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Comprehensive Study of Varian's Enhanced Dynamic Wedge and Physical Wedge

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Background: *Wedge filters are generally used to alter the shape of isodose lines to achieve desired dose coverage to target and minimize the hyper dose as well.*
Aim: *Main aim of this study was to analysis the dosimetric features of Varian's physical wedge and enhanced dynamic wedge.*
Materials and Methods: *The plan was evaluated in Varian's eclipse planning system. In order to compare the isodose lines alteration, all the plans were prepared in water phantom with 10cmx10cm field size for 6 and 15MV photon. The physical wedges of angle 15 °, 30°, 45 °and 60°; and the same of enhanced dynamic wedges were taken for this study. Beam profiles were generated by using OCTAVIUS Detector 729 T10040 and MultiCheck software.*
Discussion: *In the current study, the dosimetric features of EDW and PW were studied and compared. All profiles for 6 and 15MV photons (for both EDW and PW) at depth 10cm and d_{max} were generated in slab phantom (PTW-Freiburg, Germany) of relative density 1.04 gm/cc*
Conclusion: *In this study, the dosimetric features of Varian's EDW and PW for 6 and 15MV photons were analyzed and compared. Number of monitor units, to deliver a particular dose, with EDW was found less than that of PW. This study recommends the use of EDW rather than PW in radiotherapy planning.*
Keywords: *wedge factor, physical wedge, Isodose line, enhanced dynamic wedge.*

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I. Background

Generally, wedges are used as beam modifier to improve the dose coverage to the target and to minimize hot spot as well. Wedge can also be used as tissue compensator or to alter the shape of isodose curves so that two beams can be angled with small hinge angle at the target volume without producing hotspot [1]. In the case of enhanced dynamic wedge, the required dose distribution can be achieved by one of the collimator jaws motion in two directions (IN and OUT) [2]. Plta et. al studied about field size dependence of wedge factor using the Varian Clinac-4 wedge filters and Philip's SL75/5 auto wedge [3].The wedge angle refers to the angle through which the isodose curves are tilted, relative to their normal position perpendicular to the beam axis at reference depth. The international commission on radiation units and measurements (ICRU) recommendation for reference depth is 10cm [4]. The presence of wedge filter in the beam path reduces the beam intensity and this must be taken into account during treatment planning. It is generally assumed that for wedged fields of different size, a single wedge factor measured for a reference field size is valid for calculation. The Physical wedges (PW) have been primary means of producing the wedged fields. Required wedged dose profiles can also be achieved by computer control motion of one of the jaws. Such type of wedge is called dynamic wedge [5], which was first introduced by Varian medical system in early 1990s in linear accelerator [6]. Dynamic wedge can provide angles of 15°, 30°, 45°, and 60° only for symmetrical field size up to 20cm width. Ability of dynamic wedge is significantly improved by introducing the concept of Varian's enhanced dynamic wedge (EDW). Now the EDW provides wedge angle of 10°, 15°, 20°, 25°, 30°, 45°, and 60° for both symmetrical and asymmetrical field sizes up to 30cm width. A number of studies have been conducted on PW and EDW [7-9]. However, so far studies related to comparison of Varian's PW and EDW has not been reported [10-13].The effect of enhanced dynamic wedge factors (EDWF) for symmetrical and asymmetrical photon fields have been discussed in many literatures [14-16].
Physical wedge is going to out of phase completely in future. Therefore, it is needed to understand the Physics and dosimetric features of EDW.

II. Aim

The main aim of this study was to analyse the dosimetric features of Varian's enhanced dynamic wedge and physical wedge in radiotherapy planning.

III. Materials and methods:

A comparison of beam profiles, wedge factors for PW and EDW, calculated MUs, Maximum dose, 95% dose coverage to target, depth of 50%isodose curves ,and the shape of toe and heel of 50% of isodose curve for reference field size 10cmx10cm were studied for 6 and 15 MV photon beams produced by Clinac-iX installed at Apollo Hospitals ,Bilaspur(Chhattisgarh),India. In the current study both physical and enhanced dynamic wedge of angle 15°, 30°, 45°, and 60°, were used. Measurements were performed in water phantom (30cmx30cmx30cm) and slab phantom of relative density 1.04 gm/cc with positional accuracy of dosimetry system+/- 0.5mm.

(a)Design of Physical Wedge:

The wedge filters on the Varian Clinac-iX accelerator have nominal physical wedge of angles of 15°, 30°, 45°, and 60° with four orientation (LEFT,RIGHT,IN ,OUT). These filters are made of lead and steel. It is illustrated in figure1.

The wedge factor is defined as the ratio of dose in water at reference point of measurement on the central axis with and without wedge for same number of Monitor Units (MUs). This is calculated with the following equation:

$$\mathbf{WF\ (FS,\ d) = D_w\ (FS,\ d)\ /\ D_o\ (FS,\ d)}$$

where D_W (FS, d) is the dose at a specified point 'd' along the central axis in a specified field size 'FS' with the wedge in place and D_o (FS, d) is the dose at the same point in an open field of equal dimensions for the same number of MU.

(b) Design of enhanced dynamic wedge

In the enhanced dynamic wedge technique, no external beam modifier is used to create dose profiles, instead wedge isodose profiles are created by the sweeping action of one of the jaws from open to closed position while the beam is 'ON'. Because of the jaw motion, different parts of the field are exposed to the primary beam for different length of time. EDW factor is defined as the ratio between the ion chamber integrated reading on the central axis of a wedged field and the integrated reading at the same depth for the open field having the same size and for the same number of monitor units **[17].** The dose rate and jaw speed are also varied during the treatment, which is the function of energy, field size and wedge angle. Two wedge orientations Y1-IN andY2-OUT are possible. The EDW uses a single segmented treatment table for all field sizes, with 30cm field width, the moving jaw travels a maximum distance of 29.5 cm with 9.5cm across the central axis. The EDW also allows the use of asymmetric fields. This creates the dose gradient across the field.

(c)Measurements

The measurements were performed in Clinac- iX, a dual energy accelerator (Varian Medical Systems). The wedge factors for EDW and PW for 6 and 15 MV photons were measured in water phantom by using FC65 farmer type chamber and UNIDOS E dosimeter (PTW-Freiburg, Germany) at reference depth 10cm. The profiles of 10cmx10cm field size for EDW and PW were generated at depth 10cm by using OCTAVIUS Detector 729 T10040 and MultiCheck software (PTW–Freiburg, Germany), version 6.1.7601. Isodose curves for both the photons 6 and 15 MV with 10cm x 10cm field size were generated for 15°, 30°, 45°, and 60° wedges (both EDW and PW). Eclipse treatment system (TPS), version 10.0 was used to generate the isodose curves. All the isodose curves were generated at SSD (source to surface distance) 100cm.

IV. Results

Dosimetric features of EDW and PW have been found different in this study. In profile of 60° PW has steep gradient rather than 60°EDW for both the photons 6 and 15 MV. Less number of monitor units (MU) is observed in the plan with EDW for same dose and reference point. Wedge factor has been found higher in EDW as compared to PW. The dosimetric features like profile and isodose curves of EDW for angle 15° and 30° are almost same. But for 45° and 60° angles, these features are significantly different. The percentage difference of wedge factor(WF) among PW and EDW increases as wedge angle increases. It is also found that the percentage variation in WF for EDW and PW is higher for 6MV rather than 15MV photon. This is displayed in figure 2.

V. Discussion

In the current study, the dosimetric features of EDW and PW have been studied and compared. The clinical advantage of Varian enhanced dynamic wedges (EDW) and Siemens virtual wedge (VW) have already discussed in many articles [18-20]. All profiles for 6 and 15MV photons (for both EDW and PW)at depth 10cm were generated in slab phantom (PTW-Freiburg, Germany) of relative density 1.04 gm/cc. Isodose curves 100%, 90 %, 80%, and 50% for 6 and 15MV photons were generated in TPS. Wedge factors for 6 and 15MV were measured at 10cm depth keeping 'IN' orientation of wedges.

(a) Comparison of wedge factors: The physical and the enhanced dynamic wedge factors for the selected angles 15 °, 30°, 45°, and 60° were compared. The wedge factors for 6 and 15 MV photons are shown in table 1. The wedge factor for EDW has been found higher than PW in each angle starting from 15 ° to 60 °. This is tabulated in table 1. Percentage variation of wedge factor among EDW and PW is tabulated in table2.

(b) Comparison of profiles: Profiles of EDW and PW are not same. The profile gradient is almost same for 15°and 30° in both 6 and 15MV photon, but the difference has been observed in gradient for 45° and 60° wedge for 6 and 15 MV photons. PW of 60° has steep gradient rather than EDW. The wedge profile of Varian's PW and EDW for 6 and 15 MV photons of different wedge angles are displayed in figure 3 (a) and (b).

(c) Comparison of isodose curves: All the isodose curves of 100%,90%,80% and 50% are generated in virtual water phantom by using eclipse TPS, at SSD=100cm. These curves are generated for both the photons 6 and 15MV. Isodose curves for 15° and30° are almost same. But 80% and 50% isodose curves for both the photons are significantly differed. This is illustrated in figure4 (a) and (b).

VI. Conclusion

In this study, the dosimetric features of Varian's EDW and PW for 6 and 15MV photons were analyzed and compared. Number of monitor units, to deliver a particular dose, with EDW was found less than that of PW. This study recommends the use of EDW rather than PW in radiotherapy treatment planning.

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Figures: 1, 2, 3a& b, 4a& b.
Tables: 1 and 2

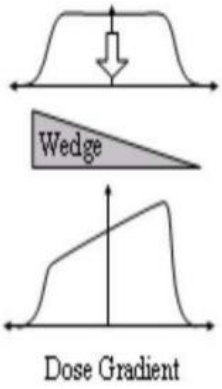


Figure 1: Wedge with profile's gradient effect.

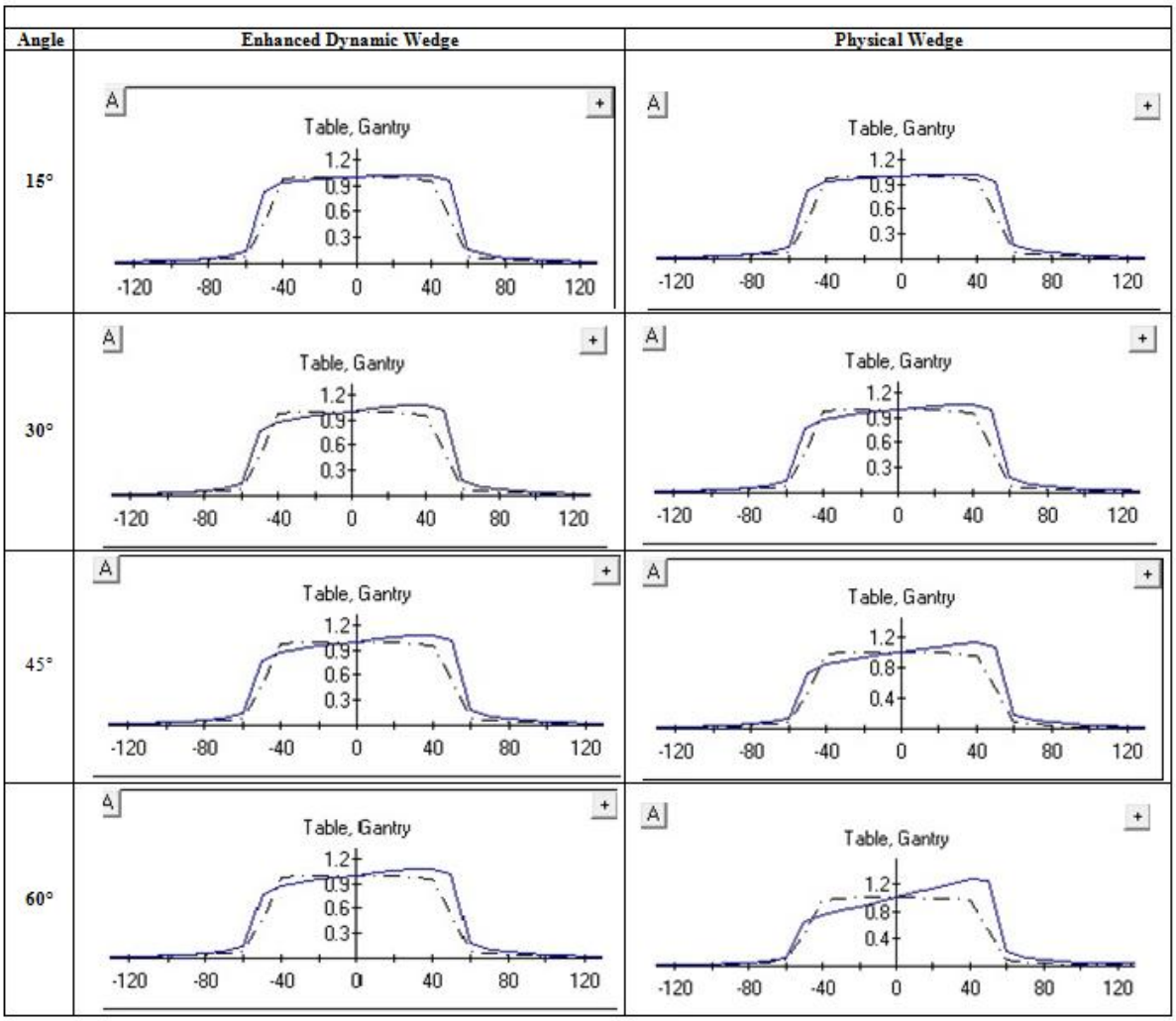


Figure 3a: Profiles at 10cm depth for Varian's physical and enhanced dynamic wedge for 6MV photon.

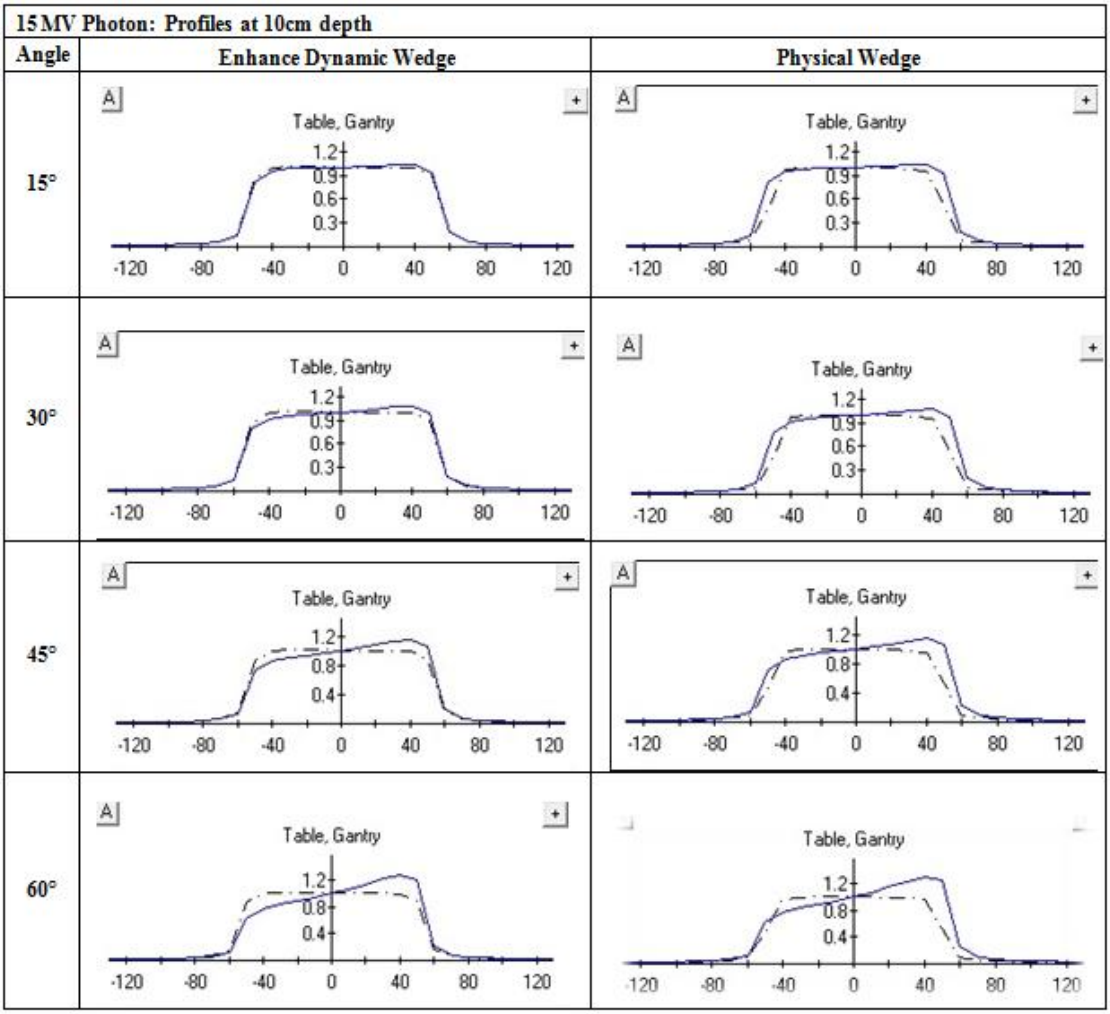
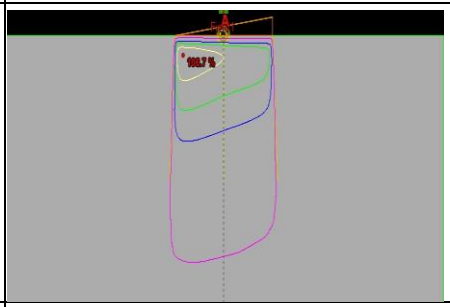
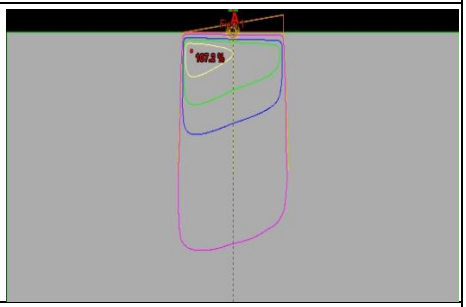
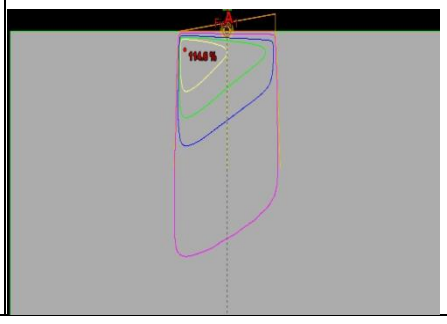
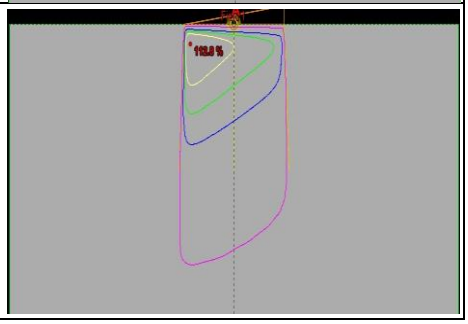


Figure 3b: Profiles at 10cm depth for Varian's physical and enhanced dynamic wedge for 15MV photon.

WedgeAngle	EDW	PW
15°		
30°		

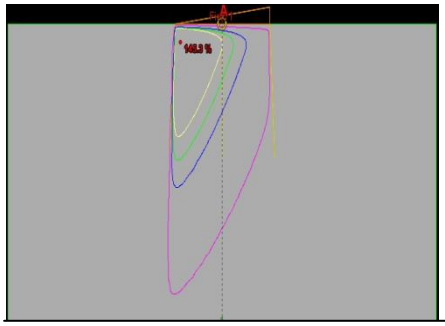
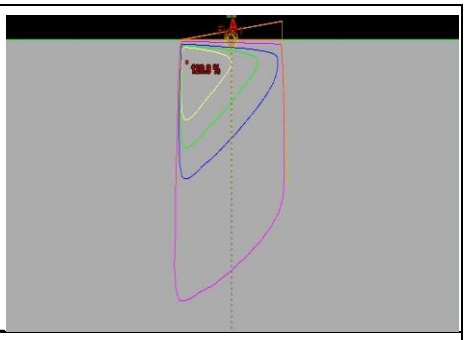
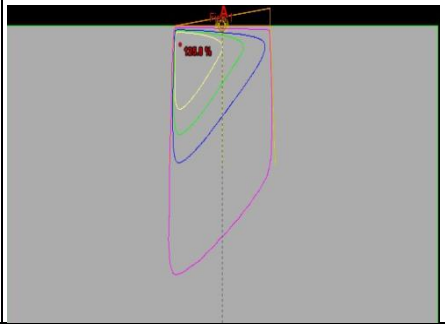
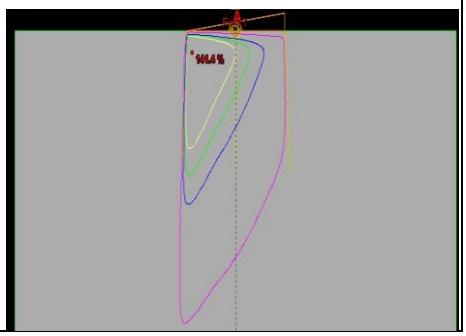
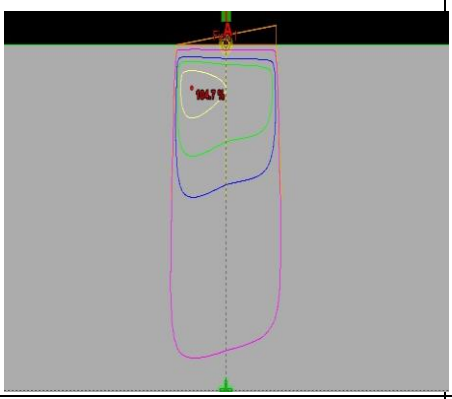
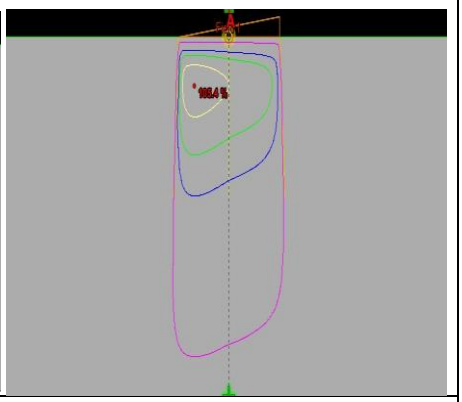
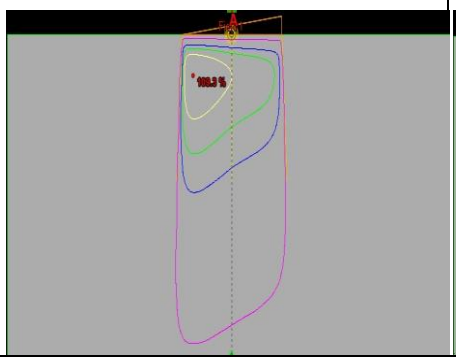
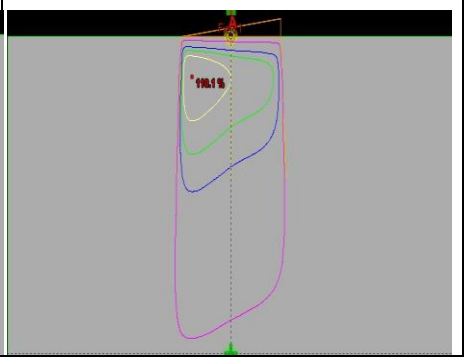
45°		
60°		

Figure 4a: Isodose curves [100%, 90%, 80% and 50%] for 6MV photon.

Wedge Angle	**EDW**	**PW**
15°		
30°		

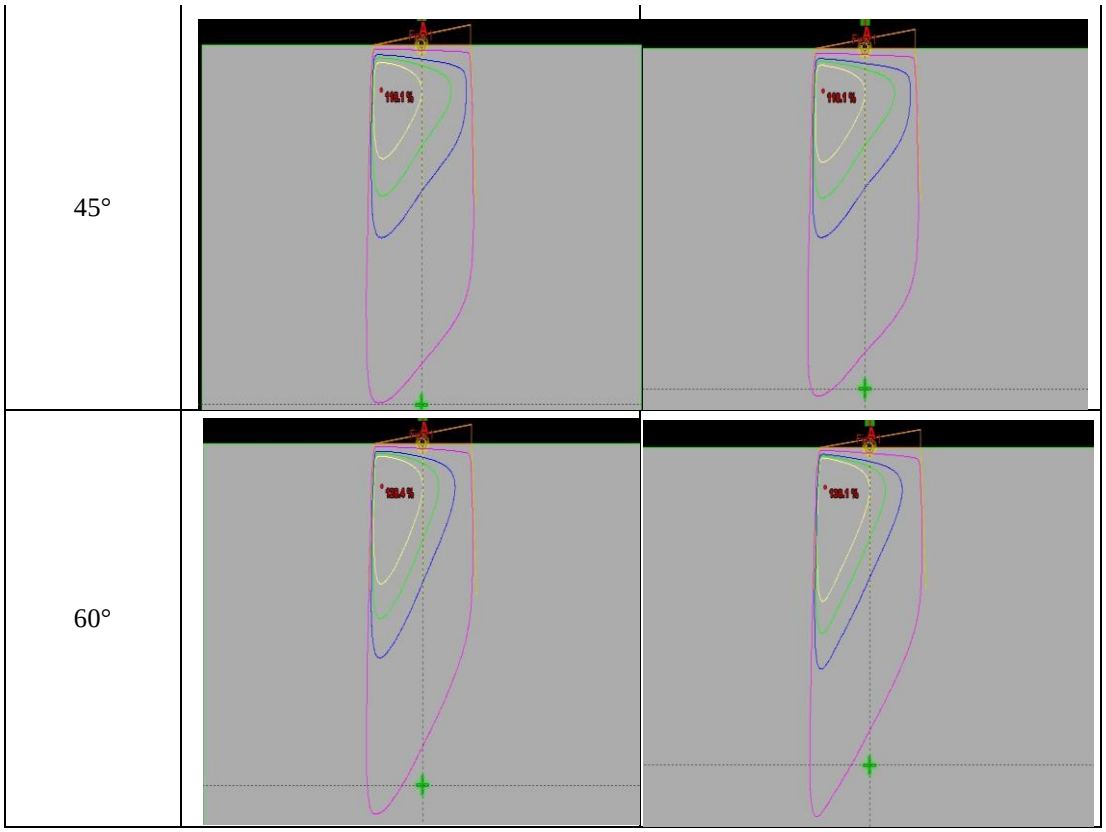


Figure 4b: Isodose curves [100%, 90%, 80% and 50% are displayed] for 15MV photon

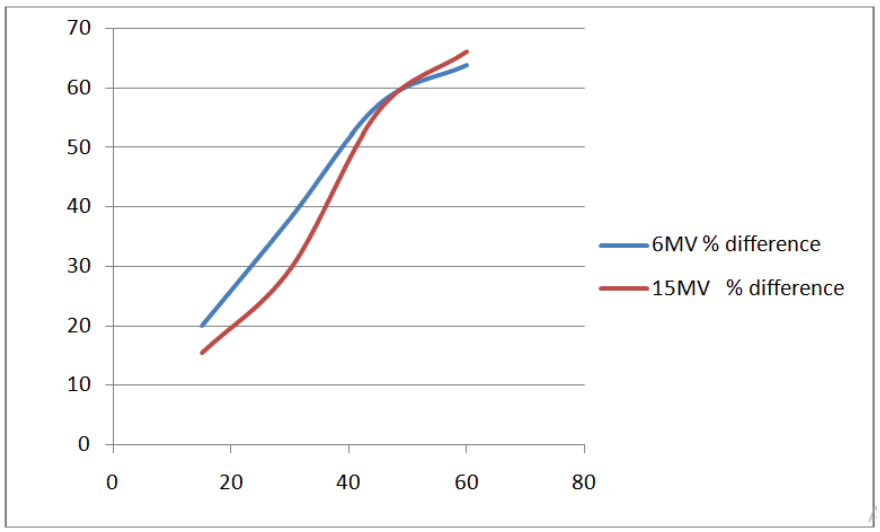


Figure 2: % difference of wedge factor with different angles of EDW and PW for 6 and 15 MV photons.

Table 1: Wedge factors of EDW and PW for 6 and 15MV at 10 cm depth.

6MV			15MV	
Wedge Factors at depth =10cm			Wedge Factors at depth =10cm	
Angle	**EDW**	**PW**	**EDW**	**PW**
15°	0.9241	0.7705	0.9409	0.8150
30°	0.8523	0.6171	0.8829	0.6812
45°	0.7704	0.4901	0.8136	0.5210
60°	0.6603	0.4030	0.7154	0.4306

Table 2: % difference of WF among PW and EDW for 6 and 15 MV photon.

6MV		**15MV**
Angle	**% difference**	**% difference**
15	19.93	15.44
30	38.11	29.60
45	57.19	56.16
60	63.84	66.14

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