Introduction
One of the methods of treating of cancerous patients is radiation therapy in the form of curative or palliative by using a Co-teletherapy machine or linear accelerators (Abral and Purdy, 1980). Acceptable dose uniformity is within ±5% in radiation therapy, wedge filters are commonly used for uniforming, modifying or optimizing isodose distribution in the target volume for better dose delivery (Khan and Gibbons, 2014). Wedge filters are one of the several types like physical or dynamical. The physical wedge is usually made of dense materials such as lead or steel and is mounted on a tray and inserted in the radiation field at a specified distance from the patient. Dynamical wedge generated electronically through the motion of independent jaws within the treatment region. Most accelerators are provided with a selection of wedges that are mounted externally on the head of the machine. The wedge isodose angle has been defined as the angle between the isodose curve passing through reference depth and the normal horizontal line on the central axis on this depth. According to the international commission on radiation units and Measurements (ICRU), the path of the radiation beam decreases the dose rate and this must be taken into account in dose calculation by a wedge transmission factor, defined as the ratio of dose in water at a point on a central axis with and without the wedge. In some systems of radiation therapy a single universal wedge maybe used that mounted inside the head and moved by remote control and is named by motorized wedge (Bentel et al., 1982). For single 600 motorized wedge, Paula and et al. (1985) explained a new method for obtaining an effective wedge angle by combining an open field with a 600 motorized wedge with specified weighting doses that can be determined as the ratio of the slopes of the central-axis depth dose curves for open and wedge fields (Petti and Siddon, 1985). For a motorized wedge, Rajesh Kumar and etal. (2011) used an analytical approach between the isodose curve passing through reference depth and the normal horizontal line on the central axis on this depth. According to the international commission on radiation units and Measurements (ICRU), the path of the radiation beam decreases the dose rate and this must be taken into account in dose calculation by a wedge transmission factor, defined as the ratio of dose in water at a point on a central axis with and without the wedge. In some systems of radiation therapy a single universal wedge maybe used that mounted inside the head and moved by remote control and is named by motorized wedge (Bentel et al., 1982). For single 600 motorized wedge, Paula and et al. (1985) explained a new method for obtaining an effective wedge angle by combining an open field with a 600 motorized wedge with specified weighting doses that can be determined as the ratio of the slopes of the central-axis depth dose curves for open and wedge fields (Petti and Siddon, 1985). For a motorized wedge, Rajesh Kumar and etal. (2011) used an analytical approach...
for an arbitrary effective wedge angle. The relationship was established between the wedge beam weight and effective wedge angle (Kumar et al., 2012). Inhikar Rajesh and et al. (2007) estimated the transit dose for motorized wedge treatment in the Equinox telecobalt machine. The actual measurements carried out with ion chamber for universal wedge and motorized wedge showed no variation between the dose delivered with TLD measurement (Kinhikar et al., 2007b). The motorized wedge filter has a number of advantages, like no probability of physical injury to operators and patient; no need to handle physical wedges; making wedge selection faster and easier, which results in higher patients throughout and less fatigue for operators and flexibility to generate arbitrary wedge angle instead of the limited standard angles. Clinical commissioning of a motorized wedge filter for a Theratron Equinox telecobalt unit has been reported in the literatures (Kinhikar et al., 2007a; Sahani et al., 2009).

Tamer Dawod (2015) evaluated the motorized wedge supported by the dosimetric performance 3-D treatment planning system for Electa Precise linear accelerator by comparing the calculated and measured doses for symmetric and asymmetric wedge fields in depth of d_max, 5cm, 10cm, 20cm in water phantom for 6mv and 15mv photon beams. By using 0.125cc ionization chamber a good agreement was found between calculated and measured dose. Maximum deviation was not longer than %5. This deviation for a symmetric field was less than asymmetric and increased with increasing wedge angle. The result of this study showed that Electa precise with motorized wedge for symmetric and asymmetric field is adequate for the clinical applications. In 2007, Rajesh A. Kinhikar et al. evaluated the telecobalt Teletron Equinox-80 with a single motorized wedge. They configured Eclipes 3-D treatment planning system for Theratron Equinox telecobalt machine. The actual wedge-shaped fields in the reference depth 10cm. For this purpose, profiles and isodose lines combining two wedged shape fields are drawn in the blue water phantom for depth 10 cm by 0.13cc ionization chamber as shown fig. 1.

According to Figure 1, one can write:

\[ \tan \phi = \frac{MN}{U} = \frac{ON-OM}{U}, \tag{1-a} \]
\[ \tan \phi = \frac{AB}{U} = \frac{(OA)(OA)-OM}{U}, \tag{1-b} \]
\[ \tan \phi = \frac{(AB)}{U} = \frac{(OB'-OA')}{U}, \tag{1-c} \]

If the wedge waithings of two fields are respectively \( \alpha \) and \( 1-\alpha \), multiplaying both sides of Eq. (1-b)by \( \alpha \) and Eq. (1-c)by \( 1-\alpha \), gives

\[ \tan \phi = \alpha (\frac{(OA)(OA)}{U}) - \frac{ON-OM}{U}, \tag{2-a} \]
\[ (1-\alpha) \tan \phi = (1(\alpha)(OB'-OA'))/U \tag{2-b} \]

by combining two Eqs. (2a)and(2b), according to Figure 1, one can obtain

\[ \tan \phi + (1-\alpha) \tan \phi = \frac{(ON-OM)}{U} \tag{3} \]
\[ \frac{(\alpha OB+(1-\alpha)OB')}{U} \tag{3} \]
\[ (\alpha OA+(1-\alpha)OA') \]

Measurements

Relative dosimetry is done for obtaining PDD, profile and isodose curves. Using scanditronixWelhopher water blue phantom, MCU500EU, OmniPro_Accept software and 0.13cc ionization chamber for 6MV photon beam of varian2100C/D linac in depths of 1, 4, 7, 10, 13cm of 10cm for universal physical wedges (15°, 30°, 45°, 60°) and reference field of 10.10cm², PDD, profiles and isodose lines curves are plotted.

Results

Using ScanditronixWelhopher water blue phantom, CU500E, OmniPro_Accept software and 0.13cc ionization chamber for 6MV photon beam of varian2100C/D linac the percentage of depth dose curves, profiles (for 10.10 cm² wedge fields 0°, 15°, 45° and 60° in depths of 1, 4, 7, 10, and 13 cm are obtained from the relative dosimetry. Combining the profiles gives isodose curves. For example,

\[ \alpha = \tan \theta - \tan \phi \]
\[ /\tan \phi \]
\[ \alpha \]

Theory

For determination of an arbitrary effective wedge angle \( 0 \) by combining the standard, universal wedge angles \( \phi \) and \( \phi' \), one can obtain a weighting factor for this combination from the isodose lines or profiles of these wedge shaped fields in the reference depth 10cm. For this purpose, profiles and isodose lines combining two wedged shape fields are drawn in the blue water phantom for depth 10 cm by 0.13cc ionization chamber as shown fig. 1.
these curves a given or 10.10 cm², 45° wedge angle fields in Figures. 2 (a, b, c).

For two arbitrary weighting α=20% and α=40%, the Eq.7 is examined. By combining four standard wedges (15°, 30°, 45°, and 60°) and open fields from Eqs.(5 and 7) the effective angle θ are derived for two above values α and tabulated in tables 1 and 2.

By using Eq.7 for these two values the related profiles are combined and plotted by the OmniPro software and the slope of these effective wedge angle profiles are measured and compared with analytical angle tabulated in tables 1 and 2.

Discussion

In this study an analytical method for generating an effective wedge arising of a combination of two physical wedges (PW) with any weighting is presented and compared with measurements and other researches.

Paula and Siddon describe a technique for determining an effective wedge angle from a combination of open and motorized 60° wedge angle fields with data from the Philips.SL/75-6MV accelerator by weighting factor parameter that interpreted physically as the ratio of the slopes of the central depth dose curves of the effective motorized wedge fields. Their results were consistent with the data within 3°(Petti and Siddon, 1985).

Jingeng Zhu introduces a new method for generating wedge-shaped dose distribution through dynamic multileaf collimator dose delivery rather than computer controlled jaw motion. His method tested by the shape of standard wedges (15°, 30°, 45°, and 60°) the maximum deviation is within 2.8% (Zhu, 2005).

By a combination of physical motorized wedge field and open field with different weighing factors, Rajesh et al. generated the desired wedge angle -shaped (0° to 60°) field. Their formula is similar to Eq.5 for φ’=0 and therefore is a special case of our formalism of the measured and calculated MV telecobalt Equinox_80. The obtained angles are well agreed within 2° (Kinhikar et al., 2012b).

In a similar research in 2010, Misbah Ahmad et al. reported maximum variation of 8.9% between EDW and PWs. Rajesh Kumar and et al for planed motorized wedge angles in different fields reported difference between planned and measured wedge angles less than 2°.

In another similar study, Sathiyan Saminathan et al., in 2012 in Greater Poland Cancer Centre the dosimetric properties of varian EDW and PW were analyzed and compared in 6MV photons. The maximum variation in the output factor is between 1.5%-3.8% for all fields and EDW has a higher wedge factor compared to that of the physical wedge for a particular wedge angle (Saminathan, 2012).

Table 1. The Combination of two Wedges Fields (15°,30°,45°, and 60°) with Weighing %40 and %60 and Generated Effective wedge Angle in Comparison with Measurement

|        | measurement | 40       | 60   | 45       | 30   | 15       | 0     |
|--------|-------------|----------|------|----------|------|----------|-------|
| 0      | 40.9        | 43.7     | 28.1 | 30.96    | 21.4 | 21.3     | 10.7  |
| 15     | 47.2        | 47.3     | 35.4 | 36.05    | 27.6 | 27.4     | 26.6  |
| 30     | 51.3        | 50.6     | 41.3 | 40.7     | 36.6 | 38.3     | 29.7  |
| 45     | 52.7        | 53.6     | 46.9 | 45.8     | 39.2 | 39.7     | 32.1  |
| 60     | 50.4        | 51.1     | 51.1 | 51.1     | 51.1 | 51.1     | 51.1  |

Table 2. The Combination of two Wedges Fields (15°,30°,45°, and 60°) with Weighing %20 and %80 and Generated Effective wedge Angle in Comparison with Measurement

|        | measurement | 20       | 80   | 45       | 30   | 15       | 0     |
|--------|-------------|----------|------|----------|------|----------|-------|
| 0      | 51.2        | 51.9     | 37.5 | 38.6     | 28.3 | 27.45    | 12.3  |
| 15     | 53.3        | 53.2     | 41.5 | 40.8     | 31.5 | 30.3     | 20.1  |
| 30     | 55.1        | 54.6     | 43.8 | 42.9     | 35.3 | 35.75    | 21.9  |
| 45     | 52.7        | 53.6     | 48.8 | 48.2     | 39.5 | 39.99    | 30.2  |
| 60     | 50.4        | 51.1     | 51.1 | 51.1     | 51.1 | 51.1     | 51.1  |
et al., 2012). In this research the wedged angle obtained by the presented formalism and measurement was less than 3° that is comparable with the studies of Tamer Dawod on the motorized 60 wedge angle of 6MV Electa Precise linac (Saminathan et al., 2012). Furthermore, it is consistent with the method analytically performed by Petti and Siddon for effective wedge angles with a 60° universal motorized wedge that by comparison with measurement had a deviation within 3° over the range of wedge angle and field size (Petti and Siddon, 1985). In our research the maximum deviation with measurement are less than 3° as shown in Table 1 and 2.

In conclusion, the effective wedge angle obtained by a combination of the universal wedge fields for clinical applications is exactly acceptable and in agreement with measured data.

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