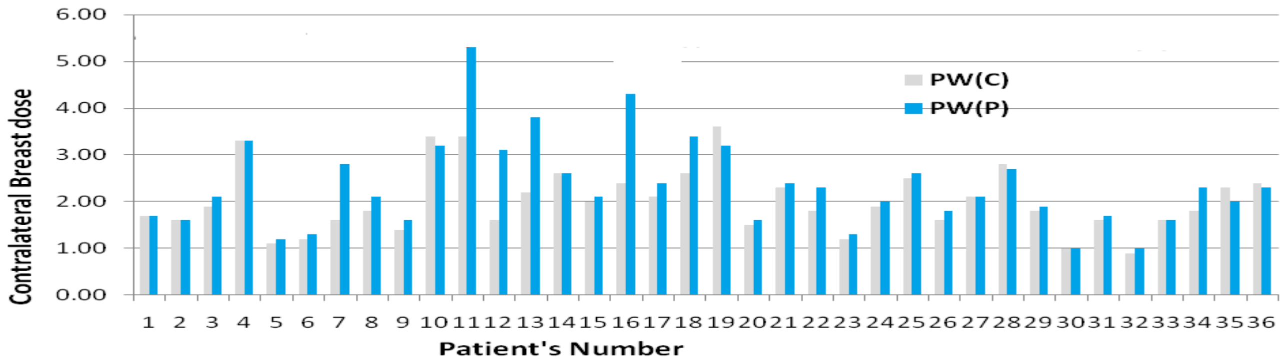


Figure 9. Comparison of contra lateral breast dose: PW(C) vs. PW (P).

In figure 10, the dark line represents contralateral breast dose (CBD) for medial wedge and the light line represents CBD for without medial wedge on Primus machine. It clearly depicts that for each patient, the contralateral breast dose for medial wedge is more compared to without medial wedge which advocates for non use of medial wedge.

The contralateral breast dose (along y-axis) is plotted against patient's Number (along x-axis). Contribution to contralateral breast dose in units of cGy under different treatment fields (lateral as well as medial fields) and wedges (physical wedge and Enhanced dynamic wedge) treated on Varian's Clinac 2100 C/D and Siemen's Primus is also depicted in a plot patient wise.

It is observed in dose calculation that:

Table 1. The contralateral breast dose mean difference is 0.25 cGy in breast case and 0.24 cGy in chest wall case as per total prescribed dose during the comparison of PW and EDW on Varian Clinac. EDW gives less CBD compared to PW.

PW compared to EDW on Varian's Clinac machine	
Patient Type	**CBD mean difference as per total prescribed dose in units of cGy**
Breast	0.25
Chest wall	0.24

Table 2. The contralateral breast dose mean difference is 0.19 cGy in breast case and 0.18 cGy in chest-wall case as per total prescribed dose during the comparison of medial EDW and without medial EDW on Varian Clinac. The medial wedge gives more CBD compared to lateral one.

Medial EDW compared to without Medial EDW on Varian's Clinac machine	
Patient Type	**CBD mean difference as per total prescribed dose in units of cGy**
Breast	0.19
Chest wall	0.18

Table 3. The contralateral breast dose mean difference is 0.08 cGy in breast case and 0.31 cGy in chest wall case as per total prescribed dose during the comparison of PW (Clinac) and PW (Primus).

PW (Clinac) compared to PW (Primus)	
Patient Type	**CBD mean difference as per total prescribed dose in units of cGy**
Breast	0.08
Chest wall	0.31

Table 4. The contralateral breast dose mean difference is 0.25 cGy in breast case and 0.51 cGy in chest wall case as per total prescribed dose during the comparison of medial PW and without medial PW on primus machine. The medial wedge gives more CBD compared to lateral one.

Medial EDW compared to without Medial PW on Primus machine	
Patient Type	**CBD mean difference as per total prescribed dose in units of cGy**
Breast	0.25
Chest wall	0.51

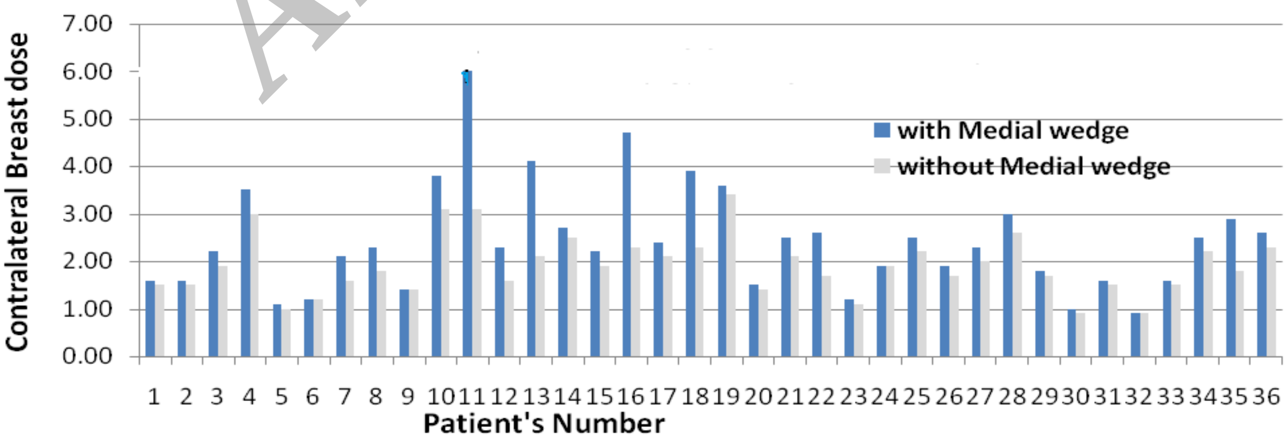


Figure 10. Comparison of contra lateral breast dose: Medial wedge vs. without medial wedge on Primus.

DISCUSSION

The incidence of secondary cancers in the contralateral breast after primary breast irradiation is several times higher than the incidence of first time breast cancer. Studies have shown that the scatter radiation to the contralateral breast may play a large part in the induction of secondary breast cancers. Reports have shown that the use of regular wedges, particularly for the medial tangential field, gives a significantly higher dose to the contralateral breast compared to an open field. This paper compares the peripheral dose outside the field using a physical wedge and dynamic wedge technique. PW is an absorbing block made by metallic material and inserted manually in the beam path at LINAC output and so it gives more scattering photons when primary photon beams interact with its materials. EDW gives less scatter dose compared to PW due to absence of scattering which results from the interactions of primary incident photons with PW metallic materials [21]. Previous studies have looked at contralateral breast doses. Kelly C *et al.* measure the CBD by comparing four primary breast irradiation techniques and advocates for EDW compared to PW [22]. Bhatnagar *et al.* also recommended the EDW compared to PW [23]. Tarcilla O, K F, L-Tsao L also favors the EDW employment in their research data [24]. Tarcilla O *et al.* evaluated the opposite breast dose and concluded that the medial wedge is the main contributor to CBD. Our data is also in accordance and shows that EDW gives less scatter dose compared to PW and hence gives less CBD as seen in figures - 3 to 10. Further, the medial wedge produces an increased scatter dose as it passes very close to contralateral breast and hence should be avoided. The dose received by the contralateral breast is capable in enhancing second breast malignancy. This contralateral dose is due to scattered and leakage dose which comes from materials present in beam path and is an important concern to clinicians.

CONCLUSION

This study is an analysis of differing doses to the contralateral breast using the enhanced dynamic wedge versus the physical wedge. The investigation of the effect of both wedges on contralateral breast (untreated) during primary breast irradiation demonstrates that the EDW produces less scattered dose compared to PW which can cause second breast malignancy. The enhanced dynamic wedge is a practical clinical advance which improves the dose distribution in patients undergoing breast conservation while at the same time minimizing dose to the contralateral breast, thereby reducing the potential carcinogenic effects. Furthermore, the medial wedge can cause second breast malignancy also and should be avoided in planning. Tissue equivalent material should also be used to complete the natural contour of the breast and to reproduce appropriate build-up and internal scatter.

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Conflict of interest: *Declared none.*

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