Comparative Study of Varian’s Enhanced Dynamic Wedge and Physical Wedge, and Their Dosimetric Impact on Radiotherapy Plan In Genitourinary Cancer Using 4 Field Box Technique

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Abstract:

Background: Wedge filters are generally used to alter the shape of isodose lines to achieve desired coverage to target and to reduce the hot spot as well.

Purpose: The main purpose of this study was to compare the dosimetric properties of Varian’s physical wedge and enhanced dynamic wedge, and their dosimetric impact in the treatment of genitourinary cancer using 4 field box technique.

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. The wedge factors were calculated in water phantom by using FC65 farmer type chamber. Beam profiles were generated by using OCTAVIUS Detector 729 T10040 and MultiCheck software.

Discussion: Alteration in isodose curves, dose coverage to target, PTV-mean dose, modal dose, median dose and hotspot were compared for all 15°, 30°, 45° and 60° EDW and PW for 6 and 15MV photons. MUs of each plan standard deviation generated and compared for all 22 patients.

Conclusion: The dosimetric properties of EDW and PW are not same for same angle of wedges; and the EDW gives better coverage, less hyper dose and comparatively less MUs than PW. Hence the use of EDW rather than PW in 4filed box technique is a prudent practice.

Keywords: Physical wedge, Isodose line, enhanced dynamic wedge, profile
Introduction:

In radiotherapy, wedges are commonly used as beam modifier to improve the dose coverage to the target and to reduce hotspots as well. 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)[1]. Wedge filters can also be used as missing tissue compensators or wedge pairs to alter the shape of isodose curves so that two beams can be angled with small hinge angle at target volume without creating any hotspot[2]. 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[3]. 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 must be measured for a reference field size, is valid for calculation. Pita et al. has already examined field size dependency of a wedge factor using the Varian Clinac-4 wedge filters and Philip’s SL75/5 auto wedge [4]. The Physical wedges (PW) have been the primarily means of producing the wedged fields. The 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]. The dynamic wedge can provide angles of 15°, 30°, 45°, and 60° only for symmetrical field size up to 20cm width. The ability of dynamic wedge are 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].

In future, Physical wedge will be totally out of use. It is, therefore, need to understand the physics and dosimetric impact of EDW in radiotherapy plan.

Purpose:

The main purpose of this study was to analyze dosimetric properties of Varian’s physical wedge and enhanced dynamic wedge, and their impact in radiotherapy planning in genitourinary cancer patients using 4 field box technique.

Materials and methods:

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 Hospital, 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 by using water phantom (30cmx30cmx30cm) and solid phantom with positional accuracy of dosimetry system +/- 0.5mm.

(a) Design of Physical Wedge:

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

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:

\[ \text{WF (FS, d)} = \frac{\text{Dw (FS, d)}}{\text{Do (FS, d)}} \]

where \( \text{Dw (FS, d)} \) is the dose at a specified point ‘d’ along the central axis in a specified field size ‘FS’ with the wedge in place and \( \text{Do (FS, d)} \) 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 technique of enhanced dynamic wedge, no external beam modifier is used to create dose profiles, instead wedge isodose profiles are created by the sweeping action 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\cite{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 and Y2-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 9.5 cm 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 carried out in Clinac- iX, a dual energy accelerator (Varian Oncology System). The wedge factors for EDW and PW for 6 and 15 MV photons were measured in water phantom (35cm x 35cm x 35cm) by using FC65 farmer type chamber and UNIDOS E eclemeter (PTW, Germany) at reference depth 10 cm. The profiles of 10 cm x 10 cm field size for EDW and PW were generated at depth 10 cm by using OCTAVIUS Detector 729 T10040 and MultiCheck software (PTW–Freiburg, Germany), version 6.1.7601. Isodose curves for 6 and 15 MV photons with 10 cm x 10 cm field size were generated for 15°, 30°, 45°, and 60° wedges (both EDW and PW) by using eclipse treatment planning system (TPS, Varian oncology system), version 11.0. All plans were generated by using 4 field box technique (4F Box). Photon 6MV or 15MV or both was used in patient’s treatment planning as per clinically required. PTV mean dose, modal dose, median dose, maximum dose, 95% of prescribed dose coverage to target (V95) and number of MUs were taken into consideration.

Results:

The dosimetric properties of PW and EDW are quite different. In the profile of 60° PW has steep gradient rather than 60°EDW for both the photons 6 and 15 MV. All plans with EDW have comparatively less MUs than PW. This is illustrated in figure 1 and 2. No significant differences are observed in maximum and minimum value of PTV mean dose, PTV-modal dose and PTV- median dose as it is tabulated in table 1. Maximum mean dose to rectum and bladder are found almost same in both type of the plan. It is tabulated in table 2. Standard deviation is reported comparatively higher in PW. Wedge factor has been found higher in EDW as compare to PW.

Discussion:

In the current study, the dosimetric characteristics of EDW and PW and its dosimetric impact on radiotherapy treatment plan for genitourinary cancer patients were studied and compared. For comparing the impact of EDW and PW, 22 patients were taken for this study and 50Gy dose was prescribed to PTV in 25 fraction, per fraction daily, and five days a week. The clinical advantage of Varian enhanced dynamic wedges (EDW) and Siemens virtual wedge (VW) have already discussed in many articles\cite{18-27}. All profiles for 6 and 15 MV photons and for EDW and PW at depth 10 cm were generated in slab phantom (relative density 1.04 gm/cc). Isodose curves 100%, 90%, 80%, and 50% for 6 and 15 MV photons were generated in TPS. Wedge factors for 6 and 15 MV were measured at 10 cm 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 3. The wedge factor for EDW has been found higher than PW in each angle starting from 15° to 60°.

(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 15 MV photon, but difference observed in gradient of 45° and 60° wedges for 6 and 15 MV photon. PW of 60° has steep gradient as compare to EDW. The wedge profiles of Varian’s PW and EDW for 6 and 15 MV photon of different wedge angles are displayed in figure 3 and 4.

(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, keeping SSD=100cm. These curves are generated for both the photons 6 and 15 MV. Isodose curves for 15° and 30° are almost same. But 80% and 50% isodose curves for both the photon 6 and 15 MV are significantly differed. This is illustrated in figure 5 and 6.

(d) Clinical comparison in genitourinary cancer patients: 4F Box technique has been
used in radiotherapy planning for all 22 patients taken for this study. Number of MUs is found less in all plans done with EDW as compared to PW. Global maximum dose is reported 55.1 Gy in a plan with EDW. Standard deviation has been found less in all plans done with EDW as compare to PW. This is shown in figure 7 and 8. PTV-mean dose is found equivalent in both type of plans.

**Conclusion:**
The use of EDW in 4F Box technique reduces the number of MUs as compared to PW, resulting reduction in treatment time; and also reduces the neutron’s menace when 15MV photon is used in radiotherapy plan. It also provides ease to operators in treating the patients and so that they can concentrate more on patient setup. The dosimetric features of EDWs and PWs are significantly different. Conclusively, the current study advices the users to use EDW, if required, in 4F Box radiotherapy plan for genitourinary cancer patients.

**References:**

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