ORIGINAL ARTICLE

Behaviour of wedges for different field sizes and depths

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ABSTRACT

Background: The relative dosimetry plays vital part in treatment planning of patients. Factors such as percent depth doses, tissue maximum ratios, tray factors, wedge factors, etc., determined from the relative dosimetry, affects the patient dose. The current study intended at measuring and evaluating the wedge factor for different field sizes and depths for ^{60}Co teletherapy unit GWXJ80 of NPIC China.

Methods: The measurements for 15°, 30°, 45° and 60° wedges for different field sizes and depths on ^{60}Co teletherapy unit GWXJ80 of NPIC China installed at Nuclear Institute of Medicine and Radiotherapy (NIMRA), Jamshoro, Pakistan, were done in water phantom of 30x30x30 cm^3 dimension at 80 cm Source-to-Surface Distance (SSD) by using calibrated Farmer's NE 2570 electrometer with NE 2571 0.6 cc ionization chamber.

Results: The evaluation of data showed that there was no significant difference in factor of each of wedge being analyzed for different field sizes and depths.

Conclusion: The current study suggests that wedge factor for a particular wedge is approximately a constant value irrespective of field size and depth. The measurement for only one field size at one depth is sufficient to calculate the wedge factor for a particular wedge.

Keywords: ^{60}Co, Quality assurance, Relative dosimetry, Field size, Depth.

INTRODUCTION

In radiotherapy, absolute dosimetry or simply dosimetry, is a systemic procedure for measuring the absorbed dose (also termed as calibration) in unit of Gy (Gray) of teletherapy machine directly under reference conditions (same field size at same depth with constant gantry and collimator angles and at a fixed SSD). All further measurements are then compared to this known dose under specific conditions termed as relative dosimetry [1]. From these relative dosimetry variables, wedge filters are one of beam modifying devices and are being used to optimize the dose distribution in patients' target tissues [2-5]. Due to the presence of wedge filter in the path of radiation beam, attenuation occurs in the beam intensity which can be expressed in the form of wedge factor (WF) at the central axis of the radiation beam [2, 4]. This attenuation is taken into consideration for calculating the patient dose and treatment time (TT) or monitor units (MU) [4-6].

Most of the times single WF is used for the patients' TT or MUs, with usually measurements made for the reference field size of 10 × 10 cm^2 at reference depth of d_{max} or d_5 or d_{10} [3]. Various researchers [2-32] have conducted studies on wedge factors for LA (Linear Accelerator), ^{60}Co (cobalt-60) or for both type of treatment machines (LA, ^{60}Co) as sumarized in Table 1. As seen from Table 1, several studies [2, 3, 6-23] have been conducted for LA only, whereas other studies [24-27] for both (LA and ^{60}Co) and still other studies [4, 5, 28-32] for ^{60}Co only. This study aimed at computing and comparig the differences in WFs of different wedges for different field sizes at different depths.

MATERIAL AND METHODS

The WF of different wedge angles (15°, 30°, 45° and 60°) on different field sizes at depths of 05 and 10 cm were studied for GWXJ80 of NPIC China installed at Nuclear Institute of Medicine and Radiotherapy (NIMRA) Jamshoro Pakistan were done in water phantom with 30x30x30 cm^3 dimension at 80 cm Source to Surface Distance (SSD) using calibrated NE 2570 Farmer Electrometer and 0.6 cc Farmer ionization chamber NE 2571. All of the measurements were performed at 0° gantry and collimeter angles [33, 34]. The setups for non-wedged and wedged beams are shown in Figures 1 and 2.

The calculation of WF for a specific field size at particular depth in water phantom was done by using the formula:

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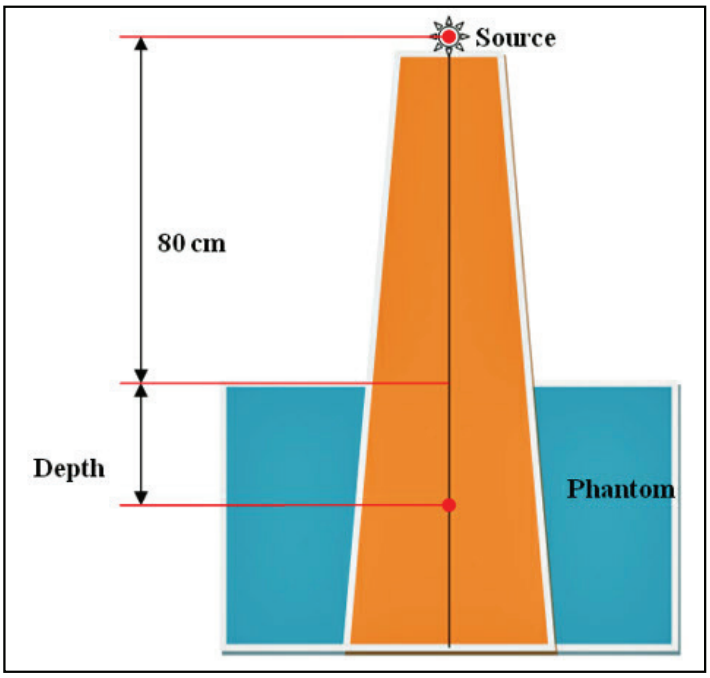

Figure 1. Measurement setup for open beam or non wedged beam

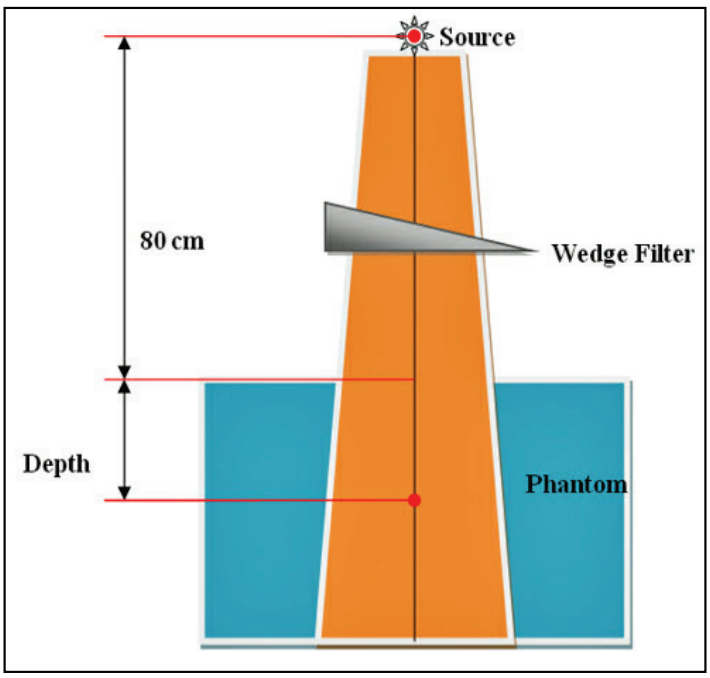

Figure 2. Measurement setup for wedged beam

$$WF = \frac{\text{Dose measured with wedge filter}}{\text{Dose measured for open beam or without wedge filter}}$$

The measurement for specific wedge is to be one at same set of parameters (like for same field size at same depth, for the same dose or time of exposure with constant gantry and collimator angles and at fixed SSD [2, 27, 33, 34].

RESULTS

The WF for different field sizes at different depths (05 and 10 cm) along with their means and standard deviations (SD) for ^{60}Co teletherapy unit GWXJ80 of NPIC China installed at Nuclear Institute of Medicine and Radiotherapy (NIMRA) Jamshoro Pakistan have been congregated into in Tables 2 and 3 whereas their graphical representation have been shown in figures 3 to 6.

DISCUSSION

The results from other researchers on wedge factors for LA, ^{60}Co or for both type of treatment machines (LA, ^{60}Co) along with current study on ^{60}Co teletherapy machines [2-9, 11,13, 14, 16-19, 22,23,25, 27-32] has been summarized in Table 4. As seen in the table 4, studies [2, 3, 6-9, 11, 13, 14, 16-19, 22] shows WF for LA only, whereas studies [23, 25, 27] shows factor for both (LA and ^{60}Co) and studies [4, 5, 28-32] for ^{60}Co only. For LA, the WF differed is between 1% to 25%, whereas for both (LA and ^{60}Co) and for ^{60}Co only including current study, the difference in WFs is between 2%-9% and 0.5%-5.5% respectively.

The current study is comparable and judged to other studies done for WF for ^{60}Co only or with all other data available for LA, or for both (LA and ^{60}Co). Most of the available data (specially for ^{60}Co only) did not show any significant influence on the Wedge factor [2, 16].

Small negligible variations within about ±2.5% for most of WF have been observed which can affect little bit on dose of the patient. The overall error in dose delivery to patients should not go beyond to ±5% [33] on recommendations of reports of International Commission on Radiation Units and Measurements (ICRU) [35, 36] and the Nordic Association Of Clinical Physicists (NACO) [37].

CONCLUSION

The current study presents a comparison of WF for Wedges supplied with the teletherapy unit. The data evaluation showed that non significant difference in WF of each of wedge being analyzed

Table 1. List of various studies done on wedge factor for LA only, ^{60}Co only or for both (LA and ^{60}Co) along with dependant factors (Field Size, Depth, SSD)

S. No.	Study	Modality LA/ Both (LA and ^{60}Co)/ ^{60}Co	Factor dependency (FS, Depth, SSD/Dist.)
1	Saffar MH et al. [2]	LA	Field Size, Depth, SSD
2	Ahmad M et al. [3]		Field Size, Depth
3	Popescu A et al. [6]		Field Size, Depth, SSD
4	Bar-Deroma RD and Bjärngard BE [7]		Field Size, Depth
5	Podgorsak MB et al. [8]		Field Size, Depth
6	Popple RA et al. [9]		Field Size
7	Sewchand W et al. [10]		Field Size, Depth
8	Palta JR et al. [11]		Field Size
9	Wu A et al. [12]		Field Size
10	McCullough EC et al. [13]		Depth
11	Liu C et al. [14]		Field Size
12	Zhu XR et al. [15]		Field Size, Depth
13	Van Santvoort J [16]		Not Available
14	Wichman BD [17]		Field Size
15	Gibbons JP [18]		Field Size
16	Cozzi FA et al. [19]		Field Size, Depth
17	Dean EM and Davis JB [20]		Field Size
18	Thomas J [21]		Field Size
19	Birgani MJT [22]		Field Size, Depth
20	Choi DR et al. [23]		Field Size
21	Niroomand-Rad A et al. [24]	Both (LA and ^{60}Co)	Field Size, Depth
22	Heukelom S et al. [25]		Field Size and Depth
23	Kalend AM et al. [26]		Field Size and Depth
24	Tailor RC et al. [27]		Field Size, Depth
25	Haq M M et al. [4]	^{60}Co	Not Available
26	Safar MH et al. [5]		Field Size, Depth, SSD
27	Kinhikar RA et al. [28]		Field Size
28	Andrabi WH et al. [29]		Not Available
29	Akinlade BI et al. [30]		Not Available
30	Malik SR et al. [31]		Not Available
31	Tagoe SNA et al. [32]		SSD

Table 2. Wedge Factor of different wedge angles for different field sizes at 05 cm depth with their mean and standard deviation

Sr. No.	Wedge Angle	Wedge Identification	Field Size cm × cm	Wedge Factor 05 cm	Mean	Standard Deviation
1	15°	W15	5 × 5	0.691011236	0.695123403	0.004542877
			10 × 10	0.694358974		
			10 × 15	0.700000000		

continued

Table 2 Continued. Wedge Factor of different wedge angles for different field sizes at 05 cm depth with their mean and standard deviation

2	30°	W30	5 × 5	0.573033708	0.576481321	0.003483690
			10 × 10	0.576410256		
			10 × 15	0.580000000		
3	45°	W45	5 × 5	0.597752809	0.600601364	0.002467054
			10 × 10	0.602051282		
			10 × 15	0.602000000		
4	60°	W60	5 × 5	0.440449438	0.448201095	0.008952596
			10 × 10	0.446153846		
			10 × 15	0.458000000		

Table 3. Wedge Factor of different wedge angles for different field sizes at 10 cm depth with their mean and standard deviation

Sr. No.	Wedge Angle	Wedge Identification	Field Size cm × cm	Wedge Factor 05 cm	Mean	Standard Deviation
1	15°	W15	5 × 5	0.693251534	0.695602077	0.002179005
			10 × 10	0.696000000		
			10 × 15	0.697554698		
2	30°	W30	5 × 5	0.582822086	0.582404445	0.000593885
			10 × 10	0.582666667		
			10 × 15	0.581724582		
3	45°	W45	5 × 5	0.605828221	0.606653165	0.000818277
			10 × 10	0.606666667		
			10 × 15	0.607464607		
4	60o	W60	5 × 5	0.447852761	0.453579406	0.004979142
			10 × 10	0.456000000		
			10 × 15	0.456885457		

Table 4. Wedge Factor from different researchers including current study with modality (for LA only, ^{60}Co only or for both (LA and ^{60}Co)

S. No.	Study	Modality LA/ Both (LA and ^{60}Co)/ ^{60}Co	WF
1	Hajizadeh SM et al. [2]	LA	<2%
2	Ahmad M et al. [3]		<10%
3	Popescu A et al. [6]]		<±1.0%
4	Bar-Deroma RD and Bjärngard BE [7]		<±1.5%
5	Podgorsak MB et al. [8]		<25%
6	Popple RA et al. [9]		<2%
7	Palta JR et al. [11]		(3.5-7)%
8	McCullough EC et al. [13]		(2-5)%
9	Liu C et al. [14]		<1%
10	Van Santvoort J. [16]		<3.5%
11	Wichman BD. [17]		(1-3)%

continued

Table 4 continued. Wedge Factor from different researchers including current study with modality (for LA only, ^{60}Co only or for both (LA and ^{60}Co)

12	Gibbons JP. [18]		(1-4)%
13	Cozzi FA et al. [19]		<1.5%
14	Birgani MJT [22]		<5%
15	Choi DR et al. [23]	Both (LA and ^{60}Co)	5%
16	Heukelom S. et al. [25]		<9%
17	Tailor RC et al. [27]		(2-5)%
18	Haq MM et al. [4]	^{60}Co	<3.5%
19	Safar MH et al, [5]		<1%
20	Kinhikar RA et al. [28]		<2%
21	Andrabi WH. Et al. [29]		<2%
22	Akinlade BI et al. [30]		<5.5%
23	Malik SR et al. [31]		<1%
24	Tagoe SNA et al. [32]		<±0.50%
25	Current Study		<±2.5%

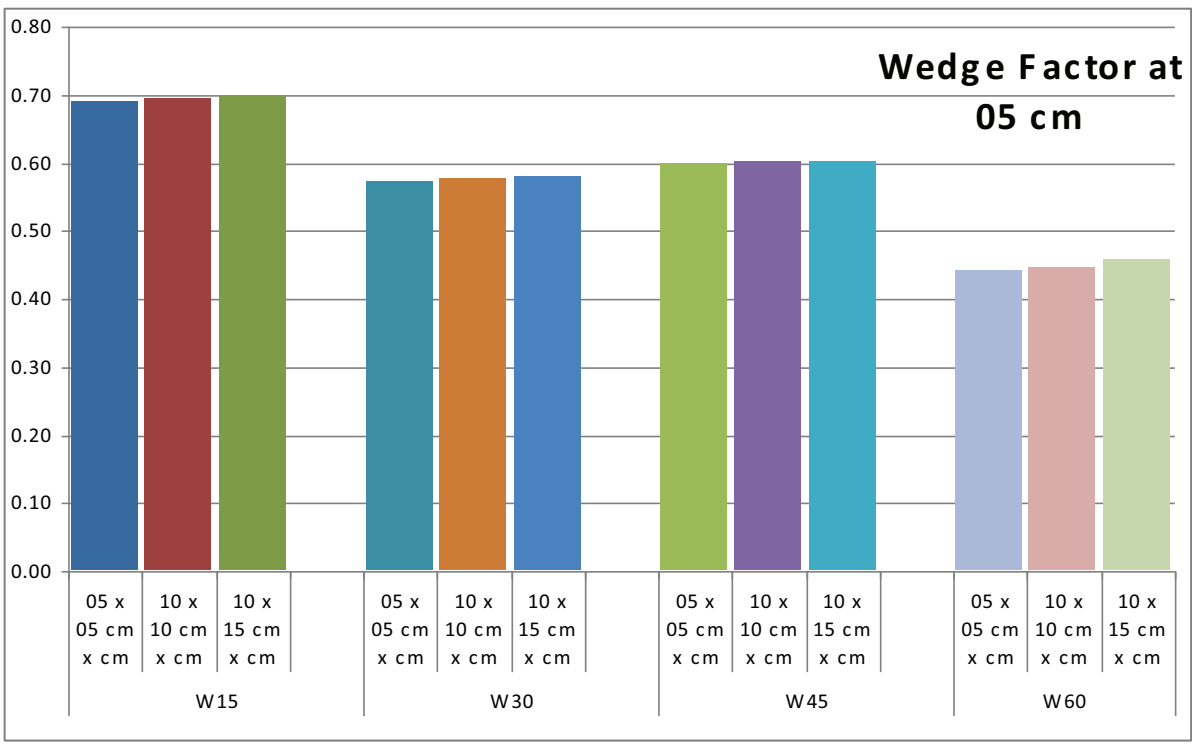

Figure 3. Graphical representation of wedge factors for different wedges for different field sizes at 05 cm depth

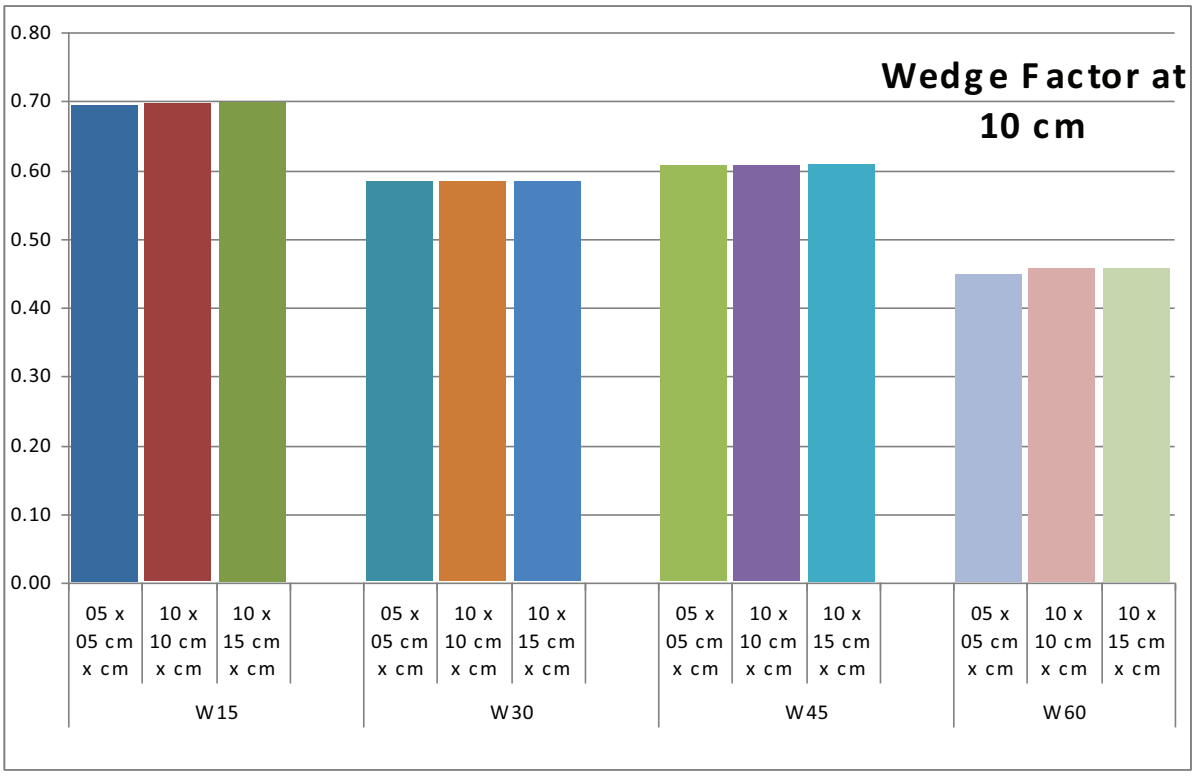

Figure 4. Graphical representation of wedge factors for different wedges for different wedges for different field sizes at 10 cm depth

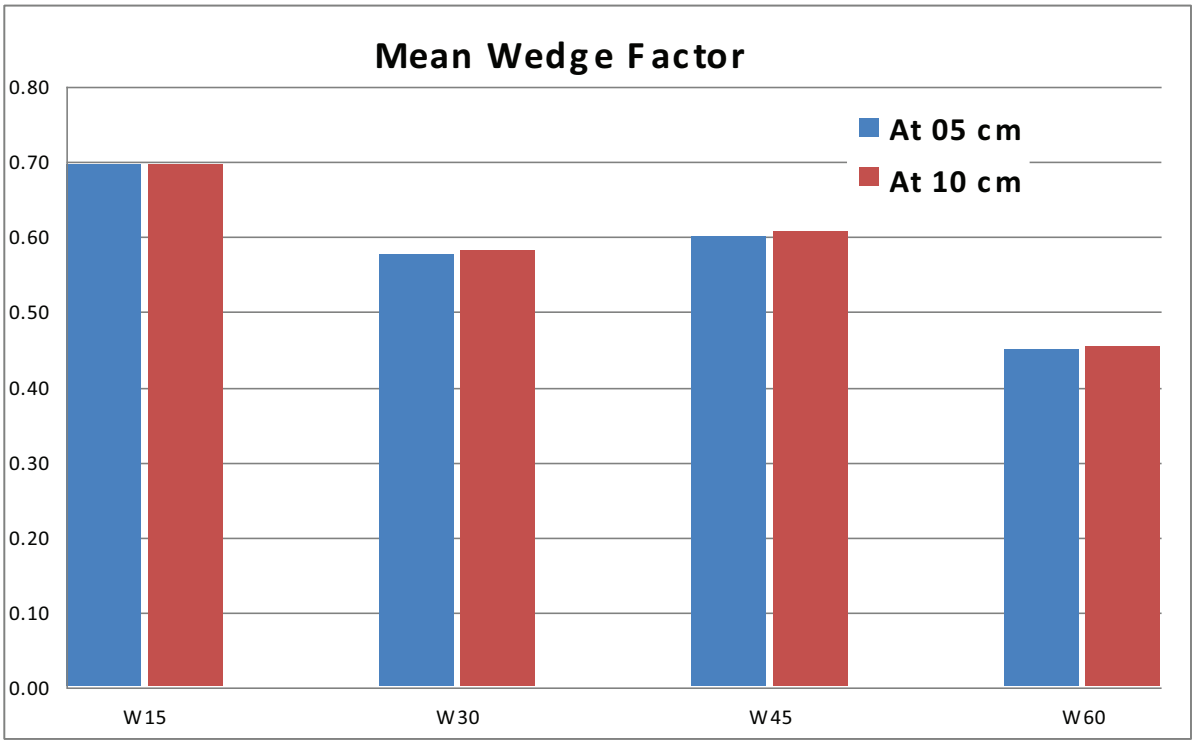

Figure 5. Graphical representation of mean Wedge Factors for different wedges at 05 and 10 cm depths

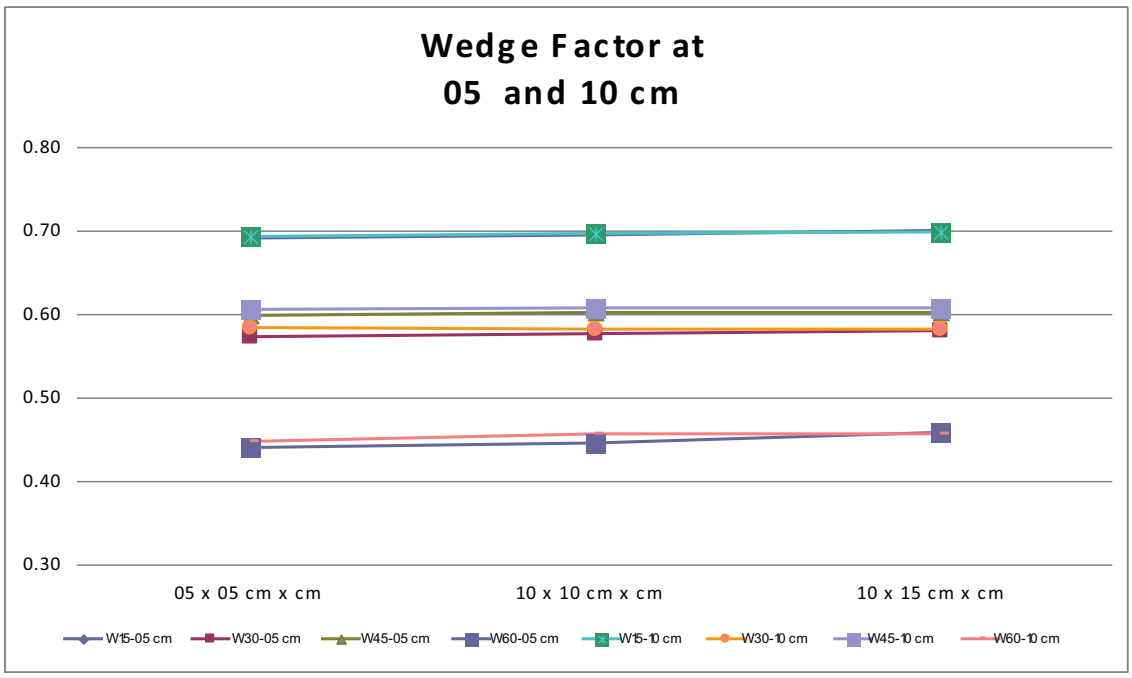

Figure 6. Graphical representation of Wedge Factors for different wedges for different field sizes at 05 and 10 cm depths

for different field sizes at different depths. This study suggested that WF for a specific wedge is approximately a constant ratio irrespective of field size and depth. The measurement for only one field size at one depth is adequate to calculate the WF for a specific wedge.

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List of abbreviation

cc	Cubic Centimeter
cm	Centimeter
^{60}Co	Cobalt-60
d_{max}	Dose at Maximum
d_5	Dose at 5 cm
d_{10}	Dose at 10 cm
Gy	Gray
IAEA	International Atomic Energy Association
ICRU	International Commission on Radiation Units and Measurements
LA	Linear Accelerator
MU	Monitor Units
NACO	Nordic Association of Clinical Physicists
NE	Nuclear Enterprises
NIMRA	Nuclear Institute of Medicine and Radiotherapy
NPIC	Nuclear Power Institute of China
SSD	Source to Surface Distance
TT	Treatment Time
WF	Wedge Factor

Conflict of Interests

None.

Ethical approval

Ethical committee of NIMRA approved the current study.

Consent for publication from the study subjects

As there is no any data of patients/ subjects has been used in study, only the teletherapy machine and dosimetry system is used, so no need of consent is required.

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