Comparing Virtual with Physical Wedge for the Transmission Factors

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INTRODUCTION

A virtual wedge, realized by a moving collimator jaw, offers an alternative over a set of fixed wedges for producing a wedged photon dose distribution. This system does not require handing of physical wedge and therefore may allow faster treatment. Furthermore, any arbitrary wedge angle and length can be created instead of the traditional four fixed wedges. The virtual wedge factor for the Siemens virtual wedge is designed to be approximately 1.00. The purpose of this work is to confirm that statement and to identify conditions in which the virtual wedge factor is not 1.00 and thus should be included in monitor unit calculations. This paper investigates the discrepancies between virtual wedge and physical wedge at the standard wedge angles of 15, 30, 45, and 60 degrees. The dose distributions for virtual wedge and physics wedge were measured by using a commercial multichamber detector array. The transmission factors (wedge factors) of each virtual wedge and physical wedge were measured for Siemens PRIMUS 3008 linear accelerator by single ion chamber. The transmission factors have been measured for two x-ray beams as a function of wedge angle, field size and depth. These factors were used to set-up the clinical treatment data tables for clinical dosimetry for virtual wedge utilization.

MATERIALS AND METHODS

The wedge transmission factor (wedge factor, WF) at a depth d, in water, for a field size, FS, is defined as the ratio of the dose with the wedge in place, D_w(FS, d), to the dose with the wedge removed (open beam), D_0(FS,d):

$$\mathrm{WF}(\mathrm{FS},d) = D_w(\mathrm{FS}, d) / D_0(\mathrm{FS},d)$$

Where FS is the length of one side of a square field defined at the isocenter.

The transmission factor measurements were performed for 6 MV X-rays and 15 MV X-rays (Siemens PRIMUS 3008) using standard physical wedge filters provided by the manufacturer [these physical wedge filters are made of iron alloy (EZ-CUT 20 steel)] with nominal wedge angles of 15^0, 30^0, 45^0, and 60^0. The Siemens PRIMUS 3008 linear accelerator is equipped with a set of virtual wedge. The transmission factor measurements were obtained with a Wellhöfer IC 15 chamber (0.13cc) in water. The chamber was installed on the chamber frame of Wellhöfer water phantom (48×48×40 cm^3). The surface of water was at 100 cm SSD. The transmission factors for virtual wedge and physical wedge were measured on the central axis of each field at 5 cm depth for 6 MV or 10 cm depth for 15 MV X-ray. Comparing virtual wedge with physical wedge for transmission factor as field size range from 4×4 to 25×25 cm^2. The dose profiles at various depths (5, 15, 20 cm depth for 6 MV and 10, 15, 20 cm depth for 15 MV) were also measured using the chamber array.

RESULTS

(1) Transmission factors versus field sizes

The transmission factors (wedge factors) of physical wedges in water as a function of field size for 6 MV and 15 MV X-ray beams are shown in Figure 1.

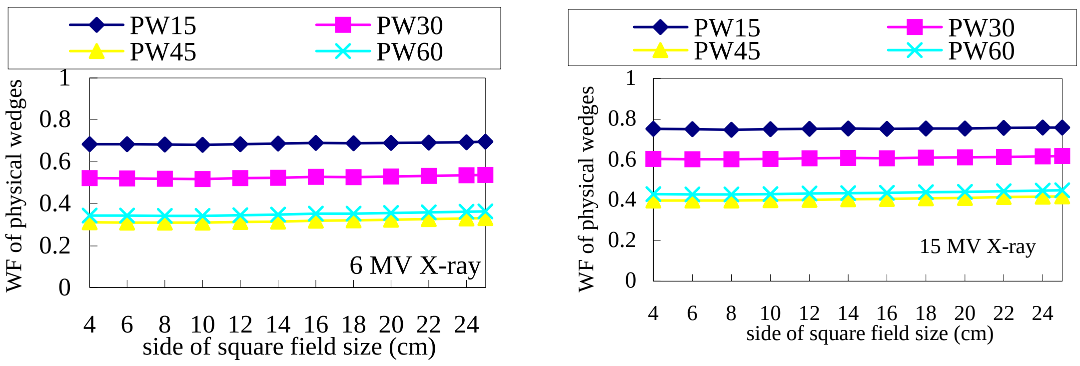

Fig 1. The wedge factors versus the sides of square field sizes for physical wedge for 6- and 15-MV beam.

The transmission factors of each virtual wedge were almost constant value as 1.0 for each wedge angle (as in Figure 2). For transmission factors of virtual wedge were constant value as 1.0 for each angles, namely output without wedge is almost equal to output with wedge on the central axis. Dependence of the wedge factor on field sizes has been attributed to the change in phantom scatter as well as to the change in scattered photons that reach the point of measurement after undergoing interactions in the flattening filter, the primary collimator, and the wedge filter.

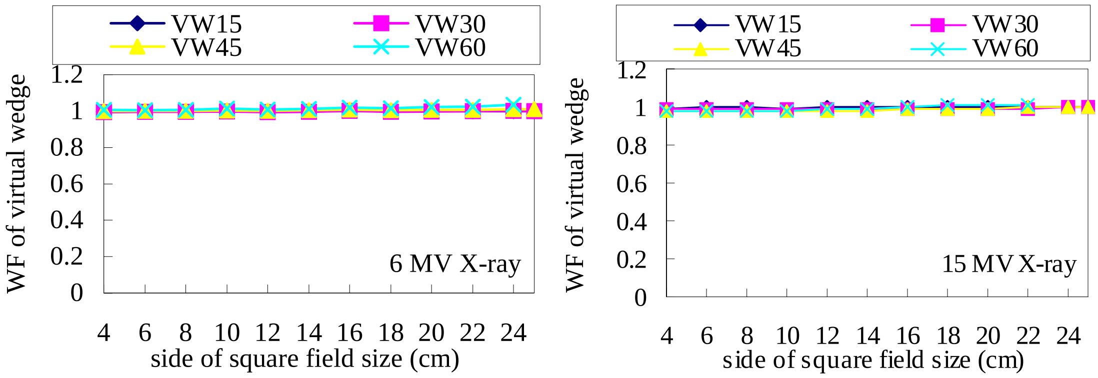

Fig 2. The wedge factors versus the sides of square field sizes for virtual wedge for 6- and 15-MV beam.

(2) Peripheral dose versus depths and wedge angles

Table I describe a series of basic measurements performed to characterize the effects of a virtual wedge upon the peripheral dose.

Table I. Peripheral dose (%) for 15 MV X-ray beam at d_{max} for the 20×20 cm^2 field of physical wedge and virtual wedge.

Off-Axis (cm)	6 MV							
	15^0		30^0		45^0		60^0	
	PW	VW	PW	VW	PW	VW	PW	VW
-15.0	4.8	4.0	5.8	3.9	7.8	3.9	7.1	3.8
-14.5	4.9	4.4	5.8	4.1	7.8	3.9	7.1	3.8
-14.0	5.3	4.8	6.0	4.6	7.8	4.2	7.5	4.4
-13.5	5.7	5.1	6.2	4.8	7.8	4.5	7.8	4.4
-13.0	6.2	5.7	7.0	5.2	8.2	5.1	8.2	4.9
-12.5	6.6	6.1	7.2	5.7	8.6	5.4	8.2	4.9
-12.0	7.3	6.7	7.7	6.2	9.0	5.7	8.5	5.5
-11.5	7.9	7.3	8.4	6.8	9.8	6.3	8.5	6.0
-11.0	9.9	9.7	10.1	9.1	11.0	8.4	9.3	7.7
-10.5	18.6	15.8	16.2	15.1	14.9	14.1	12.1	11.5
	15 MV							
Off-Axis (cm)	15^0		30^0		45^0		60^0	
	PW	VW	PW	VW	PW	VW	PW	VW
-15.0	4.7	4.1	5.2	4.0	6.8	3.9	6.6	3.9
-14.5	4.8	4.5	5.4	4.3	6.8	4.1	6.8	3.9
-14.0	5.2	4.8	5.8	4.7	6.8	4.5	7.1	4.3
-13.5	5.6	5.4	6.1	5.1	7.3	4.7	7.3	4.6
-13.0	6.2	5.9	6.6	5.6	7.8	5.3	7.5	5.3
-12.5	6.7	6.5	7.1	6.1	8.3	5.7	7.5	5.6
-12.0	7.6	7.2	7.8	6.7	8.8	6.3	8.0	5.9
-11.5	8.6	8.3	8.8	7.8	9.8	7.1	8.5	6.6
-11.0	11.9	11.3	11.8	10.3	12.1	9.4	10.4	8.2
-10.5	18.8	18.3	17.8	15.9	17.1	13.9	13.9	11.5

Peripheral dose profiles were obtained for 6 MV and 15 MV X rays at d_{max} for the 20×20 cm^2 field of physical wedge and virtual wedge. The peripheral dose is presented as a percentage of the central axis maximum. The peripheral dose outside the geometric projection of the treatment field using virtual wedge is smaller compared to physical wedged field doses.

Table II shows the percent dose of the central axis of physical and virtual wedges at various depths for

6- and 15-MV beam. These data are from the dose profiles measured by the chamber array for virtual wedge and physical wedge. From these data, we found that the deviation between physical wedge and virtual wedge increased with an increase in the depth and the wedge angle.

Table II. The percent dose (dose relative to the d_{max}) and deviation (%) of physical and virtual wedges at various depths for 6- and 15-MV beam

Depth (cm)	6 MV											
	15^0			30^0			45^0			60^0		
	PW	VW	Deviation	PW	VW	Deviation	PW	VW	Deviation	PW	VW	Deviation
5	88.3	87.7	0.6	88.7	87.7	1.0	89.0	87.9	1.1	89.0	88.1	0.9
15	55.9	55.2	0.7	56.8	55.4	1.4	57.3	55.6	1.7	57.7	56.1	1.6
20	44.0	43.0	1.0	44.8	43.3	1.5	45.5	43.2	2.3	45.9	44.2	1.7
Depth (cm)	15 MV											
	15^0			30^0			45^0			60^0		
	PW	VW	Deviation	PW	VW	Deviation	PW	VW	Deviation	PW	VW	Deviation
10	78.5	78.0	0.5	78.7	78.0	0.7	78.6	78.0	0.6	78.8	78.0	0.8
15	64.7	64.1	0.6	64.8	64.1	0.7	65.0	64.1	0.9	65.4	64.5	0.9
20	53.2	52.6	0.6	53.3	52.7	0.8	53.7	52.7	1.0	53.9	53.0	0.9

CONCLUSION

Virtual wedge dose distributions are formed without external metal wedge modifiers by sweeping one independent collimator jaw across the open field while simultaneously adjusting the dose rate. Transmission factors of all virtual wedges are almost constant, so the central axis depth doses are essentially the same as the open-field depth doses. The wedge angle is maintained over a larger fraction of the virtual wedged field. Virtual wedge has practical and dosimetric advantages over physical wedge.

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